

**VA/DoD CLINICAL PRACTICE GUIDELINE FOR  
REHABILITATION OF LOWER LIMB AMPUTATION**

Department of Veterans Affairs

Department of Defense

**QUALIFYING STATEMENTS**

The Department of Veterans Affairs (VA) and The Department of Defense (DoD) guidelines are based upon the best information available at the time of publication. They are designed to provide information and assist decision-making. They are not intended to define a standard of care and should not be construed as one. Neither should they be interpreted as prescribing an exclusive course of management.

Variations in practice will inevitably and appropriately occur when providers take into account the needs, abilities, and motivations of individual patients, available resources, and limitations unique to an institution or type of practice. Every healthcare professional making use of these guidelines is responsible for evaluating the appropriateness of applying them in the setting of any particular clinical situation.

**Version 1.0 – 2007**

---

Prepared by:

THE REHABILITATION OF LOWER LIMB AMPUTATION  
Working Group

With support from:

The Office of Quality and Performance, VA, Washington, DC

&

Quality Management Directorate, United States Army MEDCOM

Version 1.0 – 2007

---

## TABLE OF CONTENTS

<b>Introduction</b>	<b>1</b>
<b>Guideline Update Working Group</b>	<b>8</b>
<b>Key Elements Addressed by the Guideline</b>	<b>11</b>
<b>Core Module</b>	<b>20</b>
<b>Module A: Preoperative Assessment and Management</b>	<b>58</b>
<b>Module B: Immediate Postoperative Rehabilitation</b>	<b>74</b>
<b>Module C: Pre-Prosthetic Rehabilitation</b>	<b>84</b>
<b>Module D: Prosthetic Training</b>	<b>94</b>
<b>Module E: Rehabilitation and Prosthesis Follow-Up</b>	<b>103</b>

### Appendices

- Appendix A: Guideline Development Process
- Appendix B: Supporting Evidence for Pain Management
- Appendix C: Prosthetic Prescription
- Appendix D: Foot Care Interventions for Patients with Amputations
- Appendix E: Pre-Surgical Education Interventions
- Appendix F: Acronym List
- Appendix G: Participant List
- Appendix H: Bibliography

### Tables

- Table 1. Amputation Rehabilitation Health-Related Outcomes
  - Table 2. Summary of Interventions in Rehabilitation Phases
  - Table 3. Pain Control in Phases of Rehabilitation
  - Table 4. Desensitization Techniques
  - Table 5. Residual Limb Management in Phases of Care
  - Table 6. Patient Education Minimum Standards
  - Table 7. Patient Education Summary Table
  - Table 8. Advantages and Disadvantages of Recommended Assessment Tools
  - Table 9. Categories of Wound Healing (adapted from Smith, 2004)
  - Table 10. Centers for Medicare and Medicaid Services Functional Levels
-

## Introduction

The Clinical Practice Guideline (CPG) for the Rehabilitation of Lower Limb Amputation was developed under the auspices of the Veterans Health Administration (VHA) and the Department of Defense (DoD) pursuant to directives from the Department of Veterans Affairs (VA). VHA and DoD define clinical practice guidelines as:

“Recommendations for the performance or exclusion of specific procedures or services derived through a rigorous methodological approach that includes:

- Determination of appropriate criteria such as effectiveness, efficacy, population benefit, or patient satisfaction; and
- Literature review to determine the strength of the evidence in relation to these criteria.”

## BACKGROUND

The most common causes of major lower limb amputation at VA and DoD facilities are medical diseases such as peripheral vascular disease (PVD) and diabetes, and trauma. The VA and DoD both have the obligation to ensure that all individuals with amputations receive the full range of high quality care and services specific to the unique circumstances facing an individual with lower limb amputation. This guideline is designed to address the key principles of rehabilitation and streamline the care for the patient with amputation who will eventually transition from a DoD to a VA facility.

### Diabetes and Vascular Disease-Related Amputations

Diabetes or PVD are the most common causes for lower limb amputation in aging veterans being cared for in VA facilities. The advanced age of this population is a significant factor in determining successful outcomes in amputation rehabilitation. In part, this is often due to an aging related decrease in conditioning, cognition, nutritional status, and ability to heal wounds, as well as a loss of social support. All of these factors must be considered in developing a care plan for the patient with a lower limb amputation which will lead to successful prosthetic use and return to independent living in the home environment. With a comprehensive rehabilitation program, which addresses the individual patient’s needs, abilities, and level of motivation, the older veteran with an amputation usually can achieve a maximally independent lifestyle. Some of these patients may not be candidates for prosthetic use and will require other significant adaptations in lifestyle and identification of approaches to creating a functionally independent environment for the individual.

Aging veterans with amputations often have numerous comorbidities such as cardiovascular disease, hypertension, end-stage renal disease with dialysis, and arthritis. These conditions are often of a long-standing nature and, in many cases, are associated with inactivity and loss of mobility over the course of the disease. The patient’s general health status increases the challenge of amputation rehabilitation in this population. Not only must they be trained in a new skill, but they must also be reconditioned so they can handle the increased demand of

walking with a prosthesis either as functional users (wearing the prosthesis for most of the day), partial users (using the prosthesis only at home and the wheelchair for outdoor activities), or non-users (not using the prosthesis at all or only sometimes mainly for cosmetic purposes).

An amputation is frequently the end result of the disease process and in many cases can be prevented with appropriate care. An extensive effort is made to save a limb whenever possible. In 2001, the VA developed a CD-ROM based training program titled, "Preservation-Amputation Care and Treatment (PACT)." This program focuses on preventing amputations by identifying veterans who are at risk and educating them on the appropriate treatment and appropriate footwear. It provides an excellent resource for primary care staff involved in the care of a veteran who is at risk of requiring an amputation.

## Traumatic Amputations

The second type of veteran addressed in this guideline has experienced a traumatic amputation such as that occurring from motor vehicle accidents or military combat (e.g., blast, shrapnel, gunshot). While improvements in antibiotics, immediate trauma care, and advanced reconstructive surgical techniques have reduced the need for some amputations, military service members continue to be at significant risk of amputation after severe limb trauma as a result of military combat operation. Amputation continues to be, in some cases, the best option for these individuals who are typically initially treated at a DoD facility.

Battlefield trauma has necessitated amputations since before the establishment of military medicine. Almost 21,000 major amputations were documented in the Union Army during the Civil War. Over 4,000 amputations were performed on U.S. service members during World War I and almost 15,000 service members had major amputations during World War II. Thousands of others lost body parts during the Korean, Vietnam, and Gulf Wars due to traumatic injuries and cold injuries, such as frostbite. Even during peacetime, an estimated 50 military service members per year experience traumatic amputations. Recent advances in body armor have contributed to a higher survival rate from combat-related injuries, especially those secondary to blast. This has resulted in a higher percentage of service members with upper limb and/or multiple limb amputations.

While the pathophysiology of traumatic amputation may be different than dysvascular amputation, rehabilitation strategies and prosthetic component prescriptions for both should be goal oriented and maximize function and quality of life. One of the many challenges in treating patients with a *trauma-related* amputation is to address the wide variety of comorbid injuries often resulting from multi- or poly-trauma. In war-related amputations, additional injuries of peripheral nerves, disrupted blood vessels, retained shrapnel, heterotopic ossification, contaminated wounds, burns, grafted skin, and fractures require modified rehabilitation strategies in the training of activities of daily living (ADL) and ambulation.

## GOALS AND OUTCOMES

The overall goal of amputation rehabilitation is to optimize health status, function, independence, and quality of life of patients with a lower limb amputation.

The clinical practice guideline is designed to achieve several specific goals:

1. Describe prosthetic training, physical conditioning, and psychosocial rehabilitation to maximize the patient's function and quality of life.
2. Describe appropriate interventions to optimize the patient's physical function after an amputation (e.g., strength, aerobic endurance, and balance).
3. Promote an interdisciplinary team approach that is patient focused.
4. Revise existing clinical pathways to be consistent with current evidence-based rehabilitation methods.
5. Provide facilities with a structured framework of appropriate rehabilitation interventions to improve the patient's outcome and reduce current practice variation.
6. Establish priorities for future research efforts that will generate practice-based evidence.
7. Identify outcome measures that can ultimately be used to improve practice in the field and in future guidelines.
8. Assist in identifying priorities for research efforts and allocation of resources.

## Patient Health Outcomes

The Working Group defined outcomes that rehabilitation care should achieve in the categories of postoperative pain, physical health, function, psychological support and well-being, patient satisfaction, reintegration, and healthcare utilization. [Table 1. Amputation Rehabilitation Health-Related Outcomes](#) describes health-related outcomes in each category.

**Table 1. Amputation Rehabilitation Health-Related Outcomes**

<b>Postoperative pain</b>	<ol style="list-style-type: none"> <li>1. Reduce residual limb pain, improve effectiveness of coping, and reduce interference with daily function</li> <li>2. Reduce phantom limb pain</li> <li>3. Decrease consumption of narcotics (amount and type of pain medications throughout the acute surgical and early pre-prosthetic training phases)</li> </ol>
<b>Physical health</b>	<ol style="list-style-type: none"> <li>4. Reduce the risk of adverse effects due to periods of prolonged immobilization:               <ol style="list-style-type: none"> <li>a. Decrease contractures</li> <li>b. Decrease incidence of pressure ulcers</li> <li>c. Decrease incidence of deep vein thrombosis</li> </ol> </li> <li>5. Improve physical status (e.g., balance, normal range of motion especially at the hips and knees; increase strength and endurance to maximize efficient use of a prosthesis)</li> </ol>
<b>Function</b>	<ol style="list-style-type: none"> <li>6. Improve functional status (e.g., independent bed mobility, independent transfer, wheelchair mobility, gait and safety)</li> <li>7. Improve ambulation (e.g., distance of ambulation, hours of prosthetic wearing, use of an assistive device, and ability to ascend/descend stairs)</li> <li>8. Improve quality of life/decrease activity limitation (e.g., activities of daily living [ADL], recreation, physical activity beyond ADL, community re-integration; and return to home environment)</li> </ol>
<b>Psychological support and well-being</b>	<ol style="list-style-type: none"> <li>9. Reduce psychological comorbidities pre- and postoperative (e.g., depressive and anxiety disorders)</li> <li>10. Improve the quality of life</li> <li>11. Decrease the physical and mental/emotional disease burden</li> </ol>
<b>Patient satisfaction</b>	<ol style="list-style-type: none"> <li>12. Improve satisfaction with the level of skills and levels of independence individual patients have been able to achieve</li> <li>13. For patients receiving prostheses, improve satisfaction with the prosthesis (comfort, functionality, and cosmesis)</li> <li>14. Improve satisfaction with the progress of care and status at discharge</li> </ol>
<b>Reintegration (decrease participation restrictions)</b>	<ol style="list-style-type: none"> <li>15. Improve the discharge outcome (discharge to the least restrictive environment)</li> <li>16. Improve vocational outcomes</li> <li>17. Improve recreational participation</li> <li>18. Maximize community participation</li> </ol>
<b>Healthcare utilization (length of stay)</b>	<ol style="list-style-type: none"> <li>19. Optimize the length of rehabilitation stay</li> <li>20. Optimize the time from prosthetic fitting to reaching the mobility goals, regardless of the process of rehabilitation</li> <li>21. Increase life-long follow-up</li> </ol>

## SCOPE AND APPROACH

The development process of this guideline follows a systematic approach described in "Guideline for Guidelines," an internal working document of VHA's National Clinical Practice Guideline Counsel. [Appendix A](#) clearly describes the guideline development process.

In developing the recommendations, the Working Group used available evidence whenever possible. However, it was also necessary to rely heavily on the consensus of experienced VA/DoD healthcare providers and anecdotal evidence. The diverse backgrounds and interdisciplinary nature of the group provided an appropriate balance in the attempt to avoid bias in formulating the recommendations.

This Guideline is the product of many months of diligent effort and consensus building among subject matter experts from the Department of Veterans Affairs (VA), Department of Defense (DoD), academia, and guideline facilitators from the private sector. An experienced moderator facilitated the multidisciplinary Working Group. The Working Group members were physicians, nurses, physical and occupational therapists, vocational rehabilitation specialists, prosthetists, psychologists, and educators involved in the rehabilitation of patients with amputations. Additional input was obtained from several clinical directors of amputation clinics in the VHA.

### Target Population

The target population for this guideline was defined at the outset of the process. The guideline provides care recommendations for adult patients with a lower extremity amputation (bilateral and unilateral) including through-hip, transfemoral, through-knee, transtibial, through-ankle, and partial foot. The cause of the amputation may be traumatic (combat or non-combat-related), or non-traumatic (dysvascular, neuropathy, carcinoma, or infection). Management of patients with polytrauma, including head injuries, who require a lower limb amputation present additional complications that are not addressed in this guideline.

### Target Audience

This guideline is written for individual providers who are part of the medical rehabilitation team representing multiple disciplines: psychiatry, surgery, physical therapy, occupational therapy, nursing, behavioral medicine or mental health, prosthetics, social work, nutrition, case management, and primary care (for long-term follow-up), as well as patients and their support system. The guideline also provides a framework for organizing rehabilitation care provided in a variety of environments, including inpatient rehabilitation units, physical medicine and rehabilitation (PM&R) departments, post-amputation clinics, prosthetic services, primary care practices, and long-term care facilities.

Care for patients with a lower limb amputation (traumatic and non-traumatic) is complex and requires interdisciplinary management from multiple healthcare specialties. Recommendations in this guideline are not specific to individual team members or disciplines; they are patient-centered and describe the patient's needs at each step of rehabilitation care. This approach is intended to support



interdisciplinary communication and practice among team members to ensure a successful surgical outcome and rehabilitation process.

## DEVELOPMENT PROCESS

An initial literature search was conducted to identify relevant published studies in the past ten years. The search was designed to identify the best available evidence and ensured maximum coverage of studies at the top of the hierarchy of study types: evidence-based guidelines, meta-analyses, systematic reviews, and randomized trials. The search did not identify any published clinical practice guidelines that address lower limb amputation rehabilitation. In addition, very few of the source documents used an evidence-based approach. A large body of research was beyond the scope of this guideline. It is related to surgical procedures and the scientific engineering of prosthetic manufacturing (technical, mechanical, and design issues of prosthetic limbs and components).

The initial literature search revealed very limited research specific to the topic of rehabilitation (physical and functional) following lower limb amputation. Published literature has primarily consisted of epidemiologic surveys, cross section descriptive studies, clinical commentaries, single-group cohort studies, and case studies, with randomized controlled trials (RCT) noticeably absent.

Recognizing the limitations identified in the initial searches, the actual literature review for this guideline focused on three specific questions: the management of pain control, the strategy of postoperative residual limb management (e.g., post operative dressing), and behavioral health interventions throughout the rehabilitation process. The search covering the period 1995 - 2006 was conducted to identify original articles of clinical trials and empirical data evaluating efficacy and harm of intervention in the three areas. Abstracts of all studies were reviewed by members of the Working Group and the full text of ninety six RCTs was retrieved. Additional studies were supplied by the Working Group members, as well as bibliographic follow-ups of the retrieved studies. The studies were appraised for their quality and the results were summarized in 3 reports that were used by the Working Group as the evidence base for formulating the recommendations.

In general, the available trial studies were characterized by some methodological limitations that impact the ability to generalize the findings to the target population of this guideline (patients served by both the VA and DoD). These include:

- Lacks of standard protocols and tends to focus on only a few outcomes using nonstandardized measures of function and quality of life
- Inconsistent definitions of outcome measures that lead to difficulties in evaluating and comparing studies
- Inadequate study duration; especially in the domain of community usage of devices
- Large proportions of subjects are lost to long-term follow-up
- Lack of homogeneity in patient populations, since patients have unique medical and surgical issues that greatly individualize their care and are also characterized by unique social and emotional support resources.

Based on the limited body of evidence in the literature that met rigorous scientific criteria, the Working Group developed recommendations to address lower limb amputation rehabilitation. The Working Group used methods adapted from the U.S.

Preventive Services Task Force for grading strength of evidence and rating recommendations (see Appendix A) for the recommendations included in these three sections of the guideline. The strength of recommendations (SR) appears in brackets at the end of each recommendation for these three sections. The recommendations in all other annotations were based on consensus of expert opinion.

A questionnaire was also prepared and disseminated to practicing professionals within both the VA and DoD who work directly with patients who have had lower limb amputations. An effort was made to reach a maximum number of individuals from the various disciplines that provide care and services to this population. These professional staff members were queried as to care in all phases of rehabilitation of patients with amputation. In addition, they were asked to share testing techniques and approaches that they have found to be especially successful in working with patients with lower limb amputations. The results of the survey were kept from the Working Group to avoid bias and were compared to the final list of recommendations that emerged from the group discussions. The summary list of interventions was compared and consolidated with the results of the survey. ([Table 2. Summary of Interventions in Rehabilitation Phases](#))

The draft document was discussed in two face-to-face group meetings and through multiple conference calls over a period of six months. The final document is the product of those discussions and has been approved by all the members of the Working Group. The final draft document was reviewed by a diverse group of experts and by independent peer reviewers, whose input was also considered. The final document was submitted for review and approval by the VA/DoD Evidence-Based Practice Working Group (see [Appendix A](#)).

The list of participants in the Working Group is included in [Appendix G](#) to the guideline.

## Implementation

The guideline and algorithms are designed to be adapted to individual facility needs and resources. It is expected that this guideline will provide information useful for improving amputation care by reducing variability. Providers may use the algorithms to determine best interventions and steps of care for their patients to optimize healthcare utilization and achieve the best outcomes related to rehabilitation following lower limb amputation. This should not prevent providers from using their own clinical expertise in the care of an individual patient. Guideline recommendations should facilitate, not replace, clinical judgment.

This guideline represents a first attempt in providing a structure for a rehabilitation process in lower limb amputation that is evidence-based. As rehabilitation practice is evolving, new technology and more research will improve rehabilitation care in the future. The clinical practice guideline can assist in identifying priorities for research efforts and allocation of resources. As a result of implementing a more unified approach to rehabilitation practice, followed by data collection and assessment, new practice-based evidence may emerge.

## Guideline Update Working Group

GUIDELINE UPDATE WORKING GROUP	
VA	DoD
Donna J. Blake, MD	Gary E. Benedetti, MD
<b>Steve M. Brielmaier, MSPT</b>	Linda A. Coniglio, MS, OTR
<b>Joseph Czerniecki, MD</b>	John Ferguson, CPO
Helene K. Henson, MD	<b>Scott W. Helmers, MD</b>
<b>Margaret J. Kent, PT</b>	<b>Jennifer S. Menetrez, MD</b>
Martin L. McDowell, BS, LPO, CPO	Joseph Miller, MS CP
Lief Nelson, PT	Janet A. Papazis, MPT
<b>Al Pike, CP</b>	<b>Paul F. Pasquina, MD</b>
<b>Cindy E. Poorman, MSPT</b>	Robert J. Wilson, PsyD
James F. Roper Jr., MD	
Sheila Saliman, PhD	
<b>Barbara J. Sigford, MD</b>	
Deborah J. Velez, GNP, MN	
Marilyn Weber, MD	
<b>FACILITATOR</b> <b>Oded Susskind, MPH</b>	
<b>HEALTHCARE QUALITY INFORMATICS, INC.</b> Martha D'Erasmus, MPH Rosalie Fishman, RN, MSN, CPHQ Joanne Marko, MS, SLP	

\* *Bolded names are members of the Editorial Panel.*

*Additional contributor contact information is available in [Appendix G](#).*

## How to Use this Guideline

The design and implementation of any management strategy for lower limb amputation requires an understanding of the time frame of recovery. The postoperative continuum does not separate easily into "phases," yet for the purposes of this guideline, phases have been defined to facilitate discussion of how the goals evolve throughout the process. Although progression through these phases is largely individualized, the time needed to progress is consistently reported to be between 12 and 18 months. Several facets of care will need to be considered and managed including medical and surgical issues, changes in limb volume, prosthetic fitting and training, social reintegration, life planning, and goal setting.

The guideline has been organized with an initial presentation of a Core Module that cuts across all phases and Modules A-E that correspond to the individual phases of care. Each of the modules (except the Core) includes an algorithm which describes the step-by-step clinical process of decisions and interventions that occur in each phase of care. Specific recommendations for each step in the algorithm are included in an annotation section attached to each algorithm.

*CORE:* The *CORE* module includes recommendations in those disciplines that are applied continuously throughout all phases of care (e.g., pain management, behavioral health and rehabilitation intervention). The links to these recommendations are also embedded in the relevant specific steps in the algorithms for each phase of rehabilitation care in Modules A through E.

*Module A: Preoperative Phase.* The preoperative phase starts with the decision to amputate. This phase includes an assessment of the patient's health and functional status and decisions about strategies that will be applied postoperatively (e.g., pain management and dressing). In addition, the consideration of amputation level selection, preoperative education, emotional support, physical therapy and conditioning, nutritional support, and pain management occur in this phase of care.

*Module B: Immediate Postoperative Phase.* The acute hospital postoperative phase is the time in the hospital after the amputation surgery, ranging from approximately 5 to 14 days. This module addresses common postoperative recovery concerns which include such things as hemodynamic stability, wound healing and prevention of early complications, and additional specific interventions such as care of the residual limb, patient education, physical therapy (to include patient safety, initial mobility, positioning, and transfers), occupational therapy, and behavioral health.

*Module C: Pre-Prosthetic Rehabilitation Phase.* In general, this phase begins with discharge from acute care once the patient is medically stable and may extend up to 6 to 12 weeks after surgery. The focus of concern shifts from the surgical and medical issues to rehabilitation. Rehabilitation will focus on maximizing physical function as well as social function concerning daily activities, and re-integration to home and community. Rehabilitation at this phase is aimed at improving the patients' function to enable them to achieve their goals with or without prosthesis.

*Module D: Prosthetic Training Phase.* This phase starts when the first prosthetic device is fitted. The most rapid changes in residual limb volume occur during this phase due to the beginning of ambulation and prosthetic use. The immediate recovery period begins with the healing of the wound and usually extends 4 to 6 months from the healing date. This phase includes gait training, rehabilitation intervention, and emphasis on integration into the community and vocational and recreational activities. This phase generally ends with the relative stabilization of the residual limb size as defined by consistency of the prosthetic fit for several months.

*Module E: Rehabilitation and Prosthesis Follow-up Phase.* Limb volume will continue to change to some degree, for a period of 12 to 18 months after the initial healing. This will likely require adjustments to the prosthetic socket, necessitating access to a skilled prosthetist, with frequent visits during the first year of prosthetic use. In this phase, the patient moves toward social reintegration and higher functional training and development, and becomes more empowered and independent from his or her healthcare provider. This phase is not defined by an end-point. Special efforts should be made to follow up with the patient beyond the first year. Continued assessment and interventions to prevent further amputation and secondary complications as well as promoting care of the residual and contralateral limbs are part of the life-long care for the patient with a lower limb amputation.

## **Interdisciplinary Team Approach**

Care for the patient with amputation (traumatic and non-traumatic) is complex and requires multiple medical, surgical, and rehabilitation specialties. An interdisciplinary team approach to lower limb amputation rehabilitation remains vital. In addition to the patient, members of the medical rehabilitation team will most likely include the patient's support system, surgeon, physiatrist, physical therapist, occupational therapist, recreational therapist, prosthetist, nurse, social worker, behavioral health specialist, peer support visitors, and case manager. Each member has important roles and responsibilities in optimizing pre- and postoperative rehabilitation.

Achieving maximum recovery and optimal function after limb-loss demands increased efforts by the various providers to communicate on behalf of the patient. Communication among team members can be challenging as the patient may visit various team members at different locations in the same day.

The recommendations in this guideline are patient-centered and describe the intervention that should be taken by the medical rehabilitation team at each step of the care. [Table 2. Summary of Interventions in Rehabilitation Phases](#) includes a matrix of the key interventions that occur at each phase, organized by disciplines.

Key Elements Addressed by the Guideline

- 1. Defines the phases of rehabilitation care and the steps included in each phase.**
- 2. Recognizes the importance of comprehensive interdisciplinary assessment of the patient before and after surgery and understanding the physical and social support system.**
- 3. Recognizes the importance of the decision about the appropriate level of amputation to maximize function.**
- 4. Discusses surgical principles to optimize wound healing and shaping of the residual limb for prosthetic rehabilitation.**
- 5. Discusses immediate postoperative dressing and management of the residual limb to maximize healing and functional outcome.**
- 6. Identifies key elements of the rehabilitation treatment and prosthetic training across all phases of the rehabilitation process.**
- 7. Emphasizes the importance of foot care to prevent future amputation and optimize the condition of the contralateral limb.**
- 8. Describes the key components of medical management of medical comorbidities and prevention of complications.**
- 9. Addresses strategies for pain management across all phases of the rehabilitation process.**
- 10. Emphasizes the contribution of behavioral health assessment and intervention.**
- 11. Recognizes the importance of patient education.**
- 12. Emphasizes the need for life-long follow-up care.**

**Table 2. Summary of Interventions in Rehabilitation Phases**

Key: ADL – activities of daily living; CV – cardiovascular; HEP – home exercise program; LE – lower extremity; PLP – phantom limb pain; RLP- residual limb pain; ROM - range of motion; UE – upper extremity

	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
<b>1. Pain Management</b>	<ul style="list-style-type: none"> <li>Assess for existing pain prior to surgery and treat aggressively</li> </ul>	<ul style="list-style-type: none"> <li>Assess and aggressively treat RLP and PLP (liberal narcotic use, regional anesthesia, and non-narcotic medications especially for neuropathic pain)</li> </ul>	<ul style="list-style-type: none"> <li>Assess and treat RLP and PLP (transition to non-narcotic modalities including pharmacological, physical, psychological, and mechanical)</li> </ul>	<ul style="list-style-type: none"> <li>Assess and treat RLP and PLP (transition to non-narcotic modalities including pharmacological, physical, psychological, and mechanical)</li> </ul>	<ul style="list-style-type: none"> <li>Reassess and adjust treatment for RLP and PLP (transition to non-narcotic modalities including pharmacological, physical, psychological, and mechanical)</li> <li>Assess and treat associated musculoskeletal problems</li> </ul>
<b>2. Medical Comorbidity Management</b> [nutritional, cardiovascular, endocrine, neurologic, bowel & bladder, skin, musculoskeletal, infectious, & neuropsychiatric impairments]	<ul style="list-style-type: none"> <li>Complete initial assessment of medical comorbidities and consultation as appropriate</li> <li>Initiate medical interventions and education as needed</li> </ul>	<ul style="list-style-type: none"> <li>Complete initial assessment of medical comorbidities and consultation as appropriate, especially if not addressed preoperatively</li> <li>Initiate medical interventions and education as needed</li> </ul>	<ul style="list-style-type: none"> <li>Continue medical interventions and education as needed</li> </ul>	<ul style="list-style-type: none"> <li>Assess changes in medical comorbidities, and perform interventions and education as needed</li> </ul>	<ul style="list-style-type: none"> <li>Assess changes in medical comorbidities and perform interventions and education as needed</li> </ul>
<b>3. Behavioral Health</b>  Psychological Cognitive Function	<ul style="list-style-type: none"> <li>Complete psychological assessment except in urgent cases</li> </ul>	<ul style="list-style-type: none"> <li>Complete psychological assessment if not done preoperatively</li> <li>Evaluate and address psychosocial symptoms/issues</li> </ul>	<ul style="list-style-type: none"> <li>Evaluate and address psychosocial symptoms/issues</li> </ul>	<ul style="list-style-type: none"> <li>Evaluate and address psychosocial symptoms/issues</li> </ul>	<ul style="list-style-type: none"> <li>Evaluate and address psychosocial symptoms/issues</li> </ul>

	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
<b>4. Residual Limb Management</b>	—	<ul style="list-style-type: none"> <li>• Manage postoperative dressings</li> <li>• Monitor the surgical wound for signs and symptoms of ischemia or infection</li> <li>• Control edema and shape residual limb with the use of rigid dressings with or without an attached pylon, and/or residual limb- protector or ACE wrap</li> <li>• Teach ACE wrap application or shrinker application</li> <li>• Promote skin and tissue integrity with the use of a residual limb-protector or rigid dressing</li> <li>• Promote ROM and strengthening of proximal joints and muscles</li> <li>• Consider vacuum assisted wound closure device for open wounds</li> </ul>	<ul style="list-style-type: none"> <li>• Continue to monitor wound healing</li> <li>• Continue shaping and shrinkage of residual limb</li> <li>• Teach ACE wrap application or shrinker application</li> <li>• Teach patient care of residual limb</li> <li>• Promote ROM and strengthening of proximal joints and muscles</li> <li>• Instruct in desensitization exercises</li> </ul>	<ul style="list-style-type: none"> <li>• Optimize limb shaping and shrinkage prior to prosthetic fitting</li> <li>• Teach donning/doffing of prosthetic system</li> <li>• Instruct in use of shrinker or ACE wrap when out of prosthesis</li> <li>• Teach skin checks and skin hygiene</li> <li>• Teach management of sock ply (if appropriate)</li> <li>• Progress wear schedule</li> <li>• Optimize pain management in order to promote mobility and restoration of function</li> <li>• Instruct patient to observe pressure points and protect contralateral foot</li> <li>• Monitor skin and tissue integrity with limits on wearing time and frequent skin checks in the newly fitted socket</li> </ul>	<ul style="list-style-type: none"> <li>• Provide contact numbers and instructions to the patient</li> <li>• Educate regarding foot care and skin checks</li> <li>• Educate regarding signs and symptoms of ill-fitting socket</li> <li>• Monitor pain management programs and adjust with appropriate frequency</li> <li>• Continue limb volume management</li> </ul>



	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
<b>5. Patient Education</b>	<ul style="list-style-type: none"> <li>• Pain control</li> <li>• Patient safety/fall precautions</li> <li>• Prevention of complications</li> <li>• Procedural/ Recovery Issues               <ul style="list-style-type: none"> <li>○ Level of amputation</li> <li>○ Prosthetic options</li> <li>○ Postoperative dressing</li> <li>○ Sequence of amputation care</li> <li>○ Equipment</li> </ul> </li> <li>• Role of the interdisciplinary team and members</li> <li>• Psychosocial anticipatory guidance</li> <li>• Expected functional outcomes</li> </ul>	<ul style="list-style-type: none"> <li>• Positioning</li> <li>• Rehabilitation process</li> <li>• Pain control</li> <li>• Residual limb care</li> <li>• Edema control</li> <li>• ACE wrapping</li> <li>• Wound care</li> <li>• Prosthetic timeline</li> <li>• Equipment needs</li> <li>• Coping methods</li> <li>• Prevention of complications</li> <li>• Contracture prevention</li> <li>• Safety</li> </ul>	<ul style="list-style-type: none"> <li>• Positioning</li> <li>• Rehabilitation progress</li> <li>• Pain control</li> <li>• Residual limb care</li> <li>• Edema control</li> <li>• Application of shrinker</li> <li>• Prosthetic timeline</li> <li>• Equipment needs</li> <li>• Coping methods</li> <li>• Prevention of complications</li> <li>• Contracture prevention</li> <li>• Safety</li> </ul>	<ul style="list-style-type: none"> <li>• Positioning</li> <li>• Rehabilitation process</li> <li>• Pain control</li> <li>• Residual limb care</li> <li>• Energy expenditure</li> <li>• Prosthetic education               <ul style="list-style-type: none"> <li>○ Donning &amp; doffing</li> <li>○ Care of prosthesis</li> <li>○ Skin integrity</li> <li>○ Sock management</li> </ul> </li> <li>• Equipment needs</li> <li>• Coping methods</li> <li>• Prevention of complications</li> <li>• Weight Management</li> <li>• Contracture prevention</li> <li>• Safety</li> </ul>	<ul style="list-style-type: none"> <li>• Positioning</li> <li>• Rehabilitation process</li> <li>• Pain control</li> <li>• Residual limb care</li> <li>• Prosthetic timeline</li> <li>• Equipment needs</li> <li>• Coping methods</li> <li>• Prevention of complications</li> <li>• Weight management</li> <li>• Contracture prevention</li> <li>• Safety</li> </ul>

	<b>Preoperative</b>	<b>Acute Postoperative</b>	<b>Pre-prosthetic</b>	<b>Prosthetic Training</b>	<b>Long-Term Follow-up</b>
<b>6. Prosthetic</b>	<ul style="list-style-type: none"> <li>• Determine optimal residual limb length as requested by surgeon in accordance with patient goals</li> <li>• Patient visit / education</li> </ul>	<ul style="list-style-type: none"> <li>• Limb care (see residual limb management)</li> <li>• Cast changes               <ul style="list-style-type: none"> <li>○ Rigid removable dressing (RRD)</li> <li>○ Immediate postoperative prosthesis (IPOP)</li> <li>○ Nonweight bearing rigid dressing (NWB)</li> </ul> </li> <li>• Postoperative dressing if appropriate</li> </ul>	<ul style="list-style-type: none"> <li>• Initial prosthetic prescription generation if applicable</li> </ul>	<ul style="list-style-type: none"> <li>• Prosthetic fabrication, fitting, alignment, and modification if applicable</li> </ul>	<ul style="list-style-type: none"> <li>• Prosthetic fabrication, fitting, alignment, and modification if applicable</li> <li>• Schedule maintenance (components, upgrades, socket changes, specialty use devices)</li> <li>• Consider specialty leg such as running to meet newly established goals</li> </ul>
<b>7. Discharge Planning</b>	<ul style="list-style-type: none"> <li>• Complete initial assessment and initiate discharge planning</li> </ul>	<ul style="list-style-type: none"> <li>• Complete initial assessment and initiate discharge planning (if not started preoperatively)</li> <li>• Contact family / support network</li> <li>• Develop discharge plan</li> </ul>	<ul style="list-style-type: none"> <li>• Determine new needs and update discharge plan as appropriate</li> </ul>	<ul style="list-style-type: none"> <li>• Determine new needs and update discharge plan as appropriate</li> <li>• Arrange appropriate follow-up plans</li> </ul>	<ul style="list-style-type: none"> <li>• Implement appropriate follow-up plans</li> </ul>

	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
<b>8. Rehabilitation Interventions</b>  8.1 Range of Motion	<ul style="list-style-type: none"> <li>• Treat identified contractures except in urgent cases</li> <li>• Assess current ROM in joints above and on contralateral side</li> <li>• Educate on importance of contracture prevention</li> </ul>	<ul style="list-style-type: none"> <li>• Initiate passive ROM of residual and contralateral limb in flexion / extension and abduction / adduction</li> <li>• Position to prevent hip and knee flexion contractures when sitting or in bed</li> <li>• Progress to active-assistive ROM in all planes of motion for residual and contralateral limb</li> </ul>	<ul style="list-style-type: none"> <li>• Maximize ROM to stretch hip and knee flexors</li> <li>• Advance to active ROM of residual and contralateral limbs</li> </ul>	<ul style="list-style-type: none"> <li>• Continue contracture prevention with stretching program</li> <li>• Maximize ROM for prosthetic fit and training</li> </ul>	<ul style="list-style-type: none"> <li>• Readdress ROM of LE and review home stretching program if needed</li> </ul>
8.2 Strengthening	<ul style="list-style-type: none"> <li>• Assess for preoperative strength deficits of UE and LE and treat (except in urgent cases)</li> </ul>	<ul style="list-style-type: none"> <li>• Initiate strengthening program for major muscle groups of arms and legs</li> </ul>	<ul style="list-style-type: none"> <li>• Continue therapeutic exercise program for strengthening UE and LE</li> <li>• Initiate trunk and core stabilization exercises</li> </ul>	<ul style="list-style-type: none"> <li>• Progress therapeutic exercise program for all extremities</li> </ul>	<ul style="list-style-type: none"> <li>• Educate on maintenance of strength for long-term activity</li> </ul>
8.3 Cardiovascular	<ul style="list-style-type: none"> <li>• Assess current CV fitness for increased energy requirement for prosthetic use</li> <li>• Educate regarding increased energy demand in walking with a prosthesis</li> </ul>	<ul style="list-style-type: none"> <li>• Incorporate a CV component into the therapy program</li> <li>• Establish cardiac precautions to rehabilitation (heart rate, blood pressure, perceived exertion scales)</li> </ul>	<ul style="list-style-type: none"> <li>• Advance CV aspect of program to meet needs of patient</li> <li>• Maintain cardiac precautions</li> <li>• Encourage reducing risk factors</li> </ul>	<ul style="list-style-type: none"> <li>• Increase ambulation endurance to reach community distances</li> <li>• Maintain cardiac precautions</li> <li>• Encourage reducing risk factors</li> </ul>	<ul style="list-style-type: none"> <li>• Establish maintenance program for endurance and fitness</li> <li>• Maintain cardiac precautions</li> <li>• Encourage reduction of cardiovascular risk factors</li> </ul>

	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
8.4 Balance	<ul style="list-style-type: none"> <li>Assess preoperative balance, consider central and/or peripheral neurologic conditions</li> </ul>	<ul style="list-style-type: none"> <li>Initiate a balance progression:               <ul style="list-style-type: none"> <li>Sitting balance</li> <li>Sitting weight shifts</li> <li>Sit to stand</li> <li>Supported standing</li> <li>Single limb standing balance</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Progress sitting balance and single limb standing balance</li> </ul>	<ul style="list-style-type: none"> <li>Advance balance activities to equalize weight over bilateral lower extremities</li> <li>Challenge balance with advanced activities</li> </ul>	<ul style="list-style-type: none"> <li>Reassess balance as it relates to gait</li> </ul>
8.5 Mobility	<ul style="list-style-type: none"> <li>Assess current mobility</li> </ul>	<ul style="list-style-type: none"> <li>Establish upright tolerance</li> <li>Initiate and progress to independent bed mobility, rolling, and transfers</li> <li>Initiate wheelchair mobility</li> <li>Progress to single limbed gait in parallel bars</li> </ul>	<ul style="list-style-type: none"> <li>Progress single limb gait from parallel bars to use of assistive device</li> <li>Progress to independent wheelchair mobility</li> </ul>	<ul style="list-style-type: none"> <li>Increase symmetry of weight bearing, maximize weight shift, equalize stride length, facilitate trunk rotation, teach reciprocal gait pattern</li> <li>Progress out of parallel bars to use of appropriate assistive device</li> </ul>	<ul style="list-style-type: none"> <li>Address changes in medical status affecting prosthetic use (e.g., diabetes, heart disease), limb, and goals)</li> <li>Reassess gait and retrain as necessary</li> </ul>
8.6 Home Exercise Program	<ul style="list-style-type: none"> <li>Determine or obtain preoperative HEP addressing deficiencies and maximize above ROM strength, balance, etc.</li> </ul>	—	<ul style="list-style-type: none"> <li>Give patient supplies and instruction in exercise program for home</li> </ul>	<ul style="list-style-type: none"> <li>Advance HEP to focus on full ROM, strength and endurance</li> </ul>	<ul style="list-style-type: none"> <li>Address new physical requirements as patient goals change</li> </ul>

	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
<b>9. Functional Activities and ADLs</b>	<ul style="list-style-type: none"> <li>Assess preoperative activity level and independence to help establish goals and expectations</li> </ul>	<ul style="list-style-type: none"> <li>Initiate basic ADLs such as eating, dressing, grooming, bathing, toileting</li> <li>Ensure patient safety</li> </ul>	<ul style="list-style-type: none"> <li>Teach adaptive techniques for dressing, bathing, grooming, and toileting without a prosthesis</li> </ul>	<ul style="list-style-type: none"> <li>Instruct in proper care of prosthesis and suspension system</li> <li>Practice transfers and ADLs in prosthesis</li> <li>Teach stand to floor/floor to stand transfers</li> </ul>	<ul style="list-style-type: none"> <li>Obtain information on current ADLs</li> <li>Teach energy conservation principles</li> <li>Teach injury prevention techniques</li> </ul>
<b>10. Community Integration</b>  10.1 Vocation and Recreation	<ul style="list-style-type: none"> <li>Obtain preoperative vocation, recreational interests, and mode of transportation</li> </ul>	<ul style="list-style-type: none"> <li>Offer and promote trained peer visitation</li> </ul>	<ul style="list-style-type: none"> <li>Initiate outings into the community without prosthesis</li> <li>Train in use of public transportation without prosthesis if appropriate</li> <li>Complete vocational rehabilitation evaluation</li> <li>Complete recreational training activities without prosthesis</li> </ul>	<ul style="list-style-type: none"> <li>Initiate vocational and recreational training activities with prosthesis</li> <li>Progress to advanced skills such as climbing/descending stairs, curbs, ramps and gait on uneven terrain</li> <li>Increase ambulation endurance to reach community distances</li> <li>Train in the use of public transportation with the prosthesis if appropriate</li> </ul>	<ul style="list-style-type: none"> <li>Provide education on opportunities and precautions for long-term sport specific, recreation skills or resources, and prosthesis or assistive devices available.</li> <li>Provide counseling and contact information regarding opportunities in sports and recreation (paralympics, golfing, fishing, hunting, etc.)</li> </ul>
10.2 Home Evaluation	<ul style="list-style-type: none"> <li>Assess patient's home for accessibility and safety</li> </ul>	<ul style="list-style-type: none"> <li>Assess patient's home for accessibility and safety if not already completed, and provide information on home modifications</li> </ul>	<ul style="list-style-type: none"> <li>Assess patient's home for accessibility and safety if not already completed</li> </ul>	—	—

	Preoperative	Acute Postoperative	Pre-prosthetic	Prosthetic Training	Long-Term Follow-up
10.3 Driver's Training	—	—	<ul style="list-style-type: none"> <li>Evaluate patient with right LE amputation for left foot accelerator if patient will drive</li> <li>Evaluate patient with bilateral LE amputations for hand controls if patient will drive</li> </ul>	<ul style="list-style-type: none"> <li>Complete driver's training with adaptive equipment as needed</li> <li>Educate patient/family to comply with local state driving laws and individual insurance company policies</li> </ul>	—
<b>11. Equipment</b>	—	<ul style="list-style-type: none"> <li>Assess living environment including stairs, wheelchair access, and bathroom accessibility</li> <li>Educate regarding home modifications, ramps, etc</li> </ul>	<ul style="list-style-type: none"> <li>Measure and order appropriate wheelchair</li> <li>Provide appropriate assistive device for single limb ambulation</li> <li>Assess for personal equipment</li> <li>Assess for home adaptation and equipment</li> </ul>	<ul style="list-style-type: none"> <li>Provide appropriate assistive device for ambulation with or without prosthesis</li> </ul>	<ul style="list-style-type: none"> <li>Provide appropriate assistive device for ambulation with or without prosthesis</li> <li>Provide appropriate mobility device if ambulation is no longer an option</li> </ul>

## Core Module

The *CORE* module includes recommendations in those disciplines that are applied continuously throughout all phases of care (e.g., pain management, behavioral health and rehabilitation intervention). The links to these recommendations are also embedded in the relevant specific steps in the algorithms for each phase of rehabilitation care in Modules A through E.

### Table of Contents

- Core-1. Interdisciplinary Consultation/Assessment**
- Core-2. Rehabilitation Treatment Plan**
- Core-3. Pain Management**
- Core-4. Medical Care**
- Core-5. Cognitive Assessment**
- Core-6. The Residual Limb**
- Core-7. Contralateral Limb**
- Core-8. Behavioral Health Assessment And Treatment**
- Core-9. Social Environment (Support)**
- Core-10. Peer Support Interventions**
- Core-11. Patient Education**
- Core-12. Learning Assessment**
- Core-13. Physical Rehabilitation**
  - 13-1. Range-of-Motion (ROM)**
  - 13-2. Strengthening**
  - 13-3. Cardiovascular Fitness and Endurance**
  - 13-4. Balance**
- Core-14. Functional Rehabilitation**
  - 14-1. Functional Activities of Daily Living (ADL)**
  - 14-2. Mobility and Equipment**
  - 14-3: Community Reintegration**

## CORE: ANNOTATIONS

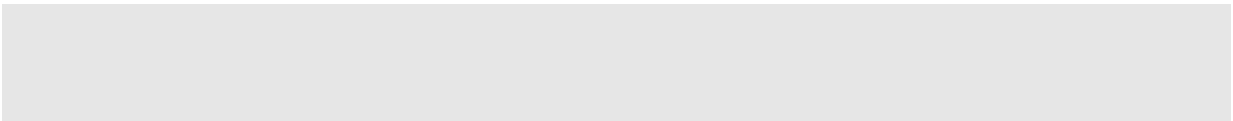
### CORE-1. Interdisciplinary Consultation/Assessment

#### BACKGROUND

Care for patients with an amputation (traumatic and non-traumatic) is complex and requires multiple medical, surgical, and rehabilitation specialties in order to:

- Develop a patient-centered treatment plan that includes comprehensive knowledge and best practices for each discipline
- Reduce the risk of missing potential complicating factors that may negatively influence operative and rehabilitation outcomes
- Enhance patient and family education

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. Key disciplines to be consulted during the preoperative (when possible) and postoperative phases of rehabilitation care include: physiatry, surgery, physical therapy, occupational therapy, prosthetics, social work services, case management, mental health, nursing, nutrition, and recreation therapy. In addition, the following specialties should be available on a case-by-case basis: vascular surgery, plastic surgery, internal medicine, pain management, vocational therapy, and spiritual advisors.
2. The patient and family members (or other caregivers) should be an integral part of the interdisciplinary rehabilitation team.
3. Interdisciplinary rehabilitation team meetings should be conducted on a regular basis within the institution to facilitate communication and integration of a comprehensive treatment plan.
4. Outpatient amputation clinics should have interdisciplinary team participation for the periodic assessment of patients to ensure appropriate life-long care in order to preserve the quality of life, achievement of maximum function, and reduction of secondary complications.

#### DISCUSSION

Interdisciplinary team models are often used to describe teams in medical rehabilitation. There is extensive anecdotal evidence of the value of interdisciplinary teamwork in improving care outcomes. In addition, there is good evidence that effective team management improves rehabilitation outcomes in patients with other disabilities such as stroke and spinal cord injury (Yagura et al., 2005) (See the [VA/DoD Clinical Practice Guideline for the Management of Stroke Rehabilitation in the Primary Care Setting](#)). However, there are no randomized clinical trials assessing the value of interdisciplinary teams on functional outcomes from amputation rehabilitation.



## CORE-2. Rehabilitation Treatment Plan

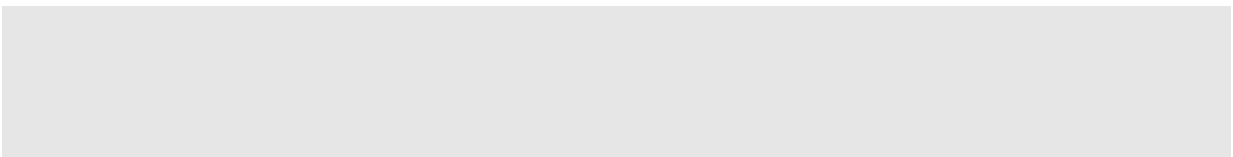
### BACKGROUND

The rehabilitation treatment plan is utilized to guide the care of a patient who has undergone a lower limb amputation throughout the entire course of rehabilitation. The treatment plan is based on evaluation by all specialties involved in the rehabilitation process, and acts as a guide for all team members to address goals important to the patient and family.

The level of rehabilitation intervention is contemplated from the date of admission to the hospital but is actually determined after the amputation surgery and prior to the discharge from the hospital. The rehabilitative process includes:

- Ongoing medical assessments of impairments
- Therapy interventions to address disabilities or activity limitation
- Ongoing assessments and intervention for handicaps and psychosocial participation restrictions

### ACTION STATEMENT



### RECOMMENDATIONS

1. Evaluations from all key team members should be included in the development of the treatment plan.
2. The treatment plan must address identified rehabilitation, medical, mental health, and surgical problems.
3. The treatment plan should identify realistic treatment goals.
4. The treatment plan should identify and address plans for discharge at the initiation of the rehabilitation process. The discharge treatment plan should include needs for specialized equipment, evaluation of and required modifications of the discharge environment, needs for home assistance, and an evaluation of the patient's ability to drive (see [CORE-9: Social Environment](#)).
5. The initial treatment plan should be established early in the rehabilitation process and updated frequently based on patient progress, emerging needs, or problems.
6. The treatment plan should indicate the anticipated next phase of rehabilitation care.

### DISCUSSION

There are no randomized clinical trials assessing the value of an interdisciplinary treatment plan. However, expert opinion and major accrediting bodies (The Joint Commission and Rehabilitation Accreditation Commission [CARF]) require the establishment of interdisciplinary treatment plans. Frequent evaluation and modification of the treatment plan assists with efficient progress through the rehabilitation phases of care.

The rehabilitation process can be delineated according to phases [pre-operative, postoperative, pre-prosthetic, prosthetic, review & maintenance] with specific goals. The latter may provide useful standards for the measurement of progress and for identifying problems (Esquenazi & Meier, 1996).

Successful rehabilitation relates to both prosthetic mobility performance and an individual's overall level of function in his or her community. Rehabilitation is important for enhancing the mobility of affected individuals and improving their health and vocational prospects (Pezzin et al., 2000).

In war-related amputations, additional injuries of peripheral nerves, disrupted blood vessels, and fractures may require modified rehabilitation strategies in the training of activities of daily living (ADL) and ambulation (Jelic & Eldar, 2003).

The Royal College of Physicians (1992) recommends that discharge criteria should include the following:

- Independence in ADLs
- Safe transfers and functional independence from a wheelchair
- Safe and functional mobility on the artificial limb
- Initial home adaptations already in place and a program for further adaptations agreed upon, which necessitates a home visit by the patient, together with the therapists, a wheelchair, and the prosthesis
- Community follow-up visit arranged.

### **CORE-3. Pain Management**

#### BACKGROUND

Multiple factors, such as comorbidities and previous injuries, may contribute to the presence and persistence of pain before and after lower limb amputation. Many patients awaiting amputation will have experienced severe pain for some time prior to surgery. Some evidence suggests that patients have an improved postoperative experience when pain has been effectively controlled before surgery. Most pain management experts agree that preventing pain yields better results than trying to control pain after it has developed or become severe.

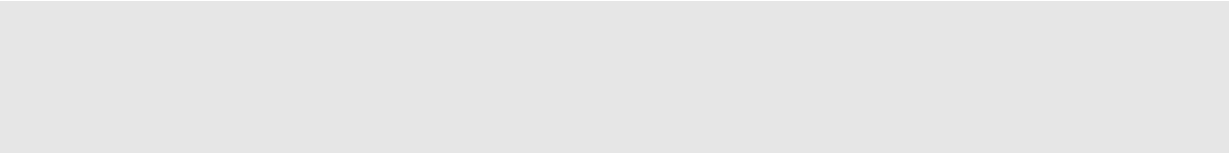
There are several different types of pain that may be experienced after surgery including:

- Immediate post-surgical pain
- Post-amputation pain:
  - Residual limb pain
  - Phantom limb pain
  - Associated musculoskeletal pain (low back, hip and knee pain).

Practitioners should be aware of the multitude of pharmacological and non-pharmacological options for treating the various pain syndromes. Often multiple different approaches or combinations of treatments must be employed before finding a successful strategy. It may be important to vary the pain management

strategies, such as pharmacological and non-pharmacological treatments, based on the time from surgery, and the type and severity of pain.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. Pain should be assessed at all phases of rehabilitation, preferably with a tool specific to pain assessment in patients with lower limb amputations. [Expert Opinion]
2. When assessing pain, standardized tools should be used. Examples include; Visual Analogue Scale (VAS), Short Form McGill Pain Questionnaire (SF-MPQ), and Pain Interference Scale (PIS). [B]
3. When possible, a postoperative treatment plan for pain control should be developed before surgery and be based on the preoperative pain assessment and treatment initiated. [I]
4. Measurement of the intensity of pain should be separately assessed at each site (i.e., phantom limb pain [PLP], residual limb pain [RLP], low back pain [LBP]) to achieve a thorough assessment of pain-related impairment. [B]
5. Prophylactic pain management should be considered prior to initiation of physical rehabilitation intervention. [I]
6. Narcotic analgesics should be considered in the immediate postoperative phase. [Expert Opinion]
7. Transition to a non-narcotic pharmacological regimen combined with physical, psychological, and mechanical modalities should be considered throughout the rehabilitation process. Treatment should target pain related to the residual/phantom limb and address pain in other body parts from a primary care approach. [C]
8. There is no consistent evidence to support or refute one specific type of pain control.  
Available modalities include: [I]
  - a. Pharmacological: anti-seizure medications (e.g., gabapentin), tricyclic antidepressants (TCA), selective serotonin re-uptake inhibitors (SSRI), non-steroidal anti-inflammatory drugs (NSAID), dextromethorathane, and long-acting narcotics
  - b. Epidural analgesia, use of patient controlled analgesia (PCA), or regional analgesia may be considered, although the benefit is unproven
  - c. Non-pharmacological: transcutaneous electrical nerve stimulation (TENS), desensitization, scar mobilization, relaxation, and biofeedback.

(See the [VA/DoD Clinical Practice Guideline for the Management of Acute Postoperative Pain.](#))

**Table 3. Pain Control in Phases of Rehabilitation**

Phase	Pain Control
<b>I. Preoperative</b>	Assess for existing pain
<b>II. Postoperative</b>	Assess and aggressively treat residual and phantom limb pain
<b>III. Pre-prosthetic</b>	Assess for specific treatable causes of residual limb or phantom limb pain and apply specific treatments appropriate to the underlying etiology. If no specific cause can be determined treat with non-narcotic medications and other non-pharmacological, physical, psychological, and mechanical modalities
<b>IV. Prosthetic training</b>	Assess for specific treatable causes of residual limb or phantom limb pain and apply specific treatments appropriate to the underlying etiology. If no specific cause can be determined treat with non-narcotic medications and other non-pharmacological, physical, psychological, and mechanical modalities
<b>V. Long-term follow-up</b>	Assess and treat associated musculoskeletal pain that may develop with time.

**Table 4. Desensitization Techniques**

<p>Desensitization is believed to reduce pain in the residual limb and may help the patient with an amputation adjust to his or her new body image that now includes limb-loss:</p> <ul style="list-style-type: none"> <li>➤ Instruct the patient how to perform desensitization and distraction techniques to reduce the phantom pain</li> <li>➤ Tap the residual limb, to include tapping the rigid dressing</li> <li>➤ Gently massage the proximal residual limb, to include pressure points in the inguinal regions</li> <li>➤ If the phantom toes or foot feel like they are twisted or cramping, move the intact limb in a position of comfort that would mimic the improved position of the phantom side.</li> </ul>
---

#### DISCUSSION

Pain management will be most successful when the team has performed a thorough assessment, uses the right types of treatment at each phase, and aims to minimize long-term problems for the patient. It is critically important to adequately treat immediate postoperative amputation pain, because adequate early control can decrease the chances of future severe problems.

#### **Assessment**

A multitude of factors may contribute to pain syndromes experienced by a patient with lower limb amputation, therefore access to a variety of medical sub-specialists may be necessary to adequately assess and treat pain. Appropriate and aggressive treatment of pain during the early stages will likely prevent the development of chronic pain. When assessing pain, it is important to distinguish distinct pain

syndromes for specific body sites and obtain subjective intensity scores for each (e.g., leg, back, knee, phantom, etc.). It is likely that the patient will need to be educated on the differences between phantom limb pain, residual limb pain, and phantom limb sensations. It is also important that the patient be assured that these symptoms are common and that numerous treatment strategies exist for each. Despite treatment, evidence suggests that phantom limb, residual limb, and back pain intensity ratings, as a group, may account for 20 percent of the variance in pain interference. In at least one study, the pain intensity ratings associated with each individual pain site made a statistically significant contribution to the prediction of pain interference with ADLs even after controlling for the pain intensity of the other 2 sites (Marshall et al., 2002).

Pain should be assessed using standard tools for pain assessment. The most commonly used tools involve numeric scales (0 to 10), visual analogue scales (VAS), or picture scales such as the Wong- Baker FACES. In addition to assessing pain location and intensity, it is also important to assess pain frequency and duration as well as aggravating and alleviating factors. Additionally, the assessment should include a determination of how much pain is affecting function, sleep, and participation in therapy. Under-treated pain may lead to poor compliance with prosthetic fitting and/or training. The degree to which pain interferes with activities may be a function of the pain location. In one study, it was found that back pain interfered more significantly with daily function than the same level of intensity of phantom limb pain. These findings have implications for understanding the meaning of pain intensity levels, as well as for the assessment of pain intensity in persons with amputation-related pain (Jensen et al., 2001).

The existence of other pre-morbid conditions such as arthritis, spinal stenosis, diabetes, or vascular disease must always be considered when assessing pain. For individuals with amputations as the result of trauma, it is particularly important to assess for previously unidentified injuries. Injuries such as herniated lumbar or cervical disks with nerve root compression or occult fractures that may refer pain to remote sites. Input from the rehabilitation team members, such as physical therapists, occupational therapists and nursing staff can be valuable in characterizing the pain and arriving at a diagnosis and treatment plan. Particular attention should be paid to patients who report greater than one month pre-amputation pain or severe pain as the result from burn, gangrene, or thrombosis, as these conditions are associated with a greater risk of chronic pain (Jensen et al., 1985).

A thorough pain assessment should also include an examination of potential psychosocial influences on pain. For example, greater catastrophizing by the patient and less family support has been shown to be predictive of greater pain severity, physical disability, and psychosocial dysfunction (Boothby et al., 1999; Jensen et al., 1991; Sullivan et al., 2001). In addition, the more long standing pain is, the more likely it will become influenced by psychosocial factors (Turk & Okifuji, 2002).

### ***Types of Pain***

#### ***Post-surgical Pain***

- **Immediate post-surgical pain** is experienced after any surgical procedure where skin, muscle, bone, and nerves are cut. Post-surgical pain following a lower limb amputation can usually be controlled with pain medication and

subsides fairly rapidly as the swelling goes down, tissues begin to heal, and the wound stabilizes as part of the natural healing process.

*There is no specific evidence to recommend for or against a specific therapeutic intervention for immediate post-surgical pain after amputations.* Immediate postoperative pain after amputation should be managed similarly to immediate postoperative pain after any other surgery. (See the [VA/DoD Clinical Practice Guideline for the Management of Acute Postoperative Pain](#).)

### **Post-amputation Pain**

- **Residual limb pain (RLP)** occurs in the part of the limb left after the amputation. It is expected immediately after surgery due to the massive tissue disruption of the surgery itself. Later, the pain can be due to a number of mechanical factors such as poor prosthetic socket fit, bruising of the limb, chafing or rubbing of the skin, and numerous other largely mechanical factors. In addition, the residual limb may be poorly perfused which may cause pain usually described as ischemic pain. Pain in the residual limb may also be caused by heterotopic ossification or post amputation neuromas).
- **Phantom pain** occurs in the missing or amputated part of the limb(s) or some part of it. It is the most difficult part of post-amputation pain to manage and is often treated differently than the pain in the residual limb. Phantom pain is experienced by 60 to 70 percent of patients; up to 40 percent may report that this pain is significantly bothersome at one year after amputation. Phantom pain is related to the intensity and duration of preoperative pain. **Phantom sensations** are likely to be experienced by most amputees and may be present throughout their entire life. Sensations such as tingling, warmth, cold, cramping, or constriction in the missing portion of the limb should be considered normal and only treated if they become uncomfortable or disruptive to functional activities. The mechanism for phantom limb pain and sensations is not well understood, although existing theories implicate central nervous system processing.

The treatment of PLP has received considerable attention in the literature. More than 60 different treatment strategies have been suggested as being effective in treating PLP, including a variety of medical, surgical, psychological, and alternative options.

*However, there is little support for any one approach. The role of preemptive analgesia in the prevention of PLP after amputation has not shown significant benefit compared to placebo. Neither perineural analgesia nor epidural blockade exhibited a beneficial effect. The various other analgesic interventions have shown mixed results in small studies. It remains to be determined whether other methodological approaches will result in any therapeutic advantages.* (See [Appendix B: Supporting Evidence for Pain Management](#) for a discussion.)

- **Associated musculoskeletal pain** occurs in body regions other than the amputated limb, such as the lower back or contralateral limb and may be related to the gait pattern with the prosthesis, design of the socket, residual limb interface, and other medical comorbidities. Aggravating factors include abnormal biomechanical stresses to joints and other musculotendinous structures and advancing age.

*There is insufficient evidence to recommend a specific therapeutic intervention for reduction of musculoskeletal pain after amputation. Providers should care for mechanical or musculoskeletal pain after amputation similar to musculoskeletal pain from any other etiology. (See the [VA/DoD Clinical Practice Guideline for Low Back Pain](#).) Some information suggests that choices of prosthetic components and optimizing prosthetic alignment may influence loading of the intact extremity. (See [Appendix B: Supporting Evidence for Pain Management](#) for a discussion.)*

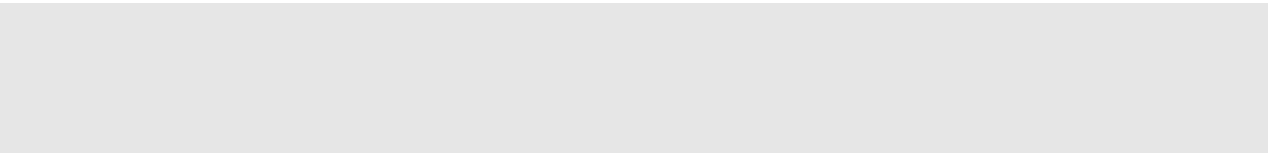
#### **CORE-4. Medical Care**

##### BACKGROUND

Individuals requiring a lower limb amputation as the result of trauma or disease must be treated holistically. Providers must be cautious of focusing too much attention on the affected extremity at the expense of missing other significant medical issues such as cardiovascular disease, pulmonary disease, diabetes, hypertension, obesity, or TBI etc. VA and DoD have published clinical practice guidelines that address many of the most common medical illnesses facing healthcare populations ([www.oqp.med.va.gov/cpg/cpg.htm](http://www.oqp.med.va.gov/cpg/cpg.htm) ).

A complete medical assessment and subsequent treatment plan is essential in providing short- and long-term care for individuals with amputation. Optimal medical management will have an effect on surgical and rehabilitative outcomes and will reduce patient morbidity and mortality. Cardiovascular and pulmonary function, along with the metabolic and nutritional state, will have a significant impact on the risk of the complications, recovery, and quality of life.

##### ACTION STATEMENT



##### RECOMMENDATIONS

1. **Medical status** including laboratory studies should be assessed and monitored as indicated to screen for infection, anemia, electrolyte imbalances, nutrition, and liver and kidney diseases.
2. The comprehensive medical care throughout the phases of rehabilitation of patient with amputation should address:
  - a. Cardiac and pulmonary function
  - b. Assessment and monitoring for infection using laboratory and radiographic studies
  - c. Assessment and management of diabetes and its complications to improve outcome and reduce the risk for complication and further amputation

- d. Assessment and management of peripheral vascular diseases to improve outcome and prevent complications such as claudication and residual limb ischemia
  - e. Prevention of secondary complications such as venous thrombosis, embolism, heterotopic bone formation, contracture, and decubitus ulcers is necessary
  - f. Attention to bone health.
3. Modifiable health risk factors should be assessed and education and treatment strategies to reduce their impact on morbidity and mortality should be implemented (e.g., smoking cessation, body weight management, diabetes management, hypertension control, substance abuse).
  4. In special populations, such as traumatic amputation, upper motor neuron lesions and burns, the risk of heterotopic ossification (HO) should be recognized. Appropriate intervention for prevention of HO includes radiation, nonsteroidal medications, and bisphosphonate medications.

## DISCUSSION

The cardiovascular demands of surgery as well as ambulation with a lower limb amputation are significant. It has been estimated that the mean oxygen consumption is 9 percent higher in patients with unilateral transtibial amputations, 49 percent higher in unilateral transfemoral, and 280 percent higher in bilateral transfemoral (Huang et al., 1979). A preoperative cardiac assessment for those with known or suspected coronary disease should be obtained. Significant risk factors for peri-operative cardiac morbidity include recent myocardial infarction and congestive heart failure. Cardiac risk may impact the survival risk from the amputation surgery and thus may play a role in the decision regarding the level of amputation (ACC/AHA, 2006; Mangano & Goldman, 1996). Additionally, exercise tolerance testing may be warranted during the rehabilitation phase to help establish clear guidelines for cardiac precautions in therapy. Providers and patients should be familiar with the use of perceived exertion scales, such as the Borg Scale, as well as the estimated amount of energy required to perform basic activities of daily living, negotiating stairs, and participating in recreational activities. Therapists may need to closely monitor vital signs during rehabilitation in order to reduce cardiac risk. Caution should be placed on monitoring heart rate for patients taking beta-blockers (Shah, 2005).

Cardiopulmonary status is important for patients with amputation and may affect the extent of ambulation.

Wound healing, in all amputations and in particular among traumatic amputation, is always at risk for developing infection. Close monitoring of early signs of infections and aggressive treatment to contain and treat the infections are important.

Evidence indicates that individuals undergoing amputation have an incidence of deep venous thrombosis (DVT) ranging from 11 to 50 percent (Burke et al., 2000; Yeager et al., 1995). Complications of venous thrombus formation may include thrombophlebitis, pulmonary embolism, or even death. DVT prophylaxis is therefore warranted in all patients with amputation as per institutional and/or consensus guidelines (The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy [Monage et al., 2004]). There exists considerable debate as to which prophylactic method is best. A recent study found equal efficacy of low molecular



weight heparin (enoxaparin) with unfractionated heparin in this patient population (Lastoria et al., 2006). Care should be taken in using anti-clotting agents in multitrauma patients, especially those with suspected intracranial hemorrhage.

Patients with conditions such as hyperlipidemia, hypertension, obesity, and diabetes should also be monitored carefully throughout the continuity of care. These healthcare concerns are the leading causes of morbidity and mortality. In the United States, 75 percent of amputations occur in people aged 65 or older, and 95 percent are performed because of peripheral vascular disease (PVD), with or without diabetes (Leonard, 1994). The importance of lowering cholesterol, managing blood pressure, reducing obesity, and achieving good glycemic control have been well established in the medical literature. Diabetes and its complications are at the top of the list for medical attention in most vascular amputations. Tight glycemic control and routine foot care combined with education for self-management may prevent common complications in the diabetic patient and reduce the risk of foot ulcer and additional amputations. For details on management for diabetes complications, see the [VA/DoD Clinical Practice Guideline for the Management of Diabetes Mellitus](#). While the patient's primary care provider is mostly responsible for these conditions, often individuals with amputations only contact the medical system with reference to their prosthetic or residual limb needs; therefore all members of the treatment team need to become advocates of good general health.

Malnourished patients are at greater risk for delayed wound healing, decubitus ulcer formation, infection, congestive heart failure, progressive weakness, apathy, and death. Evidence suggests that malnourishment is common in patients with amputations and that supplementary nutrition may improve healing (Eneroth et al., 1997).

Osteoarthritis, osteopenia, and osteoporosis occur commonly in patients with amputations (Burke et al., 1978; Kulkarni et al., 1998). The incidence of knee pain and degenerative joint disease is increased in the contralateral knee of patients with amputation. Patients with amputation commonly develop osteopenia that may result in an increase risk for fractures. In patients with amputations who are planning to pursue high impact activities in the early stages in their prosthetic use, obtaining X-rays and dexta scans to guide the progression of activities should be considered. In the elderly population, the existence of osteopenia may increase their risk of injuries due to falls.

Heterotopic bone formation has been reported in a significant portion of amputations as a result of sustaining blast injuries (Greenwell et al., 2006). In high-risk patients, monitoring alkaline phosphatase levels, radiographs, bone scans and instituting prophylaxis measures may be warranted.

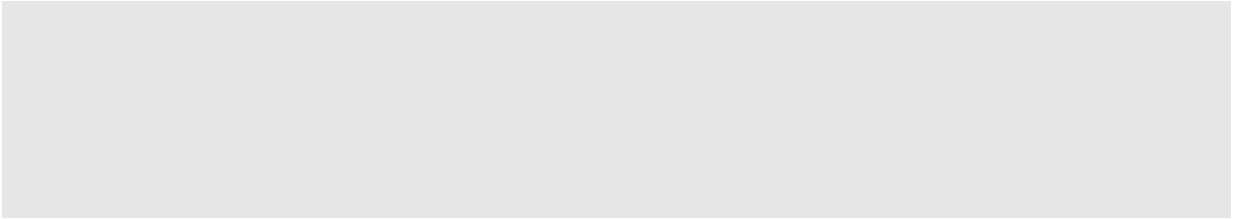
## **CORE-5. Cognitive Assessment**

### BACKGROUND

Patients with a lower limb amputation who are advanced in age, have additional medical problems (e.g., chronic hypertension), or have been traumatically injured may be at higher risk for cognitive deficits. Patients in this high-risk group are candidates for a more extensive mental status/cognitive deficit screening. Those

patients who demonstrate problems on such screening should be referred for more extensive neuropsychological assessment.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. A cognitive battery of testing should include:
  - a. Intellectual functioning and attention/concentration along with working memory and speed of processing
  - b. Executive functioning
  - c. Learning and memory: short- and long-term, auditory and visual, recall, and recognition
  - d. Self (and possibly family) reported cognition and emotional functioning.
2. Testing should be conducted by appropriately trained and certified individuals.
3. Evaluations should include standardized tests, self-reporting, behavioral descriptions and subjective estimations from family and others, careful history taking, recognition of other possible comorbid factors (e.g., depression, dementia), and acknowledgment of the limitations and sources of variability and error in measuring psychometric performance.
4. Neuropsychological referrals should be specific and guided by preliminary mental status assessment by the rehabilitation team. Neuropsychological assessments should focus on the referring question and not provide specific medical advice.

#### DISCUSSION

A preoperative cognitive assessment is a vital tool in assisting the rehabilitation team to effectively work with the patient postoperatively to:

- Shorten the acute inpatient stay
- Optimize rehabilitation
- Measure any changes from the preoperative baseline
- Effectively use the prosthesis
- Return to independent or semi-independent living.

A neuropsychological evaluation is usually able to distinguish between normal and abnormal function, identify cognitive strengths and deficits, and address diagnostic questions related to cognitive dysfunction. However, a neuropsychological evaluation does not permit definitive determination of the cause of neurologic disease. It is accepted as appropriate by the practicing medical community for the indications and conditions described in the Report of the Therapeutics and

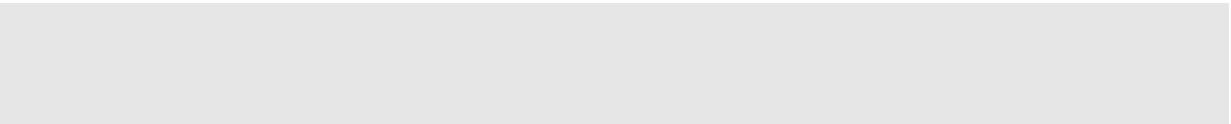
Technology Assessment Subcommittee of the American Academy of Neurology, Assessment: Neuropsychological testing of Adults. Considerations for Neurologists (1996).

## **CORE-6. The Residual Limb**

### BACKGROUND

The residual limb must be properly prepared and maintained for optimal prosthetic fitting or function without a prosthesis. This requires control of limb shaping and volume, pain and sensitivity, and skin and tissue integrity. Two significant objectives in residual limb management are to prevent contractures at both the hip and the knee and to protect the amputated limb from outside trauma. Strategies are available at each phase, from immediate postoperative to follow-up, to provide education to the patient and caregiver for optimal outcomes.

### ACTION STATEMENT



### RECOMMENDATIONS

1. Limb volume management is a critical issue throughout the lifespan of the individual.
  - a. Apply an external compressive device to optimize the limb volume (postoperative rigid dressing, ACE wrap, shrinker, liner).
  - b. Optimize overall fluid management by controlling congestive heart failure, renal failure, or dialysis treatments.
  - c. Encourage the patient to maintain a stable body weight.
  - d. Encourage the patient to wear an external compressive device when the prosthesis is not worn, especially during the early postoperative and prosthetic phases.
  - e. Discourage dependent positioning of the residual limb in a wheelchair.
2. The patient should be educated about care and management of the residual limb including:
  - a. Proper application of external compressive devices (ACE wrap, shrinker)
  - b. Proper donning and doffing technique for the prosthesis
  - c. Adjustment of prosthetic sock ply for limb volume change, if appropriate
  - d. Proper hygiene of the residual limb and prosthesis
  - e. Daily inspection of the residual limb for signs of abnormal pressure distribution
  - f. Training with a long handled mirror to assist in the inspection of the residual limb.

3. Interventions to prevent contracture at both the hip and the knee should be considered on an ongoing basis, especially in the early postoperative period and when the patient is an intermittent or marginal ambulator.
  - a. Rigid dressing and knee immobilizers may be considered for the patient with a transtibial amputation to prevent knee flexion contractures. A number of early postoperative dressing strategies help to maintain range of motion of the knee.
  - b. Initiate exercise programs to strengthen the quadriceps and gluteal muscles, along with active and passive range of motion exercises.
  - c. Initiate proper positioning and begin a prone lying program. Do not place pillows under the knee to increase comfort as it increases the chance of contractures forming.
  - d. Encourage ambulation and weight bearing through the prosthesis.
4. Bony overgrowth may become painful at any stage of its growth and cause significant pain and limitations in prosthetic fittings.
  - a. Use preventive measures where necessary in a high-risk population (radiation, bisphosphonates, NSAIDs).
  - b. Due to reductions in soft tissue volume, the relative prominence of bony overgrowth may increase, resulting in the need for prosthetic modifications or replacement.
  - c. Associated pain may be treated with prosthetic modifications and/or local injections.
  - d. Surgical excision and possible limb revision is a last resort.
5. Limb protection should be emphasized especially during the early phases when the risk of falls is greater.
  - a. The patient should be instructed to wear an external protective device on the residual limb.
  - b. An external protective device may include a postoperative rigid dressing or a prefabricated rigid dressing.
6. Skin and soft tissue should be monitored on a regular basis to detect any mechanical skin injury related to abnormal pressure distribution or signs and symptoms of infection.
  - a. Abnormal pressure distribution should be prevented by ensuring that the prosthesis is properly aligned and the prosthetic socket fit is adequate and it should be modified as needed.
  - b. Superficial infection (fungal, folliculitis, cellulites), or deep infection (osteomyelitis) should be treated early and aggressively to prevent deterioration of the residual limb condition that will have serious impact on the functional mobility of the patient.
7. Patients should be advised that a stable body weight is critical to long-term success.

**Table 5. Residual Limb Management in Phases of Care**

<b>I. Preoperative</b>	<ul style="list-style-type: none"> <li>• Desensitization exercises, skin hygiene, and description of types of pain</li> <li>• Explain and differentiate between residual limb pain, phantom pain, and phantom sensation</li> </ul>
<b>II. Postoperative</b>	<ul style="list-style-type: none"> <li>• Donning/doffing of ACE wrap or shrinker if appropriate</li> <li>• Desensitization exercises, skin hygiene, and description of types of pain</li> </ul>
<b>III. Pre-prosthetic</b>	<ul style="list-style-type: none"> <li>• Care of residual limb</li> </ul>
<b>IV. Prosthetic training</b>	<ul style="list-style-type: none"> <li>• Donning/doffing of prosthetic system</li> <li>• Use of shrinker when out of the prosthesis</li> <li>• Skin checks and skin hygiene</li> <li>• Management of sock ply if appropriate</li> <li>• Observe pressure points and protect contralateral foot</li> </ul>
<b>V. Long-term follow-up</b>	<ul style="list-style-type: none"> <li>• Foot care and skin checks</li> </ul>

DISCUSSION

***Edema Control***

Edema control through compressive therapy is the foundation of limb shaping and will reduce pain and improve mobility. Edema can be controlled by rigid dressings with or without an attached pylon, residual limb shrinkers, or soft dressings such as an ACE wrap. If a soft dressing is used, proper wrapping techniques must be taught to the staff, patient, and caregivers to reduce complications from poor application.

***Contracture Prevention***

There are several passive strategies available to prevent contractures at both the hip and the knee. Knee immobilizers and rigid dressings attempt to address the goal of knee flexion contracture prevention in the patient with a transtibial amputation. However, literature is unavailable to support any one strategy. Passive strategies to prevent hip flexion contractures in either the patient with a transtibial or transfemoral amputation have yet to be proposed.

Active strategies to prevent contractures are well documented for the patient with a transtibial or transfemoral amputation and include bed positioning, prone activities, various stretching techniques, and knee and hip joint mobilization by a physical therapist.

A seemingly innocuous and caring gesture of placing a pillow under the residual limb is actually encouraging development of hip and knee flexion contractures. A pillow or rolled towel along the lateral aspect of the thigh, however, may help prevent a hip abduction contracture and should be considered as a preventive technique.

***Heterotopic Ossification in the Residual Limbs of Individuals with Traumatic and Combat-Related Amputations***

Reports on the occurrence and treatment of heterotopic ossification (HO) in patients with amputations are rare. HO in the residual limbs of patients with amputation may cause pain and skin breakdown. Furthermore it may complicate or prevent optimal prosthetic fitting and utilization. Basic scientific research has shed light on

the cellular and molecular basis for this disease process, but many questions remain unanswered. The recent experience of the military amputee centers with traumatic and combat-related amputations has reported a greater than fifty percent prevalence of HO in residual limbs of blast induced amputations. Primary prophylactic regimens, such as NSAIDs and local irradiation, which have proved to be effective in preventing and limiting HO in other patient populations, have not been adequately studied in patients with amputations and generally are not feasible in the setting of acute traumatic amputation.

As the residual limb matures and edema diminishes, the underlying HO may become relatively more prominent. When this bony overgrowth becomes closer to the skin surface, it is also more likely to become more symptomatic and requires attention. Sometimes the overgrowth displaces a nerve and causes neurogenic pain in the residual limb, which may or may not be amenable to local injections or oral medications. The HO is more often asymptomatic and in some cases may actually serve a useful purpose, such as facilitate suspension of a transhumeral prosthesis, depending on the shape and location of the newly formed bone. When nonsurgical measures such as activity and repeated prosthetic modifications fail to provide relief, surgical excision should be considered. Potter et al. reported the results of HO surgical excision in 19 residual limbs of 18 traumatic amputations. The mean time since injury was 8.2 months (range 3 to 24 months). All patients had failed conservative management for persistent skin breakdown and prosthetic use. At early follow up, 16 patients (17 limbs) showed no radiographic evidence of recurrence. All 19 limbs were eventually successfully fitted with a prosthesis after the surgery. Four of the 18 patients experienced wound complications requiring return to the operating room (Potter et al., 2007).

### ***Limb Protection***

The amputated limb must be protected from outside trauma to reduce the potential of complications and delayed wound healing and to encourage mobility. Rigid dressing strategies (either custom or prefabricated) clearly provide better limb protection than do soft dressings. Elastomeric liner systems may intuitively provide some protection; however, comparative research trials are lacking.

## **CORE-7. The Contralateral Limb**

### **BACKGROUND**

The patient with diabetes who has incurred a major lower extremity amputation has a risk of contralateral lower extremity amputation. The preservation and optimization of function of this contralateral limb is critical to the maintenance of mobility and function of the patient.

The patient with a traumatic amputation often has concomitant contralateral lower extremity injury. It is important to evaluate this extremity from a musculoskeletal, vascular, and neurological perspective and to optimize its function to enhance the overall functional outcome of the patient.

## ACTION STATEMENT

Comprehensive evaluation of the neurological, musculoskeletal, soft tissue and vascular status of the contralateral limb is necessary to initiate educational programs and establish specialized footwear or orthotic needs.

## RECOMMENDATIONS

1. Comprehensive assessment of the contralateral limb should include:
  - a. Evaluating for the presence and severity of a sensory deficit
  - b. Quantifying the presence and extent of a motor deficit
  - c. Determining the arterial perfusion status of the extremity
  - d. Evaluating the presence of deformity
  - e. Evaluating for signs of acute or chronic abnormal pressure loading, including tissue redness, ulceration or callosity
  - f. Inspecting the patient's footwear, including wear pattern.
2. The patient and/or caregiver should be educated about strategies to protect the skin integrity of the foot (see [Appendix D](#)).
3. Appropriate foot care as indicated should provide:
  - a. Local foot care for callosities and nail care management by a health professional, especially in the context of sensory impairment or poor vision
  - b. Footwear that can be adapted to meet a patient's mobility needs, and that can accommodate a foot deformity and/or an orthotic device
  - c. Orthoses to optimize the pressure distribution on the foot or to substitute for muscle weakness or spasticity.
4. Regular follow-up to evaluate the adequacy of the footwear or orthosis should be established.
5. Specialized foot protection devices and/or mattresses should be considered for patients that are confined to bed or spend a considerable amount of time in the recumbent position.

## DISCUSSION

Patients with PVD and diabetes have a significantly increased risk for lower extremity amputation. The most common cascade of events that leads to amputation are related to abnormal pressure loading of the soft tissues in the presence of a sensory deficit, poor perfusion, and underlying deformity. These factors together contribute to mechanical skin injury. Once there is an opening in the skin, the ulceration can become secondarily infected. The eradication of the infection and healing of the ulceration may not be possible in the context of the underlying disease. Amputation may be necessary. The consequences of an additional amputation are significant in terms of additional healthcare costs, operative risks, reduction in functional outcome, and loss of independent living.

The first step, therefore, in the management of this patient population is to conduct a comprehensive evaluation. The evaluation of the sensory impairment can be multi-modality, but the use of the Semmes Weinstein filament has been best correlated with ongoing risk for ulceration. The first step in the evaluation of limb perfusion is to utilize the clinical examination and to palpate peripheral pulses. If peripheral pulses are intact, no further evaluation is necessary. If they are not present, the next step would be to determine the ankle brachial index. Here the systolic blood pressures in the foot arteries are compared to the brachial artery. It is important to note that a normal ankle brachial index may be an artifact of incompressible vessels, which is not uncommon in individuals with diabetes. The presence of deformity also suggests increased risk. Deformity, especially in the clinical context of a sensory impairment, increases the risk for ulceration. The most common deformity is a claw toe deformity. It is the result of loss of motor innervation to the intrinsic muscles of the foot and secondary over-pull of the toe long extensors and flexors. In more severe cases of neuropathy with motor impairment there can be a loss of innervation to the ankle musculature with a resultant foot drop. The second most common cause of deformity is Charcot Arthropathy, typically affecting the tarso-metatarsal joint.

Optimizing the pressure distribution on the soft tissues is critical to limb preservation. It is typically accomplished through the provision of specialized footwear that has an extra deep toe box. In more severe cases, a custom shoe may be required. In addition, custom molded in-shoe orthotics are an essential element to optimizing the pressure distribution under the foot. A vascular surgical consultation is indicated in the patient with an ankle brachial index of .5, rest pain, or functionally limiting claudication.

The patient with a traumatic amputation may have an isolated amputation without any additional involvement of the contralateral extremity. However it is common, especially in the polytrauma patient who has been injured in combat, to have multiple trauma that can result in injuries to the contralateral lower extremity. These injuries may cause impairment in neurological function or perfusion and may create patterns of complex scarring and soft tissue injuries. It is also important to consider injury to the central nervous system and its resultant adverse impact on the function of the contralateral limb.

Optimization of the overall functional status of the patient with lower extremity amputation relies upon preservation of the contralateral limb and compensation for neuromusculoskeletal impairments through the use of education, rehabilitation strategies, footwear, and orthotic devices, as well as quick access to the appropriate provider if a foot problem arises.

## **CORE-8. Behavioral Health Assessment and Treatment**

### BACKGROUND

Behavioral healthcare is essential as soon as the decision is made to amputate. Behavioral health specialists are frequently part of the interdisciplinary management of amputation. Most patients with amputations will cope adequately, but the rehabilitation team should watch for:



- Adjustment difficulties, including feelings of helplessness, sadness, anger, frustration, low self-esteem, excessive fatigue, poor motivation, sleep difficulties, poor concentration, anxiety, suicidal ideation, maladaptive coping behaviors (e.g., drugs, alcohol, withdrawal), exaggerated disability, poor social functioning, relationship problems, poor body image, and loss of functional independence.
- Psychiatric comorbidities, particularly depressive and anxiety disorders, are fairly high during the first two years post-surgery. Of the anxiety disorders, post-traumatic stress disorder (PTSD) may be most prevalent, particularly if the amputation resulted from trauma. Prevalence appears to decline thereafter to general population norms. Depressive and anxiety disorders often respond well to both medical and psychotherapeutic interventions. If untreated, psychosocial comorbidities may diminish treatment outcomes.

#### ACTION STATEMENT

Complete a psychological assessment in the preoperative phase, if possible. Evaluate the psychosocial status and treat problems throughout all phases of rehabilitation.

#### RECOMMENDATIONS

1. Psychosocial functioning should be assessed at each phase of amputation management and rehabilitation. Assessment should focus on current and past symptoms of psychopathology, particularly depression, anxiety, and post-traumatic stress symptoms. [B]
2. Interventions need to focus particularly on depressive, anxiety and post-traumatic stress disorder (PTSD) symptoms, using empirically supported medical and psychotherapeutic treatments for depression and PTSD. [B] Refer to the [VA/DoD Clinical Practice Guidelines on Major Depressive Disorder in Adults and Post-Traumatic Stress Disorder](#) for management of these common problems.
3. Effective coping goals/strategies should be developed during psychotherapeutic or counseling interventions. [B]
4. During the assessment, examples of effective and ineffective coping strategies should be discussed with the patient, such as enlisting sufficient social support versus social withdrawal and disengagement and problem solving difficulties versus helplessness and passivity. [B]
5. Specific structured interventions for problems such as depression, anxiety, sexual difficulties, substance abuse or drug overuse, and pain should be considered. [B]
6. Interventions may operate through individual, couple, family, or group therapy modalities. [B]
7. Significant others should be included in psychotherapeutic and/or psychoeducational interventions as needed. [B]
8. The use of validated tools for assessment should be considered; some examples may include:
  - a. Prosthesis Evaluation Questionnaire (PEQ) for psychometric assessment is a self-report questionnaire comprising 10 sub-scales: 4

- prosthetic function scales, 2 mobility scales, 3 psychosocial scales, and 1 well-being scale.
- b. Trinity Amputation and Prosthetic Experience Scales (TAPES) for psychosocial evaluation is also a self-report quality of life questionnaire with nine sub-scales; 3 psychosocial scales, 3 activity restriction scales, and 3 satisfaction subscales. TAPES has the advantage of being able to predict residual limb pain, phantom limb pain, and the extent of prosthetic use.
  - c. The Hospital Anxiety and Depression Scale (HAD) is a 14-item highly sensitive brief screening for anxiety and depression, commonly used in hospital settings.
  - d. The SF-36 Health Survey measures the degree of burden or dysfunction a medical condition has in a patient's life.
9. Psychological components to multidisciplinary approaches to chronic pain management should be included as needed. [B]

## DISCUSSION

### **Assessment**

Assessment should focus on current psychiatric symptoms, with a particular focus on depressive and anxiety symptoms, including post-traumatic stress symptoms. There is evidence that a relatively high percentage of patients experience such problems (Cansever et al., 2003; Desmond & MacLachlan, 2004; Fukunishi et al., 1996; Horgan & MacLachlan, 2004; Koren et al., 2005). PTSD symptoms are more common and severe for individuals whose trauma involves combat-related injury (e.g., many traumatic amputation victims) (Koren et al., 2005). Levels of depression and anxiety problems appear to be relatively high for up to two years post-amputation and then decline to normal population levels (Horgan & MacLachlan, 2004). There is good evidence that depression and anxiety (post-traumatic stress) are often effectively treated by both pharmacological and psychotherapeutic interventions (VA/DoD Clinical Practice Guidelines for Major Depressive Disorder in Adults [2000] and Post-Traumatic Stress Disorder [2003]).

While current psychiatric symptoms are most relevant, providers should also assess for a history of psychiatric problems for both the patient and his/her family, as such histories increase the risk for current or future problems for the patient. Assessment may include brief symptom checklists such as the Beck Depression Inventory, the Beck Anxiety Inventory, or the Post-Traumatic Stress Checklist (PCL) in order to acquire a quantitative measure of symptom severity. Quantitative indications of global functioning and/or disease burden over time can be obtained from outcome measures such as the SF-36.

Assessment should also address the current major stressors the patient is facing as well as his/her familial/social network, as these factors are likely to influence rehabilitation. There are a number of studies indicating that social support enhances psychosocial adjustment, overall functioning and pain management for patients (Desmond & MacLachlan, 2004; Hanley et al., 2004; Horgan & MacLachlan, 2004; Jensen et al., 2002; Livneh et al., 1999; Williams et al., 2004). The provider should also assess common effective and ineffective coping strategies. There is evidence that specific coping strategies for patients may enhance psychosocial adjustment and pain management while other strategies may diminish it. Active,

confrontive, problem-solving coping strategies enhance functioning, while passive, avoidant, disengaging strategies diminish it (Hanley et al., 2004; Jensen et al., 2002). It seems prudent therefore, that counseling interventions explicitly address coping strategies and encourage strategies demonstrated to be more effective. Finally, substance use patterns and abuse/dependence should also be assessed. Substance abuse is a method of dysfunctional coping. At later phases of rehabilitation (e.g., after the amputation), the provider should assess social and body image anxiety/discomfort, which are not uncommon, particularly among younger and female patients (Desmond & MacLachlan, 2004; Fukunishi, 1999; Horgan & MacLachlan, 2004; Rybarczyk et al., 1992). The loss of a limb distorts the body image; lowers self-esteem; and increases social isolation, discomfort, and dependence on others. They are associated with activity restriction, depression, and anxiety. The activity restriction may be a mediating factor (amongst others) for depression (Horgan & MacLachlan, 2004).

Satisfaction with the artificial limb may mitigate the problem, and body image is restored. Advances in the cosmetic appearance of prostheses can lead to the development of cosmetic covers, which are remarkably similar to the contralateral limb. The appearance of the prosthesis affects the patient's ability to disguise the disability and reduces the amputation-related body image concerns and perceived social stigma (Donovan-Hall et al., 2002). Overall activity level, including the presence of excessive activity restriction, and satisfaction with the prosthesis should be assessed. Activity level is reciprocally related to depressive and anxiety symptoms (e.g., decreased activity is often associated with such symptoms). Moreover, excessive activity restriction compromises functional outcomes.

### ***Pain***

Generally, the more chronic the pain, the more likely it is to come under the influence of other than nociceptive factors (e.g., cognitive, affective, behavioral, and social factors). Chronic pain patients have much higher rates of depressive disorder comorbidity; pain, and depressive symptoms often overlap considerably (see [CORE-3: Pain Management](#)). There is good evidence that psychological and/or multidisciplinary interventions enhance outcomes for chronic medical conditions generally and chronic pain particularly (Turk & Okifuji, 2002).

### ***Cognitive Function***

Elderly amputation patients may be at higher risk for cognitive deficits due to other medical comorbidities. Traumatically injured amputation patients are at higher risk for head injuries and associated cognitive deficits. Since cognitive deficits may compromise learning and rehabilitation, psychiatric assessment should often include a more extensive mental status/cognitive deficit screening (see [CORE-5: Cognitive Assessment](#)).

### ***Patient Readiness***

Increasingly, the concepts of motivation and "readiness" are recognized as important issues in chronic disease and chronic pain management (Jensen et al., 2003; Miller & Rollnick, 2002). Patients with chronic complex medical problems should not be passive recipients of medical interventions. More accurately, they are active collaborators in their treatment. Successful rehabilitation from amputation will require ongoing considerable effort on the part of the patient as well as optimal adherence with medical and rehabilitative prescriptions.

It is important to assess a patient's "readiness" to be actively involved and focused on treatment. Readiness and motivation may change over time, so they should be assessed intermittently throughout treatment and motivational enhancement interventions applied as needed (Miller & Rollnick, 2002). Motivational enhancement interventions attempt to validate and normalize the patient's intermittent feelings of discouragement and feeling trapped. They are not confrontive and they help patients increase their awareness of and focus on their identified reasons for working so hard in rehabilitation.

### ***Psychiatric Problems***

As depression and anxiety disorders are the most prevalent psychiatric problems for amputation patients, providers should be aware of evidence-based treatments for such problems. There are both pharmacological and psychotherapeutic treatments that have demonstrated good treatment efficacy. SSRIs and cognitive behavioral therapy (CBT) are the pharmacological and psychotherapeutic treatments with the greatest research support, respectively. (See the [VA/DoD Clinical Practice Guidelines for Major Depressive Disorder in Adults and Post-Traumatic Stress Disorder](#).)

## **CORE-9. Social Environment (Support)**

### BACKGROUND

The social and physical environments in which the patient lives contains the resources the patient may depend on in adjusting function and social role after the loss of a limb. Income, education, housing, and social connectedness are recognized social determinants of health. A baseline assessment and ongoing monitoring will help identify the social interrelations and resources that can support the patient during the rehabilitation process and help them cope with the challenges of limb loss.

An assessment of the physical environment (home, community, work place) aims to enhance accessibility, safety, and performance of daily living activities.

### ACTION STATEMENT

Identify the social and physical support system that will be available to the patient during the rehabilitation process and help cope with the challenges of limb loss.

### RECOMMENDATIONS

1. A baseline assessment should be obtained and continuously updated throughout the rehabilitation phases. The assessment should include information about the existing social environment and support system:

#### *Interpersonal Social Environment*

- a. Family and extended family
- b. Community - including workplace, employers/employees and co-workers
- c. Spiritual, religious, and cultural support
- d. Peer support system (see [Core-10: Peer Support Interventions](#))

*Physical Environment*

- e. Home environment – hazards and need for modification to address safety and accessibility
- f. Workplace
- g. Community – geographical location, distance from resources and services, and access to resources

*Economic Environment*

- h. Sources of income and/or financial support.

DISCUSSION

The amputation of a limb is experienced as a traumatic loss that produces anxiety, low self-esteem, body image concerns, the loss of a sense of wholeness, social isolation, decreased sexual activity, and depression. Understanding the psychosocial background of the patient going through this experience is essential in planning the patient's intervention and rehabilitation process. The rehabilitation team must understand emotional reactions (denial, mood disturbances, fear of the future) to be effective. The early involvement of family members and contact with other patients with amputations are important for the patient's psychological adjustment (Jelic' & Eldar, 2003).

Male gender and nonvascular amputation are predictors of positive psychological adjustment. Negative influences include low social support, poor perceived health, and high social discomfort (Rybarczyk et al., 1992). Educational level and preamputation salary (the higher, the more successful), a good social network, and an extroverted nature are also important factors (Gerhard et al., 1987). Patients who have lost limbs as a result of war injuries usually have more complex problems because of the variety of traumatic experiences to which they have been exposed (Ostojic' et al., 2001).

**CORE-10. Peer Support Interventions**

BACKGROUND

Patients with an amputation report that peer support programs are often very helpful. Peer support provides an opportunity for patients to relate to one another and/or to disclose relevant emotions. By sharing experiences with effective coping, peers can communicate to the patient that coping with an amputation is possible. Some amputation programs systematically enlist peer support interventions for prospective and new patients. Peer support interventions can be categorized into two types:

- One-on-one peer support and visitation offers information to a patient with a recent amputation from a patient who has experienced amputation for a longer time. Peer-to-peer support can provide information and education that may not be achieved in any other team relationship.
- Group peer support programs are comprised of patients at various phases of treatment, rehabilitation, and recovery.

## ACTION STATEMENT

Peer support should be considered, if available, throughout the course of amputation and rehabilitation.

## RECOMMENDATIONS

1. Peer visitation strategies may be considered throughout the rehabilitation cycle, particularly early when anxiety and adjustment problems may be most pronounced. [C]
2. Peer support interventions may be a particularly useful aspect of pre-procedural patient education interventions. [C]
3. Peer visitation volunteers should receive structured training prior to performing peer visitation services. The Amputee Coalition of America (ACA) provides a reputable training certification program. [C]
4. Patients should be referred to peer support groups or similar resources, if available. [I]

## DISCUSSION

Cross sectional studies examining the psychosocial adjustment of patients reveal that social support is a critical factor in psychosocial adjustment and functioning (Hanley et al., 2004; Horgan & MacLachlan, 2004; Jensen et al., 2002; Livneh et al., 1999, Williams et al., 2004).

There are no intervention studies that suggest peer support programs enhance psychosocial adjustment, functioning, or treatment outcome following an amputation. However, peer support interventions are commonly reported as helpful by patients and peer support programs are commonly utilized with a variety of other chronic medical conditions (e.g., diabetes and cancer).

Although there are no controlled intervention studies, there are several non-controlled descriptive studies of peer visitation and peer support programs as part of comprehensive amputation programs. These studies describe the programs as helpful and satisfying to patients, with some studies using descriptive patient satisfaction data (Fitzgerald, 2000; Marzen-Groller & Bartman, 2005; May et al., 1979; Rogers et al., 1977).

Modeling strategies have been shown to be helpful in pre-procedural patient preparation interventions (O'Halloran & Altmaier, 1995). Visitation and information given by a patient who has demonstrated impressive coping and adjustment may be conceptualized as a form of modeling.

## **CORE-11. Patient Education**

### BACKGROUND

The patient and family who have been properly educated about all phases of the treatment are likely to have a greater level of trust in their team and may have improved outcomes during the postoperative and rehabilitation phases. They are also more likely to have realistic expectations if they understand the recovery time,

the processes included in recovery and rehabilitation, and the sequence of events necessary for healing. In circumstances where surgery is urgent, patient education is often unavoidably delayed until the postoperative period.

The four stages in the education process are assessment, planning, implementation, and documentation. Patient education is categorized into three types:

- Giving information including procedural information (e.g., what will happen to you) and sensory information (e.g., what you may experience at different phases)
- Providing coping skills training
- Discussing fears and concerns.

#### ACTION STATEMENT

Patients scheduled for amputation should receive in-depth education regarding the procedure itself, and the various components of postoperative care and rehabilitation activities that will occur. A combination of information-giving and coping skills training should continue through all phases of the rehabilitation care.

#### RECOMMENDATIONS

1. Pre-procedural educational interventions should be provided to the patient before amputation, if possible, in order to decrease his/her fear, anxiety, and distress and to improve his/her post-procedural recovery. [B]
2. All members of the rehabilitation team should be involved in patient education as part of their interaction with the patient. [C]
3. Pre-procedural educational interventions should generally include information and a description of the specific procedures and events the patient will experience at the various phases of treatments, and continue throughout the continuum of care. [B]
4. Educational interventions should also include sensory information, that is a description of sensations and other feelings/symptoms the patient may experience at various stages during and following the procedure. [B]
5. Educational interventions may also include coping skills training; cognitive behavioral coping strategies are likely to be the most effective strategies. [B]
6. General supportive counseling (e.g., eliciting and validating the patient's anxieties, fears, and concerns) may also be helpful. Open-ended questioning, active listening techniques, eliciting anticipation of future stressors, and eliciting and encouraging utilization of the patient's social support resources are important strategies irrespective of whether information-giving or coping skills training interventions are being used. [C]

**Table 6. Patient Education Minimum Standards**

<b>Patient Education Regarding Rehabilitation Techniques*</b>	
Healthcare organizations should:	
➤	Provide information and educate on skills that improve the patient's health, toward both recovery and overall well-being
➤	Assess a patient prior to teaching and construct a plan that's based on the patient's needs
➤	Demonstrate the correct use of medical equipment to the patient
➤	Provide information on potential food and drug interactions specific to the illness or condition
➤	Counsel on nutrition intervention and modified diets
➤	Inform the patient about further treatment and rehabilitation techniques
➤	Provide the patient's background to home healthcare specialists and other medical care providers the patient may see during follow-up
*The Joint Commission's minimum standards	

An educational timeline for patients undergoing a lower limb amputation should include the following content:

**Table 7. Patient Education Summary Table**

Education Content	Learning assessment	Pain control	Patient safety/falls	Complication prevention	Incentive spirometry	Tobacco cessation	Bowel/bladder management	Deep vein thrombosis prevention	Contracture prevention	Pressure ulcer reduction	Edema control	Sequence of amputation care	Prosthetic options	Wound care/scar management	Role of interdisciplinary team members	Peer support	Protection of contralateral limb	Signs/symptoms of infection	Care of prosthesis	Donning/doffing prosthesis	Skin hygiene
Preoperative	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X				
Postoperative		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X
Pre-prosthetic rehabilitation		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Prosthetic training		X	X	X		X					X		X	X	X	X	X	X	X	X	X



## DISCUSSION

Patients who are active participants in their rehabilitation and maintain positive interactions with team members are more likely to succeed. Patients should be consulted and given appropriate advice and adequate information on rehabilitation programs, prosthetic options, and possible outcomes with realistic rehabilitation goals (Esquenazi & Meier, 1996; Pandian & Kowalske, 1995).

There are no randomized controlled trials on the effectiveness of pre-procedural educational interventions for adult patients undergoing amputation. However, reviews of research examining the efficacy of pre-procedural interventions reveal that such interventions are generally effective (Butler et al., 1992; O'Halloran & Altmaier, 1995). Improvements have been observed in a variety of outcomes including patient satisfaction, pain reduction, pain medication use, pre- and post-surgical anxiety, and behavioral recovery (Esquenazi, 2004). Interventions have most often included some combination of procedural and sensation information giving, instruction in cognitive-behavioral coping strategies, and elicitation of patient anxieties and fears.

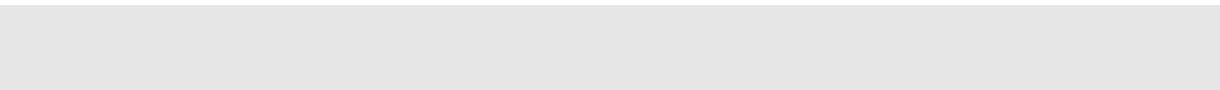
It is difficult to assess the relative effectiveness of different strategies, because multiple strategies are often "packaged" as one intervention and outcome measures are often different from one another. Overall, there appears to be a slight advantage of coping skills instruction over information giving, although both have been shown to be effective (O'Halloran & Altmaier, 1995). There is also a lack of distinction between pre-surgical preparation and preparation for invasive medical procedures in the meta-analyses. An emerging literature suggests that different interventions may be differentially effective for different "types" of patients. Overall, these results are mixed and not conclusive.

## CORE-12. Learning Assessment

### BACKGROUND

Learning is a process involving interaction with the external environment (Gagne & Driscoll, 1988) and results in a behavior change with reinforced practice (Huckabay, 1980). An assessment of the patient's learning capabilities will assist in developing tailored educational efforts to suit the patient's needs. A learning assessment evaluates this process by establishing learning goals and activities for the patient who has had an amputation in collaboration with the interdisciplinary team and the family or significant other.

### ACTION STATEMENT



### RECOMMENDATIONS

1. Prior to the learning assessment, the health professional should assess the patient with a lower limb amputation for core concerns, potential fears, support limitations, and cultural history.

2. The best time to begin a learning assessment is determined on a case-by-case basis but often begins with the initial contact with the patient who has had a lower limb amputation and their family.
3. The learning assessment should use open-ended questions to obtain the following and additional, information:
  - a. Patient/family's ability to cope with the health status, plan of care, prognosis, and outcome
  - b. Patient/family needs, concerns, roles, and responsibilities
  - c. Specific learning needs (knowledge, attitudes, skills) and educational level
  - d. Barriers to learning, including physical and/or cognitive limitations, language, emotional or psychological, and financial difficulties
  - e. Readiness to learn
  - f. Patient preferences regarding learning methods.

#### DISCUSSION

The following specific areas should be assessed:

- *Cultural and religious beliefs* including attitudes about touching, eye contact, and diet
- *Emotional/psychological barriers* including premorbid psychiatric conditions, denial, anger, anxiety, and fear
- *Physical and/or cognitive limitations* including impaired vision; hearing or thought process; attention deficit; and pain
- *Language barriers* that require a translator
- *Financial information* including income level and person responsible for bills
- *Educational level* including the highest level of formal education achieved and literacy level using the Rapid Estimate of Adult Literacy in Medicine (REALM) (Davis et al., 1993)
- *Role/responsibilities* of family and friends
- *Skill level* including prior experience and return demonstration
- *Preferred learning style* whether it is written materials, group discussion, demonstrations, internet, role playing, lectures, self-directed, games, videos, audio tapes, photographs and drawings, or models
- *Readiness to learn* including motivation, attitude, and outlook.

#### **CORE-13. Physical Rehabilitation**

The aim of rehabilitation is to achieve maximum independence and function. The individual's rehabilitation program takes into account their pre-amputation lifestyle, expectations, and medical limitations. The level of amputation, physical and psychological presentation, and social environment influence the expected level of functional independence. The rehabilitation team progresses the patient through a program based on continuous assessment and evaluation. Through regular assessment, the team should identify when the individual has achieved optimum function with or without the prosthesis, facilitating discharge to a maintenance

program, and continue to follow-up as needed. The following areas of interventions include a suggested step approach, indicating the key elements in each area as they progress throughout the rehabilitation process. For a summary of the key elements, see [Table 2. Summary of Interventions in Rehabilitation Phases](#) in the Introduction to the guideline.

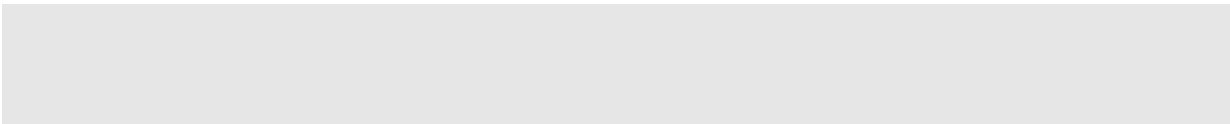
Physical rehabilitation includes assessments and activities that improve the baseline status of the musculoskeletal system and include range of motion (ROM), strengthening, cardiovascular fitness, and balance.

### CORE-13.1 Range of Motion

#### BACKGROUND

Maximal range of motion (ROM) of the residual limb is paramount to successful prosthetic use. A combination of ROM assessment, intervention, and education can reduce the risk of contractures. Attention should also be given to ROM of the proximal lower extremity joints of the amputated side as well as the contralateral limb in order to maximize gait efficiency and help minimize stresses on the joints and spine.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. The residual limb should always be properly positioned to avoid contractures that could interfere with future prosthetic fit and ambulation. In a transtibial amputation, the residual limb should be placed in knee extension when in bed. For a transfemoral or transtibial amputation, the residual limb should be kept in neutral alignment for adduction/abduction and internal/external rotation. At no time should a pillow be placed under the residual limb.
2. A prone lying program should be initiated with all patients who have a lower extremity amputation to avoid hip flexion contractures. Progressively advance the length of time from the patient's tolerance to 30 minutes twice per day if possible.

(See [Table 2. Summary of Interventions in Rehabilitation Phases](#) for detailed interventions by phases of care.)

#### DISCUSSION

A lower limb amputation results in an inherent weakness of the residual limb due to the new attachments of the cut distal muscles to either bone or other muscle. The patient with the transfemoral amputation has a greater propensity for hip flexion and abduction contracture due to the relative weakness of the adductor magnus muscle, which normally is a strong hip adductor and extensor.

Some hip and knee flexion contractures can be accommodated by modifications in the prosthesis. However, normal ROM of all joints should be pursued.

Proper positioning will decrease the risk of developing joint contractures, particularly at the hip and knee of the involved limb. Contractures at these joints may adversely affect prosthetic fitting and subsequent mobility and function. Munin and colleagues used a clinically relevant regression model to demonstrate the effectiveness of early inpatient rehabilitation. Contractures were aggressively addressed and preventive strategies, such as prone and side lying and aggressive pain control, were implemented to decrease the risk of contracture. The investigators also found that these strategies, combined with the initiation of prosthetic gait training, led to a higher rate of successful prosthetic use (Munin et al., 2001). A study by Davidson and colleagues found similar results to be particularly important at the proximal joints (Davidson et al., 2002).

## CORE-13.2 Strengthening

### BACKGROUND

The lower extremities should be strengthened to control the prosthetic limb and prevent muscle atrophy. Upper extremity strengthening is important for transfers, ambulation with an assistive device, and wheelchair mobility. Strengthening of the core trunk muscles contributes to stability during ambulation with a prosthesis.

### ACTION STATEMENT

Throughout the continuum of care, assess and improve the strength of all muscle groups that impact use of a prosthesis and overall functional capacity.

### RECOMMENDATIONS

1. A strengthening program should be initiated for the major muscle groups of the upper extremities, trunk, and the residual and contralateral limbs in order to maximize functional use of the prosthesis and prevent the development of comorbidities such as low back pain.
2. Both open and closed-chain exercises and isokinetic and progressive resistance exercises should be included in the strengthening program.
3. Specific muscle groups to strengthen include hip extensors, hip adductors, hip abductors, abdominal musculature, back musculature, knee extensors, rotator cuff, and elbow extension.
4. A home exercise program should be designed and tailored to a patient's individual needs for use on a long-term basis.

### DISCUSSION

It has been found that ambulating with a prosthesis results in an increase in energy expenditure (Waters & Mulroy, 1999). In addition, higher metabolic costs were found in patients with higher anatomic levels of amputation (i.e., transfemoral vs. transtibial), advanced age, or history of PVD (Huang et al., 1979). Because of this increase in work associated with ambulation, the patient with a lower limb amputation must improve strength and cardiovascular endurance in order to maximize function.

### **CORE-13.3 Cardiovascular Fitness and Endurance**

#### BACKGROUND

A higher energy demand is placed on the cardiovascular system of patients who use a prosthesis. Ongoing strengthening, endurance, and cardiovascular training will enable the prosthetic user to maximize functional level.

#### ACTION STATEMENT

Increase cardiovascular fitness and endurance to maximize the efficiency of gait, both with or without a prosthesis.

#### RECOMMENDATIONS

1. A tailored cardiovascular training program should be initiated as soon as possible in the postoperative phase and continue throughout the rehabilitation process.
2. The cardiovascular program should include upper body ergometry regardless of the ability to use a lower extremity prosthesis.
3. Gait training should progress from use of an appropriate assistive device and increase to community distances as cardiovascular fitness improves.
4. Consultation to a cardiac rehabilitation program should be considered, particularly in patients with known cardiopulmonary disease or dysvascular amputation.
5. Higher level sporting activities should be pursued to supplement routine cardiovascular fitness in younger individuals with traumatic amputation.

#### DISCUSSION

Upper body ergometry has been shown to be an effective way to determine safe maximal heart rates for exercise and to prognosticate information concerning functional outcome after rehabilitation. Patients who achieved a maximum work capacity of 45 watts per minute were able to ambulate with a prosthesis without an assistive device. Those who achieved a maximum work capacity of 60 watts per minute were able to ambulate outdoors with their prosthesis (Priebe et al., 1991).

A study by Pitetti and colleagues showed that cardiovascular training of patients with amputations not only improved their cardiovascular fitness but also increased the economy of walking at a normal walking speed based on the reduction of heart rate and oxygen consumption (Pitetti et al., 1987).

### **CORE-13.4 Balance**

#### BACKGROUND

Patients with a lower extremity amputation are at an increased risk of falling, because the limb-loss severely impacts a patient's dynamic and static balance.

#### ACTION STATEMENT

Initiate, measure, and adjust a balance re-training program to minimize a patient's risk of falling and increase the efficiency of gait, both with and without a prosthesis.

#### RECOMMENDATIONS

1. Sitting and standing balance should be assessed throughout the rehabilitation process using standardized assessment tools such as the Berg or Tinetti Balance Assessment.
2. Interventions should start with sitting balance and progress to sitting weight shifts, then sit to stand, supported standing, single-limb balance, and dynamic balance training.
3. Balance should be challenged with a variety of activities such as weight shifting on a soft surface, rocker board, ball rolling under the sound foot, and step-ups.

#### DISCUSSION

Long-term studies have shown that individuals with lower extremity amputations have decreased balance confidence, which is preventable and modifiable. These patients often restrict their activities which lead to further limitations in balance and function (Miller & Deathe, 2004).

### **CORE-14. Functional Rehabilitation**

Functional rehabilitation includes assessment and activities, such as activities of daily living (ADL), transfers, and mobility, which are performed to achieve a functional goal.

#### **CORE-14.1 Functional Activities of Daily Living**

##### BACKGROUND

Bed mobility, transfers, and other ADLs must be taught early in the post-amputation period to promote and encourage independence, increase strength, and reduce the fear of falling. Pain or the fear of pain limits bed mobility, so any strategy that provides limb protection may improve mobility. Physical therapy and occupational therapy are essential to improvements in ADLs.

#### ACTION STATEMENT

Interventions to improve functional activities of daily living (ADL) should be initiated, measured and adjusted as needed during the postoperative phases.

#### RECOMMENDATIONS

1. The self-care component of functional activities of daily living (ADL) should include dressing, feeding, grooming, bathing, and toileting, with and without a prosthesis.

2. The transfers component of functional activities of daily living (ADL) should include the following, with and without a prosthesis:
  - a. sit to stand
  - b. bed to chair
  - c. chair to toilet
  - d. chair to tub
  - e. vehicle transfers
  - f. floor transfers.
3. Patients should be educated in strategies to prevent falls and improve safety.

#### DISCUSSION

It is recommended that a pre-prosthetic rehabilitation program begin as soon as possible after surgery to assist the patient in attaining the highest functional level (Esquenazi & DiGiacomo, 2001). Independence in ADLs was a key factor in returning successfully to the home (Jones et al., 1993).

#### **Falls Prevention**

Complications secondary to falls may result in significantly increased healing time, additional surgical intervention, other injuries, and increased hospitalization. Initiation of early functional activities, strengthening, balance, and mobility will optimize patient safety and fall prevention.

There is some evidence that the application of a strategy that incorporates a pylon and foot system reduces the number of falls (Schon et al., 2002). However, the addition of a pylon and foot may make bed mobility slightly more difficult because of the extra length, weight, and bulk, particularly if knee flexion is not possible. Other strategies, such as "limb-loss reminders" (i.e., placing a chair on the side of the bed where the patient gets up to "remind" him/her to be careful) may reduce the incidence of complications from falls, but additional study is needed. Therapeutic interventions such as balance and strength training may help reduce the number of falls.

### **CORE-14.2 Mobility and Equipment**

#### BACKGROUND

Mobility training directly and positively influences the quality of life for the patient with a lower limb amputation by increasing the patient's independence and function. Patients with an amputation are likely to need appropriate durable medical equipment (DME) for community re-entry and a return to their selected living setting. The least restrictive assistive device will result in the most normalized and efficient gait.

#### ACTION STATEMENT

Initiate mobility training to optimize the patient's ability to move from one location to another by means of adaptive equipment, assistive devices, and vehicle modifications.

## RECOMMENDATIONS

1. Standardized measures of mobility can assist with outcome measurement and determine additional social support and equipment needs. Consider utilizing one or more of the following measures, but note that they may not be helpful in the young active individual with traumatic amputation (see Table 8).  
Advantages and Disadvantages of Recommended Assessment Tools):
  - a. Amputee Mobility Predictor (AMP)
  - b. Functional Independence Measure (FIM)
  - c. Two-Minute Walk Test
  - d. Timed Up and Go Test (TUG)
  - e. Upper Extremity Ergometry.
2. The training program to improve mobility should include both the physical components of strengthening and cardiovascular fitness and practicing the actual activity.
3. Assistive devices (e.g., combination of canes, crutches, walkers, and manual and/or powered mobility) that the patient has demonstrated to be able to use safely and which improve the ability to navigate different environments should be prescribed.
4. A wheelchair should be prescribed for individuals with amputations who may experience times when they can not use their prosthesis(es) and/or assistive devices for mobility.
5. Advanced wheelchair mobility skills should be taught to navigate such environments such as stairs, escalators, curbs, uneven terrain, and soft surfaces (grass, sand, gravel).
6. Vehicle modifications should be prescribed for those who can not safely drive a vehicle due to right lower limb amputation, or left lower limb amputation with comorbidities to the right lower limb, or any individual with bilateral lower extremity amputations.

## DISCUSSION

The key to independence and reintegration after amputation is personal mobility, which comprises both ease and freedom of movement. Ease is greater with transport, but only walking provides freedom of movement and is indispensable for independence (Collin & Collin, 1995). Several studies describe a positive association between a patient's mobility and their quality of life. Pell and colleagues used the Nottingham Health Profile in 1993 to determine that persons with amputations rated their overall quality of life as poor compared to a control group. They found that mobility was the only significant factor that impacted this rating (Pell et al., 1993). Esquenazi & DiGiacomo (2001) emphasized that regaining ambulation is a key to returning patients to their previous lifestyles, roles, activities, and socialization. These studies suggest that a rehabilitation program should put a major focus on improving the mobility of the patient.

Turney and colleagues found no difference between the mobility of patients amputated for vascular reasons as compared to those amputated for orthopedic or other causes. With a rigorous inpatient rehabilitation program they achieved a 77 percent ambulation rate in their patients. The only predictor of decreased mobility



was the level of amputation. Their study demonstrates that a strong rehabilitation program can improve mobility, independence, and quality of life for a patient with a lower limb amputation (Turney et al., 2001).

Baseline assessment is needed to evaluate outcomes and establish goals for future rehabilitation care. Immediate outcomes consist mainly of the degree of independence in basic ADLs and of the extent of mobility and can be measured with the Functional Independence Measure (FIM). The FIM (Granger et al., 1995) is sensitive and wide ranging but is cumbersome and time-consuming to score (Turner-Stokes & Turner-Stokes, 1997). It is also not sufficiently sensitive for functional changes in patients with amputations (Melchiorre et al., 1996; Muecke et al., 1992). Two studies have reported on the general rehabilitation outcome gains in the FIM scores in this population but have not specifically addressed the prosthetic use of patients (Granger et al., 1995; Heinemann et al., 1994). The FIM does not enable the accurate evaluation of mobility, which is the central component in the functional limitation of a patient with a lower limb amputation. Nevertheless, the FIM is frequently used, at least in the United States and Canada (Deathe et al., 2002) and was recommended as the measurement tool in the VA guideline for amputation rehabilitation 1999.

Intermediate outcomes relate to the use of prostheses after discharge from inpatient rehabilitation. They are measured by the duration of the daily wear of a prosthesis, the capability to don and doff it, and by the extent to which it serves as the main means of ambulating and for various activities in everyday life. Most patients with traumatic amputations are functional users, use their prostheses most hours of the day, don and doff it independently, and use their prostheses as the main means of ambulating. Partial users wear prostheses mainly at home but for outdoor activities use wheelchairs; it is important to identify them to ensure that they are provided with wheelchairs and that their homes are adapted for wheelchair use.

The level of amputation, age and comorbidity, male gender, and walking ability prior to the amputation are predictors of successful rehabilitation. These factors should be considered in the preadmission prediction and assessment of appropriateness for rehabilitation.

Long-term outcomes are assessed in relation to the ultimate rehabilitation goals. Successful long-term rehabilitation outcomes must take into account not only the success of prosthetic fitting but also an individual's overall level of function in a community setting (Purry & Hannon, 1989).

**Table 8. Advantages and Disadvantages of Recommended Assessment Tools**

Assessment	Pros	Cons
<b>Amputee Mobility Predictor (AMP)</b>	<ul style="list-style-type: none"> <li>Valid both with and without a prosthesis</li> <li>High inter- and intra-rater reliability</li> <li>Correlates with the 6-Minute Walk as a predictor of prosthetic success</li> <li>Negative correlation with age and comorbidity</li> <li>Can be performed in 15 minutes or less in the clinic</li> <li>Requires little equipment</li> </ul>	<ul style="list-style-type: none"> <li>None found in the literature review</li> </ul>
<b>Functional Independence Measure (FIM)</b>	<ul style="list-style-type: none"> <li>Easily performed during evaluation and at intervals during rehabilitation</li> <li>Good intra- and inter-rater reliability</li> <li>Good predictor of continued prosthetic use after discharge</li> </ul>	<ul style="list-style-type: none"> <li>Does not act as a predictor of prosthetic success</li> <li>Does not fully capture functional changes with progression of therapy</li> <li>Highest functional level that can be attained with a prosthesis is 6 out of 7 regardless of the patient's functional abilities (ceiling effect)</li> </ul>
<b>Two-Minute Walk</b>	<ul style="list-style-type: none"> <li>Easily performed in the clinic</li> <li>High intra- and inter-rater reliability</li> <li>Responsive to change with continued rehabilitation</li> <li>Correlates with other measures of physical function (6-Minute Walk, 12-Minute Walk)</li> </ul>	<ul style="list-style-type: none"> <li>Increases in distance may simply be related to external cues rather than a response to therapy</li> </ul>
<b>Timed Up and Go (TUG)</b>	<ul style="list-style-type: none"> <li>Easily performed in the clinic</li> <li>High intra- and inter-rater reliability</li> </ul>	<ul style="list-style-type: none"> <li>No studies found regarding predictive validity</li> <li>No studies found regard TUG in gait with a single limb and assistive device</li> <li>One study indicates that the TUG is dependent on the chair type (arms and height)</li> </ul>
<b>Upper Extremity Ergometry</b>	<ul style="list-style-type: none"> <li>Has been shown to be an effective way to determine safe maximal heart rates for exercise and prognostic information concerning the functional outcome after rehabilitation</li> <li>Patients that achieve a maximum work capacity of 45 watts per minute were able to ambulate with a prosthesis without an assistive device; those that achieve a maximum work capacity of 60 watts per minute were able to ambulate outdoors with their prosthesis</li> <li>Easy to administer and inexpensive</li> </ul>	<ul style="list-style-type: none"> <li>Severe cardiac disease is prevalent in patients with dysvascular amputations</li> <li>Patients should be monitored for arrhythmias and ST-segment depression throughout testing or exercise programs</li> </ul>

Whatever measure is used, some important principles emerge, including:

- Patients should always be assessed on what they actually do, not what they can do.
- Outcome measures should be selective to reflect rehabilitation goals.
- Although measures of mobility and independence may be useful in evaluating immediate outcomes of prosthetic rehabilitation, longer term evaluation is required using measures that focus on restriction in participation and the quality of life.

### **CORE-14.3 Community Reintegration**

#### BACKGROUND

Community reintegration includes drivers training, home evaluation, home exercise programs, vocational rehabilitation, social roles, and recreation.

#### ACTION STATEMENT

Establish goals for community reintegration and initiate, measure, and adjust interventions such as driver's training and vocational rehabilitation during the postoperative phases

#### RECOMMENDATIONS

1. Training in the use of public transportation, with and without a prosthesis, should be provided, if appropriate.
2. Endurance should be increased with ambulation to community distances if appropriate.
3. Information on organizations with opportunities for adaptive recreational activities should be provided.
4. Driver's training and vehicle modifications should be pursued, if not already done. Any patient with a right lower extremity amputation should be evaluated and trained on a left foot accelerator. A patient with bilateral lower extremities amputation should be evaluated and trained in hand controls.
5. The patient's home should be evaluated for accessibility and information on home modifications should be provided.
6. Patient's worksite should be evaluated for the potential need for accommodations to facilitate return to the work setting.
7. Patients should be provided with a list of resources for information regarding amputations, support groups, and accessibility for people with disabilities.

#### DISCUSSION

Reintegration into a normal life is generally poor for the patient with a lower limb amputation in the areas of community mobility, work, and recreation. Return to work after severe lower extremity trauma remains a challenge. Nissen and Newman

found that 75 percent of their patients in the working-age group, even though they rated their perceptions of self-worth, home mobility, and psychosocial adjustment satisfactory, considered their integration into work unsuccessful. Dependent factors were prior education, type of employment (sedentary vs. manual work), underlying medical condition, level of amputation, the availability of retraining assistance, the attitudes of employers and coworkers, and their own attitudes to work. Emphasis should be placed on these aspects in rehabilitation (Nissan & Newman, 1992).

Factors that were significantly associated ( $p < 0.05$ ) with higher rates of return to work include younger age, being Caucasian, higher education, being a nonsmoker, average to high self efficacy, preinjury job tenure, higher job involvement, and no litigation. Early (3 month) assessments of pain and physical functioning were significant predictors of return to work (MacKenzie et al., 2006).

Factors negatively associated with returning to work were residual limb problems, phantom pain, age, and higher level of amputation. Frequent prosthesis use and the receipt of vocational services improved the prognosis for returning to work (Millstein et al., 1985). Livingston and colleagues (1994) found that their patients were only infrequently referred for vocational rehabilitation and that job retraining efforts were minimal.

Transportation is also a concern for patients with a lower limb amputation. Jones and colleagues (Jones et al., 1993), in Australia, found problems of accessibility to public transportation and many patients with amputations stopped driving their cars.

In a survey done in Canada, overall, 80.5 percent of participants ( $N=123$ ) were able to return to driving an average of 3.8 months after amputation, although the majority reported a decreased driving frequency. Female sex, age of 60 years or greater, right-sided amputation, and preamputation driving frequency of less than every day were all significantly related to a reduced likelihood of return to driving post-amputation. The level of amputation, cause for amputation, preamputation automobile transmission, and accessibility to public transit were not associated with return to driving. Common barriers to return to driving included preference not to drive, fear and/or lack of confidence, and related medical conditions (Boulias et al., 2006). Major automobile modifications are commonly performed for patients with a right sided amputation. Several predictors of return to driving and barriers preventing return to driving were identified.

Lifestyle after a lower limb amputation also may undergo severe changes. Several studies that surveyed patients' activities after the amputation have shown that patients less frequently attended cultural performances and less frequently visited friends or relatives than before their amputations. Free time activities also changed; decreasing time spent in outdoor sport activities and spending more time in reading, watching television, listening to music, and housekeeping (Jelic´ & Eldar, 2003). These studies demonstrate the importance of including recreational activities in the overall rehabilitation program.

## **Module A: Preoperative Assessment and Management**

### **Summary**

Algorithm A commences at the point that an adult patient has been evaluated in the clinical setting and the decision has been made that amputation is necessary. Complete interdisciplinary assessments of the patient's medical, functional, and psychological status are performed as baseline to postoperative treatment and rehabilitation. Patient education is initiated prior to the surgery. The patient will proceed to surgery only when the patient's status is determined to be optimal for surgery, unless a trauma or urgent life threatening infection exists. If the case is urgent, the patient proceeds almost immediately to surgery and other assessments and patient education will take place in the immediate postoperative phase.

### **Table of Contents**

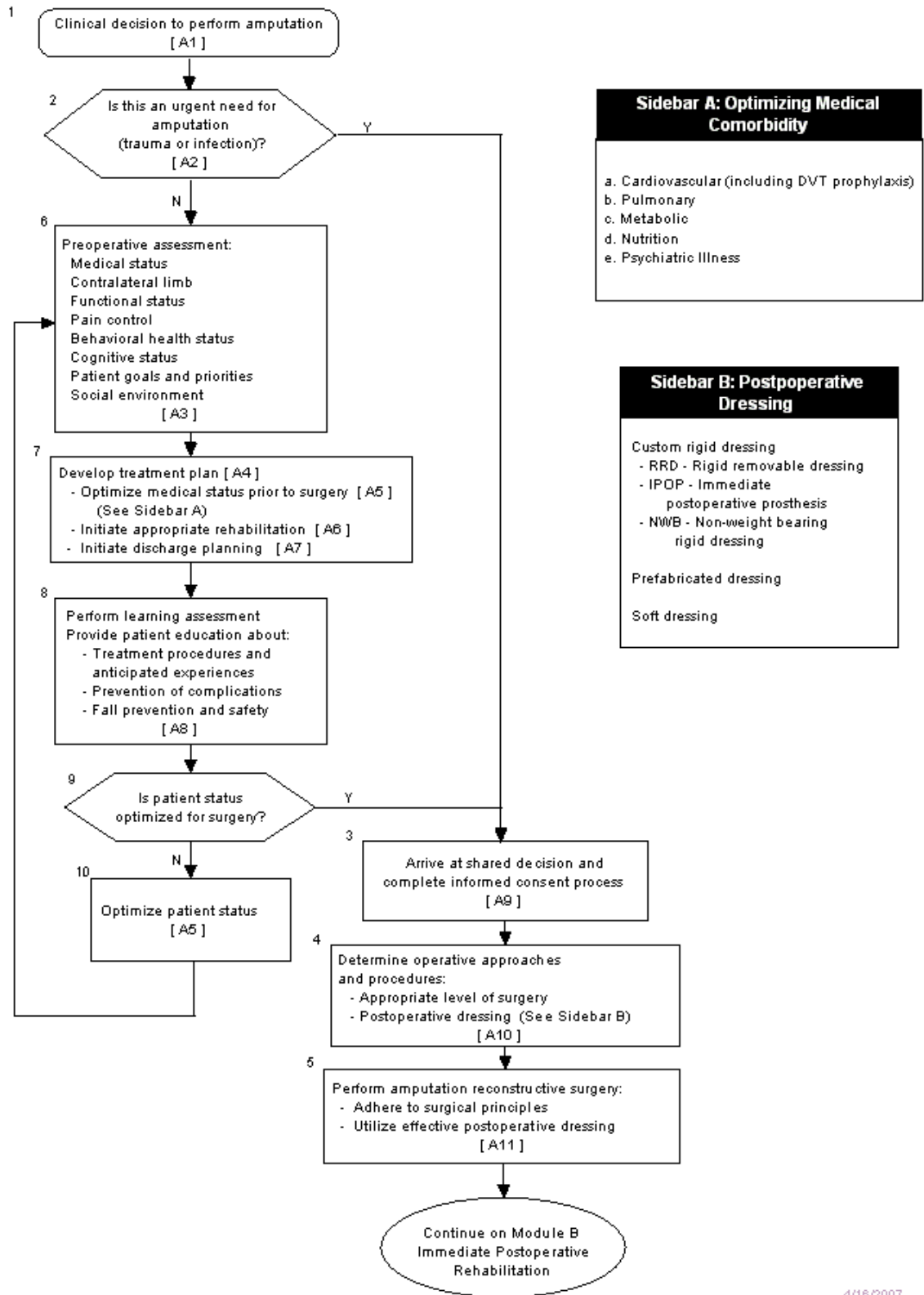
#### **Algorithm**

#### **Annotations**

- A-1. Clinical Decision to Perform Amputation**
- A-2. Is This an Urgent Need for Amputation (Trauma or Infection)?**
- A-3. Preoperative Assessment**
- A-4. Develop the Treatment Plan**
- A-5. Optimize the Patient's Medical Status Prior to Surgery**
- A-6. Initiate Appropriate Rehabilitation Interventions**
- A-7. Initiate Discharge Planning**
- A-8. Perform Learning Assessment and Provide Patient Education**
- A-9. Arrive at Shared Decision and Complete Informed Consent Process**
- A-10. Determine Operative and Postoperative Approaches and Procedures**
  - A-10.1: Determine the Appropriate Level of Surgery
  - A-10.2: Determine Postoperative Dressing
- A-11. Perform Amputation Reconstructive Surgery**
  - A-11.1: Adhere to Surgical Principles
  - A-11.2: Utilize Effective Postoperative Dressing

VA/DoD Clinical Practice Guideline for  
Rehabilitation of Lower Limb Amputation  
Module A: Preoperative Assessment and Management

**A**



4/16/2007

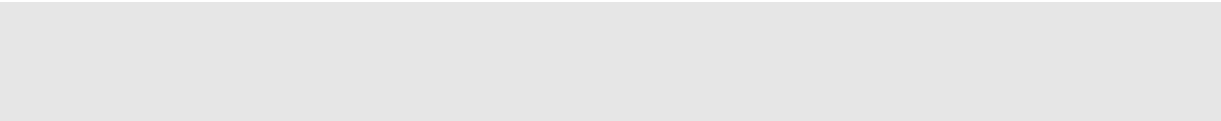
## Module A: ANNOTATIONS

### A-1. Clinical Decision to Perform Amputation

#### BACKGROUND

Until recently, the main aim of amputation was to save life by removing a badly damaged limb or for malignancy. Today, amputation is a refined reconstructive procedure to prepare the residual limb not only for motor functions of locomotion but also for sensory feedback and cosmesis. Common reasons for lower limb amputation are trauma, vascular conditions, neoplastic conditions, infective conditions, and congenital conditions.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. Amputation should only be considered if the limb is non-viable (gangrenous or grossly ischemic), dangerous (malignancy or infection), or non-functional.

#### DISCUSSION

The decision about amputation should be made by an experienced surgeon. The surgeon should be familiar with the multiple approaches of the various levels of amputation, muscle balancing, and wound closure (Smith, 2004). Elective amputation may be considered in situations of failed limb salvage. In cases of trauma, careful consideration should be made with respect to the decision about limb salvage versus amputation (Bosse et al., 2001 & 2005) When considering amputation as a treatment for cancer, a trained orthopedic oncologist or general surgical oncologist should be involved in the decision process.

### A-2. Is This an Urgent Need for Amputation (Trauma or Infection)?

#### BACKGROUND

In developed countries, the majority of lower extremity amputations are performed for PVD secondary to atherosclerosis and/or diabetes mellitus (DM). In developing countries, the main causes are trauma and infection. The presence of trauma and/or significant infection generally requires an urgent amputation. An amputation may be required when vessel occlusion and subsequent extremity necrosis results from using vasoconstrictor agents to treat infections (sepsis).

#### ACTION STATEMENT

Assess the degree of urgency in order to put the appropriate steps in motion to optimize the patient's outcome.

## RECOMMENDATIONS

1. Consider urgent surgery in severe life-threatening situations including infection and trauma.

## DISCUSSION

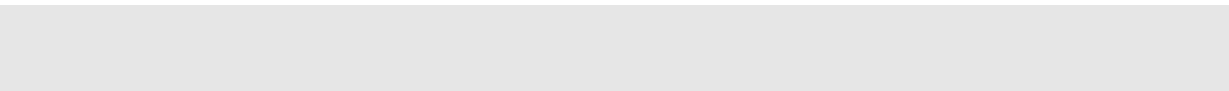
In trauma cases in which the immediate threat to life is not serious, a period of conservative management may even restore collateral circulation in the limb and help to avoid amputation or minimize the segment to be removed. Emergency repair of torn blood vessels by the vascular surgeon can make limbs viable and even help to avoid amputation. Providers and patients should be aware that extensive reconstructive surgery to preserve a limb may result in a limb that is painful, non-functional, and less efficient than a prosthesis.

### A-3. Preoperative Assessment

#### BACKGROUND

An interdisciplinary team assessment provides the baseline to follow after the operation and throughout the rehabilitation process. Assessment by multiple specialties helps reduce the risk of missing potential complicating factors that may negatively influence operative and patient rehabilitation outcomes (see [CORE-1: Interdisciplinary Consultation/Assessment](#)).

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. A thorough medical assessment should be completed preoperatively to evaluate the patient's physical condition, nutrition, infection, neuropsychiatric impairment, and bowel and bladder function as well as a review of systems (cardiovascular, respiratory, endocrine, skin, neurological, and musculoskeletal).
2. Condition and function of the contralateral limb should be assessed including (see [CORE-7: Contralateral Limb](#)):
  - a. Quantify the severity of the sensory deficit
  - b. Observe for the presence of deformity
  - c. Observe for signs of abnormal soft tissue loading
  - d. Limb perfusion
  - e. Education, specialized heel protectors, or specialized mattresses should be used to assure that the patient does not develop ulceration on the remaining limb.
3. Baseline function should be evaluated prior to amputation surgery (see [CORE-13: Physical Rehabilitation](#) and [CORE-14: Functional Rehabilitation](#)):
  - a. Range of motion (ROM)
  - b. Strength



- c. Exercise endurance
  - d. Balance
  - e. Mobility
  - f. Activities of daily living (ADL).
4. Pain control measures should be initiated in the preoperative period to optimize the postoperative rehabilitation (see [CORE-3: Pain Management](#)).
  5. A psychological assessment and preparation strategies should be completed in the preoperative phase whenever possible (see [CORE-8: Behavioral Health Assessment and Treatment](#)).
  6. A preoperative cognitive assessment should be conducted to assist in the process of determining the patient's ability to learn, adapt to, and utilize a prosthesis following surgery as well as the ability to participate in rehabilitation and to maximize functional independence and community reintegration (see [CORE-5: Cognitive Assessment](#)).
  7. Patient's goals and priorities should be assessed prior to amputation surgery.
  8. Assess patient's social environment, home and community environments, and support system (see [CORE-9: Social Environment](#)).

#### DISCUSSION

Medical status should be optimized in order to facilitate the best surgical and rehabilitative outcomes.

The patient's premorbid and current functional status need to be determined prior to amputation surgery in order to maximize rehabilitation results, evaluate outcomes, and establish goals for future care.

Many patients awaiting amputation may experience severe pain for some time. Pain control prior to surgery is essential to enable the patient to rest and be as comfortable as possible. Some patients will have an improved postoperative experience when pain has been effectively controlled in the preoperative period.

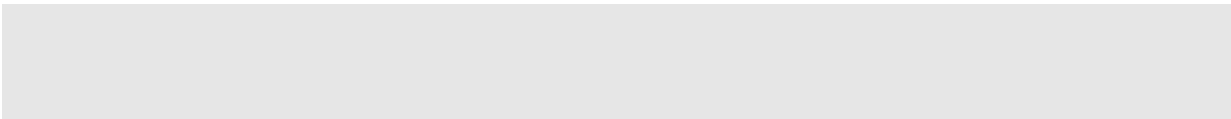
Appropriate behavioral health preparation procedures prior to surgery may enhance the patient's rehabilitation and post surgical adjustment including the length of the inpatient hospital stay and the amount of required medications.

#### **A-4. Develop the Treatment Plan**

##### BACKGROUND

A treatment plan should be established early in the process. Initiating treatment and discharge plans in the preoperative phase will assist in optimizing long-term patient outcomes and ease the transition of the patient to home.

##### ACTION STATEMENT



## RECOMMENDATIONS

1. A unified, cohesive, and comprehensive treatment plan should be developed prior to surgery that includes specific interventions for treatment by the interdisciplinary rehabilitation team members and updated throughout the full continuum of care.

(see [CORE 2: Rehabilitation Treatment Plan](#)).

### A-5. Optimize Medical Status Prior to Surgery

#### BACKGROUND

In addition to influencing the patient's morbidity and mortality, multiple factors may significantly affect the patient's ability to resist infection and heal surgical wounds (e.g., cardiopulmonary function, nutrition, and vascular health). Many of these factors can be controlled or modified prior to surgery. Particular attention should be given regarding diabetic and blood pressure control.

#### ACTION STATEMENT

Optimize the patient's medical status before surgery.

#### RECOMMENDATIONS

1. When possible, every effort should be made to correct controllable factors prior to undertaking surgical amputation, including (see [CORE-4: Medical Care](#)):
  - a. Cardiovascular
  - b. Pulmonary
  - c. Metabolic
  - d. Nutrition
  - e. Psychiatric illness
  - f. Risk factor reduction (including cardiovascular risk and diabetes mellitus risk reduction)

#### DISCUSSION

A review of studies (VATAP, 2005) focused on predictors of outcome measures associated with prosthetic use and mobility during or immediately following rehabilitation in older patients with nontraumatic causes of amputation. The majority of studies were conducted with male patients age 60 years or older with primarily non-traumatic (vascular) causes of unilateral transtibial amputation. Comorbidities such as diabetes, cardiovascular disease, and cerebrovascular disease were frequently present in these populations, reflecting chronic systemic diseases common to an aging population.

The results of the review suggest, along with clinical experience, that advancing age is a negative predictor for most outcome measures identified in this review, but not by itself. Baseline pre-amputation functional capability, general health status, and socioeconomic situation may also be important predictors of prosthetic use and

functional ability; however, most of these predictors were defined differently across studies or identified only in single studies.

## **A-6. Initiate Appropriate Rehabilitation Interventions**

### ACTION STATEMENT

**Maximize the patient's physical function before surgery.**

### RECOMMENDATIONS

1. Initiate appropriate rehabilitation interventions while the patient is awaiting amputation surgery, to maintain current function and prevent secondary complications (see [CORE-13: Physical Rehabilitation](#); [CORE-14: Functional Rehabilitation](#)).

## **A-7. Initiate Discharge Planning**

### ACTION STATEMENT

Establish a treatment plan for the rehabilitation process.

### RECOMMENDATIONS

1. A discharge plan should be initiated early in the pre-operative period and updated throughout the rehabilitation process to address:
  - a. Location of rehabilitation
  - b. Social support/financial resources
  - c. Home environment assessment
  - d. Transportation
  - e. Vocational considerations
  - f. Durable medical equipment (DME).

## **A-8. Perform Learning Assessment and Provide Patient Education**

### BACKGROUND

All members of the rehabilitation team should be involved in providing information to the patient and family throughout the assessment process. Initial education may raise additional questions by the patient and family that need to be addressed. Effective education will help to alleviate fear and anxiety as well as facilitate safe discharge planning.

An assessment of patient learning capabilities assists in developing tailored education to meet patient needs. A learning assessment establishes learning goals and activities for the patient in collaboration with the rehabilitation team and family or significant other.

#### ACTION STATEMENT

Pre-procedural patient education should include learning assessment, and a combination of information presentation, and discussing of coping strategies.

#### RECOMMENDATIONS

1. A learning assessment and identification of barriers to learning or communication should be performed preoperatively.
2. Patients scheduled for amputation should receive education regarding the procedure and the various components of postoperative care and rehabilitation activities, including (see [CORE-11: Patient Education](#)):
  - a. Pain control
  - b. Patient safety/fall precautions
  - c. Prevention of complications
  - d. Procedural/recovery issues:
    - Level of amputation
    - Prosthetic options
    - Postoperative dressing
    - Sequence of amputation care
    - Equipment
  - e. Expectation for functional outcome
  - f. Potential psychosocial issues
  - g. Role of the rehabilitation team members.

### **A-9. Arrive at a Shared Decision and Complete the Informed Consent Process**

#### BACKGROUND

The informed consent process is essential to any surgical intervention and is required by law. The discussion prior to surgery is usually the first contact between the patient and the surgeon who will conduct the operation. This discussion is the opportunity to form a trusting relationship and open communication to address the patient's fears, wishes, and concerns. The surgeon must make the patient aware of the risks and benefits of each viable treatment option. Patient should be encouraged to ask questions and to express their own personal desires, verbalize a good understanding of their options, and agree to a treatment plan before undertaking surgical lower limb amputation. Special consideration must be given in cases where the patient is unable to consent to surgery.

#### ACTION STATEMENT

Informed consent must be obtained whenever possible prior to amputation.

## RECOMMENDATIONS

1. Based on a clinical evaluation by the treating surgeon with input from the interdisciplinary rehabilitation team, the patient (or person giving consent) should be presented with all viable treatment options and the risks and benefits for the following:
  - a. Level of amputation
  - b. Management of postoperative wound
  - c. Type of postoperative prosthesis.
2. The patient (or person giving consent) should be encouraged to ask questions. The surgeon should make every effort to answer those questions to the patient's satisfaction. The patient (or person giving consent) should be able to verbalize a good understanding of their treatment options at the end of the process.
3. Involvement of the patient's family and/or significant others should be encouraged.
4. The patient (or person giving consent) must agree to the surgical and immediate post-surgical treatment plan.
5. The informed consent process should be in compliance with institutional policy (satisfying The Joint Commission's requirements).

## **A-10. Determine Operative and Postoperative Approaches and Procedures**

### **A-10.1 Determine the Appropriate Level of Surgery**

#### BACKGROUND

Once the patient is optimized for surgery, the surgeon must determine the level of amputation. The level of amputation will affect the patient's rehabilitation, functional outcome, and long-term quality of life. Several factors are incorporated in this decision that include the patient and family perspective, input from other members of the rehabilitation team, and principles of amputation surgery.

#### ACTION STATEMENT

Determine the appropriate level of amputation prior to surgery.

#### RECOMMENDATIONS

1. The choice of amputation level should take in consideration the risks and benefits. The factors in the risk-benefit assessment include the patient's goals and priorities, the patient's general condition and risk of additional surgeries, the potential for healing of the limb, and the predicted probable functional outcome.
2. Optimal residual limb length:
  - a. Transtibial

- Optimum – length that allows space for the prosthetic foot and sufficient muscle padding over the residual limb – typically mid-tibia
  - Minimum – junction of middle third and proximal third of tibia just below the flair of the tibial plateau to allow sufficient tibia for weight-bearing.
- b. Transfemoral
- Optimum – length that allows space for an uncompromised knee system – typically just above the condylar flair
  - Minimum – junction of middle third and proximal third (below the level of the lesser trochanter) to allow sufficient femur length/lever arm to operate the prosthesis.
- c. If there is uncertainty of the optimal length of the residual limb, preoperative consultation with an experienced physiatrist or prosthetist should be considered.
3. The potential for wound healing should be determined. The following may be considered: [I]
- a. Laboratory studies:
- C-reactive protein to check for infection
  - Hemoglobin to check for treatable anemia to ensure an appropriate oxygenation level necessary for wound healing
  - Absolute lymphocyte count to check for immune deficiency and/or infection
  - Serum albumin/prealbumin level to check for malnutrition and diminished ability to heal the wound.
- b. Imaging studies:
- Anteroposterior and lateral radiography of the involved extremity
  - CT scanning and MRI as necessary
  - Doppler ultrasonography to measure arterial pressure.
- c. Additional tests:
- Ischemic index (II) is the ratio of Doppler pressure at the level being tested to the brachial systolic pressure – a II of 0.5 or greater at the surgical level is necessary to support healing.
  - Assess preoperative amputation TcPO<sub>2</sub> levels – preoperative levels greater than 20mmHg are associated with successful healing after amputation. [A]

## DISCUSSION

Determining the optimum amputation level involves balancing the patient's goals and expectations, the risks associated with additional surgery, the functional and cardiovascular consequences of more proximal amputations, the surgeons' clinical experience, and the physiological potential for the residual limb to heal. Other

factors that might be considered include cosmesis, mobility goals, and specialized vocational or recreational priorities.

The ultimate functional desires and expectations of the patient need to be included in the decision-making process. Whether the patient wishes to return to high-level athletics versus non-ambulatory status may significantly influence the ultimate level of ambulation, and may lead a surgeon to preserve a longer limb with a lower chance of healing. Conversely, if the patient's underlying medical condition makes any surgical intervention potentially life-threatening, the surgeon may elect to perform the amputation at a more proximal level with a greater chance of healing.

Studies have shown that there are significantly increased energy expenditures in a transtibial amputation and even greater in a transfemoral amputation. Due to the patient's underlying comorbid cardiovascular disease, this increased energy expenditure may result in the patient having a lower level of function, and possibly not being able to ambulate at all. In fact, the level of amputation is more predictive for mobility than other factors including age, sex, diabetes, emergency admission, indication for amputation and previous vascular surgery [Turney et al., 2001].

The decision regarding the level of amputation must also consider the reason for the amputation (e.g., disease process, trauma), the vascular supply to the skin flaps, and the requirements of limb fitting procedures and techniques available at the time.

Additionally, the physiological potential for the amputated wound to heal is a significant factor which must be balanced into the decision-making. Many noninvasive tests have been advocated. The underlying vascular status must be considered (McCollum et al., 1986; Apelqvist et al., 1989; Wagner 1979; Cederberg et al., 1983; Barnes et al., 1976). The best studied is transcutaneous O<sub>2</sub> pressure measurement, which measures the partial pressure of oxygen diffusing through the skin. This is believed to be the most reliable and sensitive test for wound healing (Pinzur et al., 1992; Burgess & Matsen, 1982; Matsen et al., 1980; Lalka et al., 1988). Values greater than 40 mm Hg indicate acceptable wound healing potential. Values less than 20 mm Hg indicate poor wound healing potential. However, none of these tests should supplant the role of sound clinical judgment (Wagner et al., 1988).

Amputation should preserve as much of the limb as possible, because the longer the lever arm, the more control a patient will have over a prosthesis. If possible, the knee should be salvaged to decrease the energy consumption required for ambulating. In transtibial amputations, the increased energy expenditure in walking is 25 to 40 percent above normal, and in transfemoral amputations, it is 68 to 100 percent above normal; hence, patients with transtibial amputations usually have better mobility than those with transfemoral amputations (Esquenazi & Meier, 1996; Volpicelli et al., 1983).

The site of an injury largely determines the decision regarding the level of section. In addition to preserving length, it is important to ensure that the residual limb be covered with skin that has normal sensation and is free of scar tissue as much as possible and that the end of the residual limb is adequately covered with muscles (Kostuik, 1981).

## A-10.2 Determine Postoperative Dressing

### BACKGROUND

Postoperative dressings are used to protect the limb, reduce swelling, promote limb maturation, and prevent contractures. There are two major classifications of postoperative dressings that are commonly used:

<p><b>Soft dressing</b></p>	<ul style="list-style-type: none"> <li>• <b>ACE wrap</b></li> <li>• <b>Shrinker</b></li> <li>• <b>Compression pump</b></li> </ul>
<p><b>Rigid dressing</b></p>	<ul style="list-style-type: none"> <li>• <b>Non-weight bearing rigid dressing (NWB)</b></li> <li>• <b>Immediate postoperative prosthesis (IPOP)</b></li> <li>• <b>Custom rigid removable dressing (RRD)</b></li> <li>• <b>Prefabricated rigid removable dressing (RRD)</b></li> <li>• <b>Prefabricated pneumatic immediate postoperative prosthesis (AirPOP)</b></li> </ul>

### ACTION STATEMENT

An appropriate postoperative dressing should be selected by the surgeon in the preoperative phase to protect the residual limb, decrease edema, and facilitate wound healing; consider the use of a rigid postoperative dressing.

### RECOMMENDATIONS

1. The appropriate postoperative dressing should be determined by the surgeon before surgery, recognizing that circumstances occurring during the surgery may necessitate changes. [I]
2. Consider the use of a rigid or semi rigid dressing to shorten the time to healing and readiness for prosthesis in dysvascular transtibial amputations. [B]
3. There is inconclusive evidence to recommend for or against a specific kind of rigid dressing. [I]
4. Properly fitted shrinkers should be used as soon as possible, after amputation. [I]
5. Patients with a bulbous transtibial limb are more likely to do better with a rigid dressing applied above the knee and changed every three to five days until they are able to tolerate a shrinker. [I]



## DISCUSSION

Postoperative dressings are designed to protect the residual limb, decrease edema, and facilitate wound healing. Traditionally, plaster dressings or soft dressings have been applied in the operating room to fulfill this function. The plaster dressings can be incorporated into a temporary prosthesis (IPOP) or left without a prosthesis (NWB). With the manufacture and use of plastic shells, there are many commercially available rigid removable dressings (RRD), both custom or “off-the-shelf”, with even some having air bladders to form a more custom fit (AirPOP). Soft dressings can be used with ACE wraps, shrinkers, and airbladders used to control edema; however, soft dressings offer little protection to the residual limb.

There have been numerous descriptive case series reports on the different types of management strategies but relatively few randomized comparative studies. Although the safety and efficacy of the various strategies for postoperative management are debated, definitive evidence to support the benefit of any single technique is lacking.

There is inconclusive evidence for or against any specific postoperative dressing with or without immediate postoperative prosthesis. Current protocols and decisions are based on local practice, skill, and intuition. The primary goal remains to maintain the integrity of the residual limb. The current available literature is challenging, and difficulties include variations in healing potential, in comorbidity, in surgical-level selection, in techniques and skill, in experience with postoperative strategies, and with poorly defined outcome criteria (Smith et al., 2003).

Despite the limited high quality literature, a critical review of the literature [Smith et al., 2003] indicates that:

- Rigid postoperative dressings improve time to heal and readiness for a prosthesis (Vigier et al., 1999).
- Semi-rigid postoperative dressings may improve time to heal and readiness for a prosthesis (Wong et al., 2000).
- Other studies showed similar outcomes for rigid dressings but were not statistically significant (Baker et al., 1977; Dasgupta et al., 1997; Datta et al., 2004; Graf & Freijah, 2003; Mueller, 1982; Pinzur et al., 1996; Woodburn et al., 2004).

A recent systematic review [Nawijin et al., 2005] found a trend in favor of rigid dressings compared to soft dressings in time of healing, residual limb volume, and prosthetic fitting. The results did not demonstrate a trend toward improved functional outcomes based on the type of dressing used; this may be due to a lack of a standardized outcome measure and timing of follow-up (Nawijin et al., 2005).

Most of the 11 RCT studies evaluating postoperative dressing had small sample sizes, different study populations often with no reported patient ages, multiple different definitions for wound healing, and high variability in application of rigid and soft dressings. Nawijin and colleagues (2005) assessed the quality of the 11 studies and rated only 3 studies (Vigier et al., 1999; Mueller, 1982; Baker et al., 1977) to be of acceptable methodological level. No studies were rated as good quality and the remaining studies were rated poor due to significant flaws in the study designs (subject selection, standardized outcome, statistical methods) Due to the methodological limitations, the interpretation of the results and generalization of the conclusion should be done with caution.

Six studies have measured healing of the stump. Vigier and colleagues (1999) demonstrated improved time to residual limb healing using rigid or semi-rigid dressings. This improvement was also supported by two other studies that had some methodology flaws (Mooney et al. 1971; Nicholas and Demuth 1976). Baker et al. (1977) did not show a difference in wound healing rates when comparing a soft dressing with a rigid dressing. Another poor level study (Barber et al., 1983) also found no differences. No studies found any negative wound healing effects as a result of the application of rigid dressings.

Residual stump volume was a main outcome measure in one of four studies. Mueller et al. (1982) found a significantly greater degree of stump shrinkage with the Removable Rigid Dressing (RRD) when compared to the use of elastic compression bandages. The use of elastic bandages did not decrease stump volume significantly in this study, similar to the results reported in studies of Golbranson et al. (1988) and Manella (1981).

Readiness for prosthetic fitting constitutes an outcome measure in which both stump healing and stump volume are incorporated. In two studies (MacLean & Flick, 1994; Wong et al., 2000) time to readiness for prosthetic fitting in the group treated with semi-rigid dressings was found to be significantly shorter with the treatment of elastic bandages.

Non-uniform functional outcome was one of the main outcome measures assessed in three studies. Vigier et al. (1999) found no significant difference in time to initial success in walking more than 20 minutes. However, Baker et al. (1977) found a reduced rehabilitation time, i.e., time from amputation to gait training, when using plaster dressing compared to elastic bandages. Wong et al. (2000) found that more patients that use a semi-rigid dressing become ambulatory when compared to those who use elastic bandages. Other studies found no differences in functional outcome as a result of the interventions applied.

Future RCTs are needed that apply a standardized protocol and consistent time-related outcome measures concerning wound healing, edema reduction, and functional outcomes. Postoperative dressing and management strategies are not the only determinant of outcome, and other variables might have a greater impact on outcome. Future studies are needed to more accurately document and control for variables such as amputation-level selection, surgical skill and technique, healing potential, comorbidity, and functional status.

## **A-11. Perform Amputation Reconstructive Surgery**

### **A-11.1 Adhere to Surgical Principles**

#### BACKGROUND

Amputations are complex reconstructive operations which require adherence to many surgical principles. Surgical technique and decisions will have a profound influence on the patient's rehabilitation and prosthetic use.

#### ACTION STATEMENT

Consider the implications of the surgical reconstructive procedure on the patient's rehabilitation and the potential for prosthetic use.

#### RECOMMENDATIONS

1. Perform the appropriate amputation at the selected level, adhering to good surgical and amputation principles

#### DISCUSSION

A surgeon experienced in amputation techniques should perform the amputation, using a recognized surgical approach. Future prosthetic requirements should be considered at the time of surgery, because this may affect the surgical technique. If there is any doubt about the level of the amputation, consultation with a rehabilitation physician is recommended (Amputation Rehabilitation: Recommended Standards and Guidelines, 1992; Esquenazi & Meier, 1996).

The handling of the bone, muscles, and nerves during the surgical amputation can have a profound impact on the patient's prosthetic fitting and rehabilitation. Bone cuts should be made transversely and beveled to avoid bony prominence with minimal periosteal stripping to avoid heterotopic bone formation. These bony prominences and heterotopic bones can make prosthetic fabrication and wear very difficult. A bone bridge can be considered in traumatic, non-dysvascular transtibial amputations. Muscle should be divided distal to the bone resection to ensure adequate soft tissue to cover the bone. Rigid myodeses are preferred in patients with good healing potential to facilitate muscle tone, balance, and strength in the residual limb. Nerves should be individually identified, placed under gentle traction, sharply transected, and allowed to retract proximally. This will ensure that when the neuroma forms in the transected nerve, it will be in an area less likely to cause the patient significant pain and problems with prosthetic wear.

### **A-11.2 Utilize Effective Postoperative Dressing**

#### BACKGROUND

At this phase, the postoperative dressing is applied. The decision-making for the dressing was done pre-operatively; however, the course of surgery intraoperatively may affect the final choice of dressings, particularly if heavy contamination leads to the decision to perform an open amputation. The goals remain to protect the residual limb, decrease edema, and facilitate wound closure. There is no consensus on how to use wound dressings to optimize healing after trans-tibial amputation.

#### ACTION STATEMENT

Apply the postoperative dressing of choice to protect the residual limb, decrease edema, and facilitate wound healing; especially consider the use of a rigid postoperative dressing.

#### RECOMMENDATIONS

1. Appropriate postoperative dressing should be applied after amputation.

2. The use of rigid postoperative dressings should be considered (which is preferred in situations where limb protection is the priority). [B]

## DISCUSSION

See Section [A-10.2: Determine Postoperative Dressing](#).

### ***Soft Dressings***

Descriptive studies indicate several disadvantages of soft dressings, such as high local or proximal pressure, tendency to loosen or fall off, limited mobilization, and extended hospital stays. Controlled studies found that the frequency of uncomplicated healing rates, postoperative pain, eventual use of a prosthesis, and mortality were not significantly different between soft and rigid types of dressings. Furthermore, data presenting health and financial impact of complications and disadvantages are not well presented.

### ***Rigid Dressing***

*Short removable rigid casts.* No descriptive studies have provided outcome data using this type of dressing. One study reported a large reduction in the time from surgery to ordering a temporary prosthesis, but this variable would be subject to other influences besides wound healing. Of the two controlled studies of the short removable rigid dressing, only one showed that this dressing resulted in significantly less edema compared to soft dressings.

*Thigh-level rigid casts with immediate postoperative prosthesis (IPOP).* Benefits claimed include a low percentage of limb complications, few surgical revisions, and a short time period to custom prosthesis fitting. However, these claims were from descriptive studies with no comparison groups. Similarly, controlled studies did not support statistically significant differences in wound healing rates, complications, pain, or other outcomes.

*Thigh-level rigid casts.* Descriptive studies claim that rigid plaster dressings reduce edema, pain, and healing times; increase tolerance to weight bearing; and enable early ambulation. They are also more difficult to apply and they require specialized training. However, claims are made without comparison groups and so the conclusions may be masked by other factors. Furthermore, while controlled studies found considerably shorter rehabilitation times compared to soft dressings, small sample sizes and high variation failed to show statistical significance. Other outcomes not statistically different for thigh-level rigid dressings included frequency of uncomplicated healing, post surgical pain, time to rehabilitation, length of stay, or failure rate.

*Prefabricated pneumatic IPOPs.* Studies are limited, and there are several variations of manufactured pneumatic IPOP. Consequently, it is difficult to make consistent comparisons. Studies reported, however, that this design is lighter in weight, has more controlled compression of the limb to minimize edema, and is removable. Another study showed that patients with the pneumatic IPOP had fewer postoperative complications.

## **Module B: Immediate Postoperative Rehabilitation**

### **Summary**

Algorithm B commences at the point that an adult patient is in the immediate postoperative phase following a single lower limb amputation. This algorithm and associated annotations guide the provider through the postoperative dressing and the patient management issues that are required at this critical juncture. The algorithm addresses problems with wound healing, assessments for medical stability, and discharge criteria from acute care. Follow-up pursuant to rehabilitation and prosthetic fitting is discussed in Module C.

### **Table of Contents**

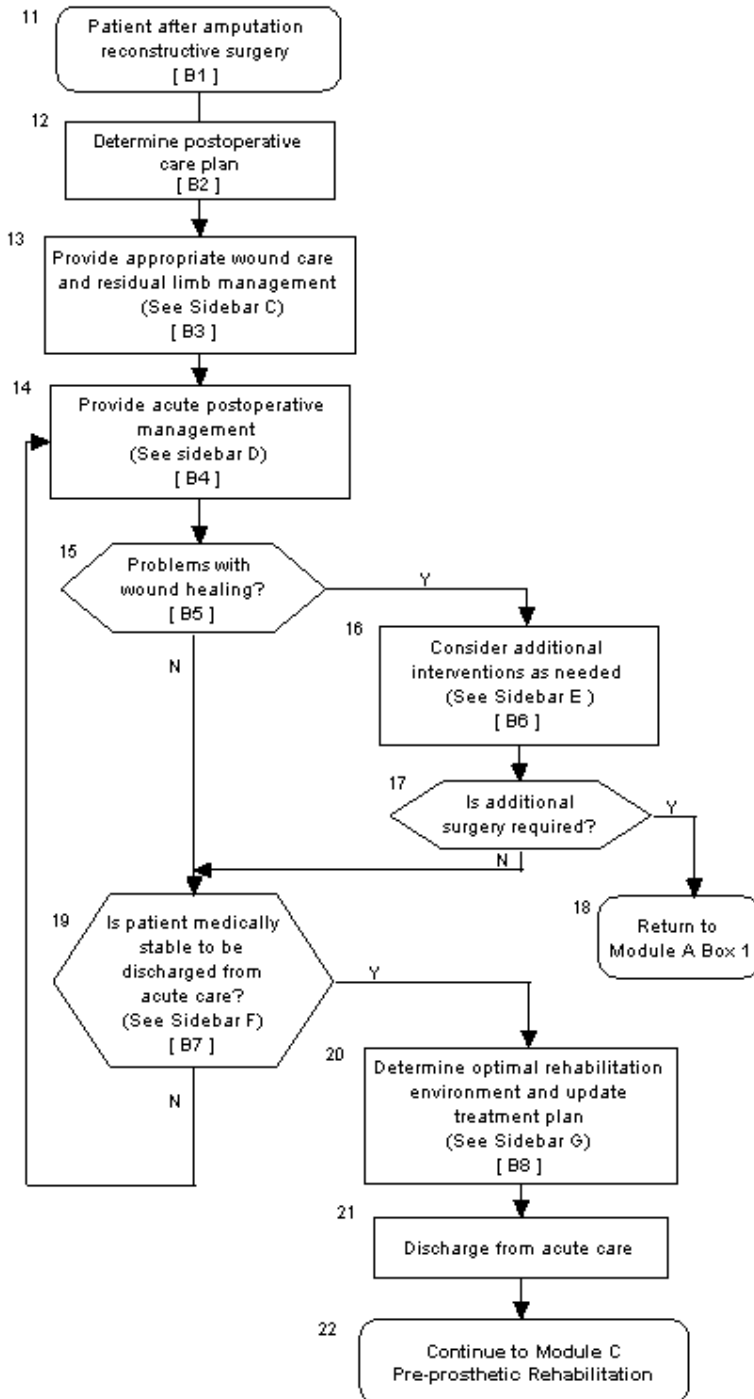
### **Algorithm**

### **Annotations**

- B-1. Patient After Amputation Reconstructive Surgery**
- B-2. Determine the Postoperative Care Plan**
- B-3. Provide Appropriate Wound Care and Residual Limb Management**
- B-4. Provide Acute Postoperative Management**
- B-5. Problems with Wound Healing?**
- B-6. Consider Additional Interventions for Postoperative Wound Management as Needed**
- B-7. Is the Patient Medically Stable To Be Discharged from Acute Care?**
- B-8. Determine the Optimal Rehabilitation Environment and Update the Treatment Plan**

**VA/DoD Clinical Practice Guideline for  
Rehabilitation of Lower Limb Amputation  
Module B: Immediate Postoperative Rehabilitation**

**B**



**Sidebar C: Residual Limb Management**

- Edema control
- Prevention of contractures
- Protection from trauma
- Management of postoperative dressing

**Sidebar D: Acute Postoperative Management**

- Medical comorbidity
- Rehabilitation intervention
- Discharge planning
- Pain control
- Behavioral health

**Sidebar E: Interventions to Resolve Wound Healing Problems**

- Revision surgery
- Vascular evaluation/intervention
- Infection evaluation and treatment
- Aggressive local wound care
- Hyperbaric oxygen (HBO)

**Sidebar F: Criteria for Discharge from Acute Care**

- Wound healing appropriately
- Lack of infection
- Acceptable bowel and bladder function
- Medical comorbidity controlled
- Hemodynamically stable

**Sidebar G: Possible Rehabilitation Environment**

- Acute inpatient rehabilitation
- Outpatient rehabilitation
- Sub-acute rehabilitation
- Home therapy
- Self-directed therapy
- Skilled nursing facility
- Long-term care

## Module B: ANNOTATIONS

### B-1. Patient after Amputation Reconstructive Surgery

#### BACKGROUND

The patient is in the immediate recovery phase following an amputation of the lower extremity.

#### DISCUSSION

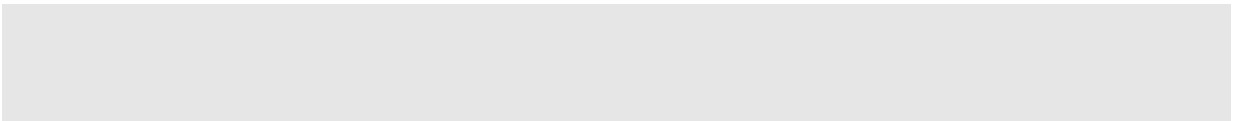
Module B applies to patients in the immediate postoperative phase. During this critical phase of recovery, the focus of treatment is on the surgical and medical needs of the patient. As time progresses, and the patient becomes medically stable, the rehabilitation needs will outweigh the medical needs of the patient. The focus of the interdisciplinary team will then turn to rehabilitation intervention, targeting optimization of function, mobility, and quality of life.

### B-2. Determine the Postoperative Care Plan

#### BACKGROUND

The anticipated approach to postoperative care is addressed in the preoperative phase when the rehabilitation team is prepared to initiate treatments and interventions immediately and patients can be prepared for what to expect.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. The postoperative plan should include a care plan to address:
  - a. Medical requirements
  - b. Wound or surgical requirements
  - c. Rehabilitation requirements including:
    - Prevent contractures
    - Reduce postoperative edema through the use of compression therapies
    - Protect the amputated limb from external trauma
    - Ensure patient safety

### **B-3. Provide Appropriate Wound Care and Residual Limb Management**

#### BACKGROUND

As part of the surgical assessment, the decision is made for either immediate or delayed closure of the surgical wound. Amputation wounds can be difficult to manage; different clinical situations may require different management of the surgical wounds. Based on the clinical evaluation by the treating surgeon, with input from the interdisciplinary rehabilitation team, the treating surgeon must decide the appropriate postoperative wound management.

#### ACTION STATEMENT

The appropriate postoperative wound care and residual limb management should be prescribed by the surgeon performing the operation.

#### RECOMMENDATIONS

1. For a closed amputation and primary closure, the following procedures should be performed:
  - a. May apply sterile, non-adherent dressing secured with stockinet
  - b. Apply a compressive dressing to reduce edema and shape the residual limb
  - c. Monitor for infection
  - d. Remove the sutures or staples per the advice of the surgeon
2. For an open amputation, the following procedures should be considered:
  - a. Staged closure at a later date may be required for wounds heavily contaminated from infection or trauma
  - b. A vacuum-assisted-closure device may be helpful for open wounds
3. Residual limb management should continue with the focus on postoperative dressings, control of the edema and shaping of the residual limb, control of the pain, and protection of the residual limb from further injury.

(See [CORE-6 : Residual Limb](#))

### **B-4. Provide Acute Postoperative Management**

#### BACKGROUND

The patient may still have acute medical issues that warrant inpatient care following surgical amputation. Appropriate postoperative medical and surgical care is essential to avoid secondary complications, speed recovery, and optimize outcomes. For example, monitoring limbs for postoperative complications such as peripheral nerve or vascular compromise is important for ultimate limb function. Monitoring for signs of local or systemic infection (i.e., an elevated temperature, abnormal wound drainage, or an elevation in the white blood count) facilitates appropriate immediate management. Combat casualties have a particularly high infection rate and therefore, the treating physician must be aware of endemic organisms associated with the location of injury. Additionally, proper institutional infection



control procedures must be observed, such as contact guard precautions or isolation rooms as needed.

Residual limbs with complex skin grafting, muscle flaps, or vascular repair that are commonly seen with combat casualties require the interdisciplinary management of various surgical subspecialties. Comorbid conditions such as injury to the brain, spinal cord, peripheral nerves, bones, soft-tissues, or internal organs must also be continuously monitored and treated accordingly.

Pain in the postoperative phase is often multi-factorial. Likely nociceptive sources include injury to bone, soft tissue, and nerves. Aggressive pain management in the acute phase may reduce future chronic pain.

#### ACTION STATEMENT

Specific medical and surgical interventions need to be initiated immediately in the postoperative phase. Combat casualties with polytrauma may be best treated in a designated polytrauma center.

#### RECOMMENDATIONS

1. A thorough medical assessment should be completed postoperatively to assess physical condition, nutrition, lack of infection, and bowel and bladder function as well as a review of systems (cardiovascular, respiratory, endocrine, skin, neurological, and musculoskeletal).
2. Treatment of pain should be started immediately and address the specific source of pain:
  - a. Post surgical pain – appropriate edema control, liberal use of narcotics
  - b. Neuropathic/phantom pain –consider use of anticonvulsant (e.g., pregabalin, gabapentin, antidepressants (e.g., SSRIs, or TCAs)
  - c. Consider use of epidural or regional anesthesia.
3. Specific measures for deep vein thrombosis (DVT) and pulmonary embolism (PE) prophylaxis should be applied.
4. A nutrition assessment should be documented and specific recommendations should be applied; referral to a nutrition specialist should be considered.
5. A thorough sepsis workup for any signs/symptoms of systemic infection should be completed.
6. Medical and surgical comorbidities resulting from polytrauma, such as that seen in combat casualties, are best managed in rehabilitation centers that provide interdisciplinary management including multiple medical and surgical subspecialties with trauma experience.
7. Bowel and bladder functions should be monitored to maintain fluid balance as well as to avoid urinary retention and constipation, which may be brought on by medications (particularly opioids and anticholinergics) and/or decreased mobility.
8. Behavioral health support should be provided as necessary.
9. The following rehabilitation interventions should be initiated as tolerated:

- a. Range of motion (ROM)
  - b. Strengthening
  - c. Cardiovascular fitness and endurance
  - d. Balance
  - e. Mobility
  - f. Functional activities and activities of daily living (ADL).
10. Patient and family education on positioning, skin care, and pain management; preservation of the intact limb; and approaches to modify risk factors should be re-enforced from preoperative training.

#### DISCUSSION

Therapy involvement in the immediate postoperative period is needed to minimize complications and maximize the progression of rehabilitation. Rehabilitation that begins soon after surgery has a number of advantages such as minimizing phantom and residual limb pain and mastering prosthetic ambulation.

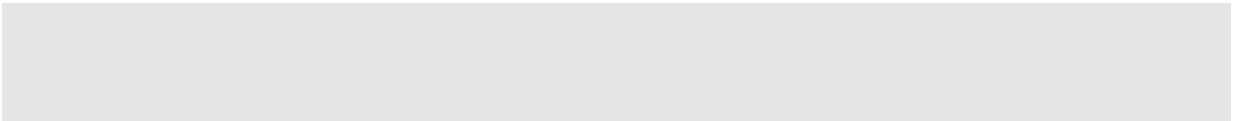
(See [CORE-13: Physical Rehabilitation](#) and [CORE-14: Functional Rehabilitation](#))

### **B-5. Problems with Wound Healing?**

#### BACKGROUND

Wound healing problems are usually multifactorial and are common in patients with amputation, especially those with vascular disease or diabetes. Risk factors for poor wound healing include infection, vascular compromise, tobacco use, metabolic derangement, underlying medical conditions, and the nature of the initial injury.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. Patients undergoing lower limb amputations should be assessed using a standardized approach like the one described in [Table 9. Categories of Wound Healing \(adapted from Smith, 2004\)](#). The depth and extent of involvement of the non-healing and nonviable skin, subcutaneous tissues, muscle, and/or bone will assist in the evaluation and treatment of problematic wounds.

**Table 9. Categories of Wound Healing (adapted from Smith, 2004)**

<b>Category I:</b>	<i>Primary</i> ; heal without open areas, infections or wound complications; no wound healing intervention required.
<b>Category II:</b>	<i>Secondary</i> ; small open areas that can be managed and ultimately healed with dressing strategies and wound care. Additional surgery is not required. May be possible to stay with the original plan with some portion of the wound intentionally left open.
<b>Category III:</b>	Skin and subcutaneous tissue involvement (no muscle or bone involvement); requires minor surgical revision.
<b>Category IV:</b>	Muscle or bone involvement; requires major surgical revision but heals at the initial amputation "level."
<b>Category V:</b>	Requires revision to a higher amputation level; for example, a transtibial amputation that must be revised to either a knee disarticulation or a transfemoral amputation.

**B-6. Consider Additional Interventions for Postoperative Wound Management as Needed**

BACKGROUND

Wound healing is often a problem in disvascular and diabetic and severely traumatized limbs. The exact treatment to facilitate the most rapid healing of the wound is often very difficult to ascertain. Prolonged attempts at conservative/non-operative interventions may prolong the patient's recovery and result in overall deconditioning, increased risk of medical comorbidities, and a reduced functional outcome. Sometimes early revision surgery facilitates the most rapid recovery.

RECOMMENDATIONS

1. Early revision surgery may be considered for wounds that are slow to heal, particularly in Category III, IV, and V wounds.
2. Early vascular evaluation may be considered for patients with delayed healing and consultation for vascular intervention may be considered for patients with impaired peripheral arterial blood flow.
3. Early evaluation and treatment for potential superficial and deep infections may be considered for patients with delayed healing. The evaluation may include wound cultures, laboratory studies, and radiological studies. Debridement, intravenous antibiotics, and/or revision may be necessary to achieve infection control.
4. Early aggressive local wound care should always be initiated for any degree of wound breakdown. This may include the use of topical agents (regranex, aquacel silver, panafil)
5. Hyperbaric oxygen can be considered as an adjunct treatment for impaired wound healing.

## **B-7. Is the Patient Medically Stable to be Discharged from Acute Care?**

### BACKGROUND

Medical stability is essential to a safe discharge and an optimal achievement of postoperative goals. Certain medical conditions must be met prior to proceeding to another level of care.

### RECOMMENDATIONS

1. Medical status should be assessed prior to proceeding to another level of care. The following criteria must be met prior to discharge to the next level of care:
  - a. Hemodynamically stable
  - b. Lack of systemic infection or an appropriate course of treatment in place
  - c. Stable surgical site
  - d. Acceptable bowel and bladder management
  - e. Comorbid conditions addressed.

## **B-8. Determine the Optimal Rehabilitation Environment and Update the Treatment Plan**

### BACKGROUND

Rehabilitation following amputation can occur in a variety of settings. Rehabilitation intervention will benefit both prosthetic and non-prosthetic candidates. Some patients will be best served in an outpatient environment, some may need an inpatient rehabilitation setting, and others may be best served in an intermediate- or long-term care facility. The following describes recommended interventions regardless of the location.

### ACTION STATEMENT

Determine the level of rehabilitation to be performed after discharge from the acute care setting.

Update the treatment plan to reflect the level of rehabilitation and the patient's disposition.

### RECOMMENDATIONS

1. Rehabilitative placement following a lower limb amputation should be based on the patient's medical status, current and anticipated function, ability to participate in rehabilitation interventions, social support system, and community resources.
2. To be discharged from acute care the patient's medical condition needs to be stable.
3. Patients are able to be discharged to home when:
  - Medically stable

- Able to be mobile and transfer with available social support systems utilizing appropriate assistive devices (walker, cane, wheelchair)
  - Able to perform basic daily living skills independently or have a social support system to compensate for the deficiencies
  - There is an accessible home environment
  - There is access to continued rehabilitation interventions as needed.
4. Patient who do not meet criteria for discharge to home may be referred to:
- a. Acute inpatient rehabilitation care when:
    - Able to follow a minimum of two-steps commands
    - Able to actively participate and benefit from at least two hours of therapy per day.
  - b. Sub-acute rehabilitation care or an extended nursing facility when:
    - Able to follow single step commands
    - Able to actively participate in less than two hours of therapy per day.
5. Patients not meeting the criteria for discharge to a rehabilitation program (e.g., they do not meet the above cited criteria and nursing care outweighs rehabilitation care) may be discharged to a program that is primarily focused on skilled nursing care when:
- a. Medically stable
  - b. Able to tolerate only a few hours of therapy per week.

## DISCUSSION

The determination for the rehabilitation level is made on clinical consensus guided by local practice and patient resources.

Medical stability for participation in an *acute inpatient* rehabilitative program requires the patient to be able to follow a minimum of two-step commands; have the capacity to acquire and retain new information; have no evidence of sepsis (temperature less than 100.5 degrees F) or ileus; tolerate feedings; have a stable cardiovascular status (hemoglobin greater than 8 mg/dl, blood pressure greater than 90/60 and less than 200/100, resting heart rate less than 115 at rest); and have the ability to tolerate more than 2 hours of therapy per day (tolerate sitting for at least 2 hours, fair sitting balance).

Medical stability for inclusion in a *sub-acute* rehabilitation program requires the patient to follow simple (single-step) commands; have the capacity to acquire and retain new information; have no evidence of sepsis or ileus; tolerate feedings; have a stable cardiovascular status; and have the ability to tolerate only one to two hours of therapy per day (tolerate sitting for 1 to 2 hours per day, fair sitting balance).

Medical stability for inclusion in a program that is primarily *skilled nursing care* requires the patient to have no evidence of sepsis or ileus; tolerate feedings; have a stable cardiovascular status; can tolerate only several hours of therapy per week; and is unable to function independently in a home environment (requires more nursing care than rehabilitation care).

Medical stability for discharge to a *home* environment requires that the patient is able to perform basic daily living skills safely and independently or have a social support system to compensate for the deficiencies and possibly the capacity to arrange transportation to an outpatient facility.

## **Module C: Pre-Prosthetic Rehabilitation**

### **Summary**

Algorithm C commences at the point that an adult patient has been discharged from the acute care setting after amputation surgery. Complete interdisciplinary assessments of the patient's medical, functional, and psychological status are performed. The patient will receive continued treatment to optimize their medical condition for rehabilitation. The rehabilitation team will educate the patient with details about postoperative care and rehabilitation services; they will also work together to set goals for rehabilitation. The pre-prosthetic phase includes continued control of edema formation by wrapping the stump and its shrinkage and shaping, as well as the continuation of physical and occupational therapy. This phase should take place in a facility equipped, staffed, and experienced in the rehabilitation of patients with amputations. If the patient is not a candidate for a prosthesis, the team will perform basic rehabilitation and provide durable medical equipment (DME).

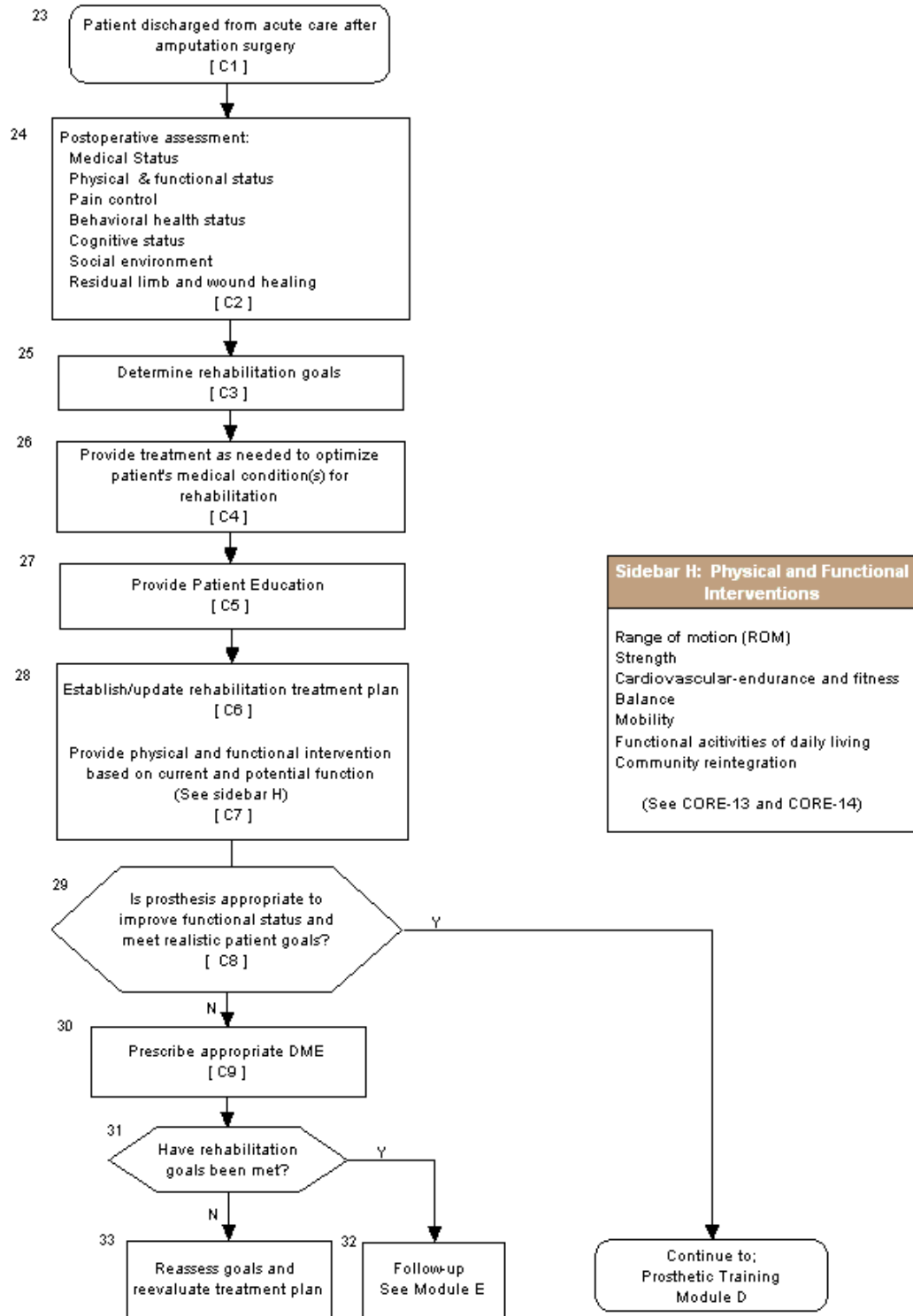
### **Table of Contents**

#### **Algorithm**

#### **Annotations**

- C-1: Patient Discharged From Acute Care after Amputation Surgery**
- C-2: Postoperative Assessment**
- C-3: Determine Rehabilitation Goals**
- C-4: Provide Treatment as Needed to Optimize the Patient's Medical Condition(s) for Rehabilitation**
- C-5: Provide Patient Education**
- C-6: Establish/Update the Rehabilitation Treatment Plan**
- C-7: Provide Physical and Functional Intervention Based on the Current and Potential Function**
- C-8: Is a Prosthesis Appropriate to Improve Functional Status and Meet Realistic Patient Goals?**
- C-9: Prescribe Appropriate Durable Medical Equipment (DME)**

VA/DoD Clinical Practice Guideline for  
Rehabilitation of Lower Limb Amputation  
Module C: Pre-Prosthetic Rehabilitation



Sidebar H: Physical and Functional Interventions
Range of motion (ROM)
Strength
Cardiovascular-endurance and fitness
Balance
Mobility
Functional activities of daily living
Community reintegration
(See CORE-13 and CORE-14)

4/16/2007



## Module C: ANNOTATIONS

### C-1. Patient Discharged from Acute Care after Amputation Surgery

#### DEFINITION

Patient is medically stable after an amputation surgery, discharged from acute care, and able to actively participate in rehabilitation.

#### DISCUSSION

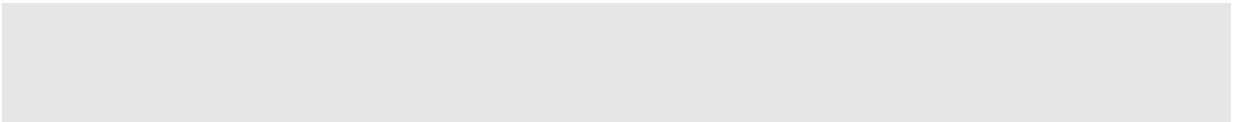
Module C applies to patients in a variety of settings. Some patients will be able to return home and be treated in an outpatient setting, while others might be admitted to a rehabilitation program.

### C-2. Postoperative Assessment

#### BACKGROUND

Multiple factors contribute to a successful outcome following amputation. Careful assessment of these factors is important and will contribute to formulating the rehabilitation goals and optimizing the patient's status for rehabilitation.

#### ACTION STATEMENT



#### RECOMMENDATIONS

1. A thorough medical assessment should be completed upon admission to rehabilitation to include: cardiovascular, pulmonary, endocrine, neurological, bowel and bladder, skin and musculoskeletal.
2. Special attention should be taken to assess the health of the contralateral leg and foot including vascular health, sensation, presence of deformity, abnormal skin or other tissue, and appropriate footwear.
3. Assess the healing of the wound by monitoring:
  - a. Wound closure
  - b. Drainage or seepage
  - c. Excessive redness or induration around the wound site
  - d. Temperature of the surrounding tissue
4. Involve the surgeon in problems with wound healing and wound management regardless of the patient's disposition.
5. Consult the specialized wound care team as needed.
6. Protect the residual limb from external trauma to reduce potential complications, delayed wound healing and encourage mobility.

7. Residual limb management should continue with the focus on control of edema, shaping the residual limb and control of the pain.  
(See [CORE-6: The Residual Limb](#))
8. Postoperative physical and functional assessment should be performed after amputation surgery and prior to postoperative rehabilitation. Include the following:
  - a. Patient history, including
    - Past medical history
    - Home environment
    - Premorbid functional level – activities of daily living (ADL), mobility, and cognition
    - Social environment (see [Core-9: Social Environment \[Support\]](#))
  - b. Physical assessment, including:
    - Range of motion (ROM) – bilateral hips, knees, and upper extremities
    - Strength – upper extremities and lower extremities
    - Sensation – involved limb and contralateral limb
    - Proprioception – involved limb and contralateral limb
    - Balance – sitting and standing
  - c. Functional assessment including:
    - Mobility – current level of function and use of assistive devices (bed, transfers, ambulation)
    - Basic ADLs – eating, grooming, toileting, bathing, and dressing
  - d. Screen for other impairments (e.g., vision and hearing, or other trauma)
9. Consider using standardized measures at admission and discharge to demonstrate progress and the efficacy of the rehabilitation process. The recommended tools for assessment include:
  - a. Amputee Mobility Predictor (AMP)
  - b. Functional Independence Measure (FIM)
  - c. Two-Minute Walk
  - d. Timed Up and Go Test (TUG)
  - e. Upper Extremity Ergometry(See [CORE-14.2: Mobility and Equipment](#))
10. Pain assessment should be performed by all members of the rehabilitation team.
11. Patients should be assessed for pain and treatment should be based on etiology and initiated/continued to optimize rehabilitation.

12. Consider prophylactic pain management prior to the rehabilitation session.  
(See [CORE-3: Pain Management](#))
13. A psychological assessment should be completed if not done preoperatively.
14. Continuous monitoring of behavioral health should be performed by all members of the rehabilitation team.  
(See [CORE-8: Behavioral Health Assessment and Treatment](#))
15. A postoperative cognitive/neuropsychological assessment should be conducted if not completed preoperatively.  
(See [CORE-5: Cognitive Assessment](#))

## DISCUSSION

The medical status of the person will impact their rehabilitation outcomes. A careful evaluation of the medical condition with particular attention to the health of the residual limb is critical.

Wound healing should have reached or be progressing toward primary closure. If closure has not been achieved, continued active management will be required. The surgeon should remain involved and a specialized wound care team may be consulted. The residual limb needs continued management and protection to enhance progress and prevent complications.

Obtaining baseline information about physical condition and functional status is important to evaluate the efficiency of rehabilitation interventions. The use of objective, validated measuring tools allows standardized measurement of outcomes and progress.

The etiology of pain is likely to remain multifactorial. Phantom and residual limb pain may persist for an extended period. Other sources of pain should also be identified in order to facilitate aggressive treatment. Pain can be a barrier to the patient's participation in rehabilitation.

Prevalence of psychiatric comorbidities, particularly depressive and anxiety disorders, is fairly high during the first two years post surgery. They appear to decline thereafter to general population norms (Desmond & MacLachlan, 2004; Horgan & MacLachlan, 2004). Depressive and anxiety disorders often respond well to both medical and psychotherapeutic interventions (see the [VA/DoD Clinical Practice Guidelines for the Management of Major Depressive Disorder in Adults \[2000\]](#) & the [Management of Post-Traumatic Stress Disorders \[2003\]](#)). If untreated, psychosocial comorbidities may diminish treatment outcomes. If not done preoperatively, a postoperative psychological assessment creates a baseline to utilize during rehabilitation.

Cognitive function influences an individual's ability to learn new material which is important for participation in the rehabilitation process and the successful use of a new prosthesis, DME, or assistive devices, and the ability to successfully function in the ultimate discharge environment.

### **C-3. Determine Rehabilitation Goals**

#### BACKGROUND

Rehabilitation goals are established by the interdisciplinary rehabilitation team including the patient and family. Early establishment of goals helps to increase the patient's involvement in his/her plan of care. Each team member uses the goals to guide the treatment plan.

Goals provide a way to measure the patient's progress and the final outcome of the care provided. It is important for the patient to provide input to increase motivation and involvement in the rehabilitation process. The team must be sensitive to the needs and desires of the patient and work closely to develop realistic goals.

#### ACTION STATEMENT

Establish rehabilitation goals at the beginning of the rehabilitation process involving members of the rehabilitation team and the patient, to guide the treatment.

#### RECOMMENDATIONS

1. Members of the rehabilitation team should work with the patient to establish goals specific to their area of expertise.
2. Goals should be written, be measurable, and be specific.

### **C-4. Provide Treatment as Needed to Optimize the Patient's Medical Condition(s) for Rehabilitation**

#### BACKGROUND

Multiple factors influence the patient's ability to resist infection, heal their surgical wounds, and prepare for full rehabilitation. When possible, every effort should be made to correct controllable factors prior to undertaking surgical amputation. Following surgery, efforts should be directed at continual management of reversible medical comorbidities including but not limited to: metabolic, nutritional, psychiatric, and vascular.

#### ACTION STATEMENT

Optimize medical status before, as well as during, pre-prosthetic rehabilitation.

#### RECOMMENDATIONS

1. The following conditions, if present, require aggressive management:
  - a. Hyperglycemia
  - b. Cardiac, respiratory, renal, and metabolic
  - c. Nutritional deficiency
  - d. Major psychiatric illness
  - e. Vascular lesions.

(See [CORE-4: Medical Care](#))

### **C-5. Provide Patient Education**

#### BACKGROUND

In the postoperative phase patient education will change in focus from acute medical issues to learning needs to optimize function in the community and self-management. Information sharing, skills development in the area of self management, treatment procedures, new equipment, and recognition of the timeline for progression towards independent function are essential components of this phase.

#### ACTION STATEMENT

Provide in-depth patient education regarding the various components of postoperative care and anticipated rehabilitation activities.

#### RECOMMENDATIONS

1. During the pre-prosthetic rehabilitation phase the following should be covered with the patient:
  - a. Positioning
  - b. Rehabilitation process
  - c. Pain control
  - d. Residual limb care
  - e. Prosthetic timeline
  - f. Equipment needs
  - g. Coping methods
  - h. Prevention of complications
  - i. Safety and fall prevention (essential).

(See [CORE-11: Patient Education](#))

### **C-6. Establish/Update the Rehabilitation Treatment Plan**

#### BACKGROUND

The treatment plan is initially developed pre-operatively and is updated and changed throughout rehabilitation based on evaluation by all specialties involved in the rehabilitation process. Rehabilitation care is driven by identified, individualized, patient-centered goals; these goals are delineated in the comprehensive treatment plan.

(see [CORE-2: Rehabilitation Treatment Plan](#)).

ACTION STATEMENT

Update the rehabilitation treatment plan to reflect the patient's progress, goals, and needs.

RECOMMENDATIONS

1. Rehabilitation goals should be documented in the treatment plan.
2. The treatment plan should be updated by the rehabilitation team to reflect changes in the patient's status.

(See [CORE-2: Rehabilitation Treatment Plan](#))

**C-7. Provide Physical and Functional Intervention Based on Current and Potential Function**

BACKGROUND

The following areas of intervention include a suggested *step approach*, indicating the key elements in each area as they progress throughout the rehabilitation process.

ACTION STATEMENT

Initiate, assess, and adjust the rehabilitation interventions to improve the patient's physical and functional status.

RECOMMENDATIONS

1. Provide physical and functional rehabilitation interventions in the following:
  - a. Residual limb management (teach care of the residual limb and the use of ACE wrap and shrinkers)
  - b. Range of motion (ROM) (residual and contralateral limbs at the hip and knee)
  - c. Strengthening (add trunk and core stabilization exercises; initiate a home exercise program)
  - d. Cardiovascular endurance (tailored to patient's fitness level and progressed as tolerated)
  - e. Balance (progress program to dynamic balance training).

(See [CORE-13: Physical Rehabilitation](#) and [CORE-14: Functional Rehabilitation](#))
2. Provide interventions to evaluate and promote community reintegration:
  - a. Home evaluation and modification
  - b. Mobility (progress single limb gait from the parallel bars to the use of an appropriate assistive device)
  - c. Equipment (independent wheelchair mobility)
  - d. Functional activities and activities of daily living (ADL)

- e. Driver's training and vehicle adaptation
- f. Vocational rehabilitation or return to school
- g. Recreation activities without a prosthesis.

(See [CORE-14: Functional Rehabilitation](#))

### **C-8. Is a Prosthesis Appropriate to Improve Functional Status and Meet Realistic Patient Goals?**

#### BACKGROUND

Patients with a lower limb amputation will vary in their potential to benefit from use of a prosthesis. The most fundamental question when developing a prosthetic prescription for a patient is their need for a prosthesis and the *patient's ability to adapt to and utilize the prosthesis*.

#### ACTION STATEMENT

Determine if the patient is a candidate for a prosthesis.

#### RECOMMENDATIONS

1. Patient's candidacy for a prosthesis should be determined by the rehabilitation team based on the patient's characteristics, goals, and an objective evaluation of their functional status. Some areas to be considered:
  - a. Patient is willing and motivated to move forward for prosthetic rehabilitation
  - b. Patient has the ability to understand and apply knowledge to the fitting and use of a prosthesis
  - c. Contralateral limb will tolerate weight bearing
  - d. Patient is in adequate physical condition to tolerate walking with a prosthesis
  - e. Prosthesis contributes to quality of life or self image.

#### DISCUSSION

The rehabilitation team should initiate discussions about a possible prosthesis in the preoperative phase. It is important to understand the goal of the patient when making this decision and consider the contribution of the prosthesis to the individual potential function and quality of life.

### **C-9. Prescribe Appropriate Durable Medical Equipment (DME)**

#### BACKGROUND

Patients after amputation will need to develop new ways to perform various activities in their daily lives. Patients who have not been deemed candidates for prosthetic prescription will also need DME to maximize their functional status. If the

patient has reached a plateau in their functional status, additional durable medical equipment may be required to assist these patients in their daily activities.

#### ACTION STATEMENT

Provide durable medical equipment (DME) prescription (e.g., wheelchair, walker, crutches, shower chairs).

#### RECOMMENDATIONS

1. Additional equipment to facilitate mobility and activities of daily living (ADL) is required for a patient with a lower extremity amputation.
2. The type of equipment should be based on the current and anticipated functional status.

#### DISCUSSION

Home modifications are required for individuals who have difficulty with transfers or stairs as well as modifications to accommodate wheelchairs. Modifications may include the installation of ramps, stair lifts, grab bars, handheld showers, mechanical lifts, bedside commodes, tub transfer benches, tub seats or benches, and shower seats or benches. Usage of durable medical equipment requires training for the individual to gain maximum benefit. For example, manual wheelchair skills such as wheelie's, curb climbing, curb-descent, ramps and uneven terrain should be mastered.



## Module D: Prosthetic Training

### Summary

Module D, Prosthetic Training, follows the pre-prosthetic rehabilitation phase. The patient and team will determine if the patient is a candidate for a prosthesis and if so, will write a prosthetic prescription and perform basic rehabilitation, prosthetic management, and gait training based on the identified goals. If the patient is not a candidate for a prosthesis, the team will perform basic rehabilitation and provide durable medical equipment (DME). The prosthetic phase aims at the attainment of maximal functional independence and mobility with the artificial limb. It includes prosthetic fitting and intensive gait training interventions to reduce the occurrence of phantom pain, and improve long-term outcomes, including returning to work. During this phase, patients are given advice on employment, recreational activity, driving, and vocational rehabilitation. The continuation of care at the community level should be promoted and arranged.

### Table of Contents

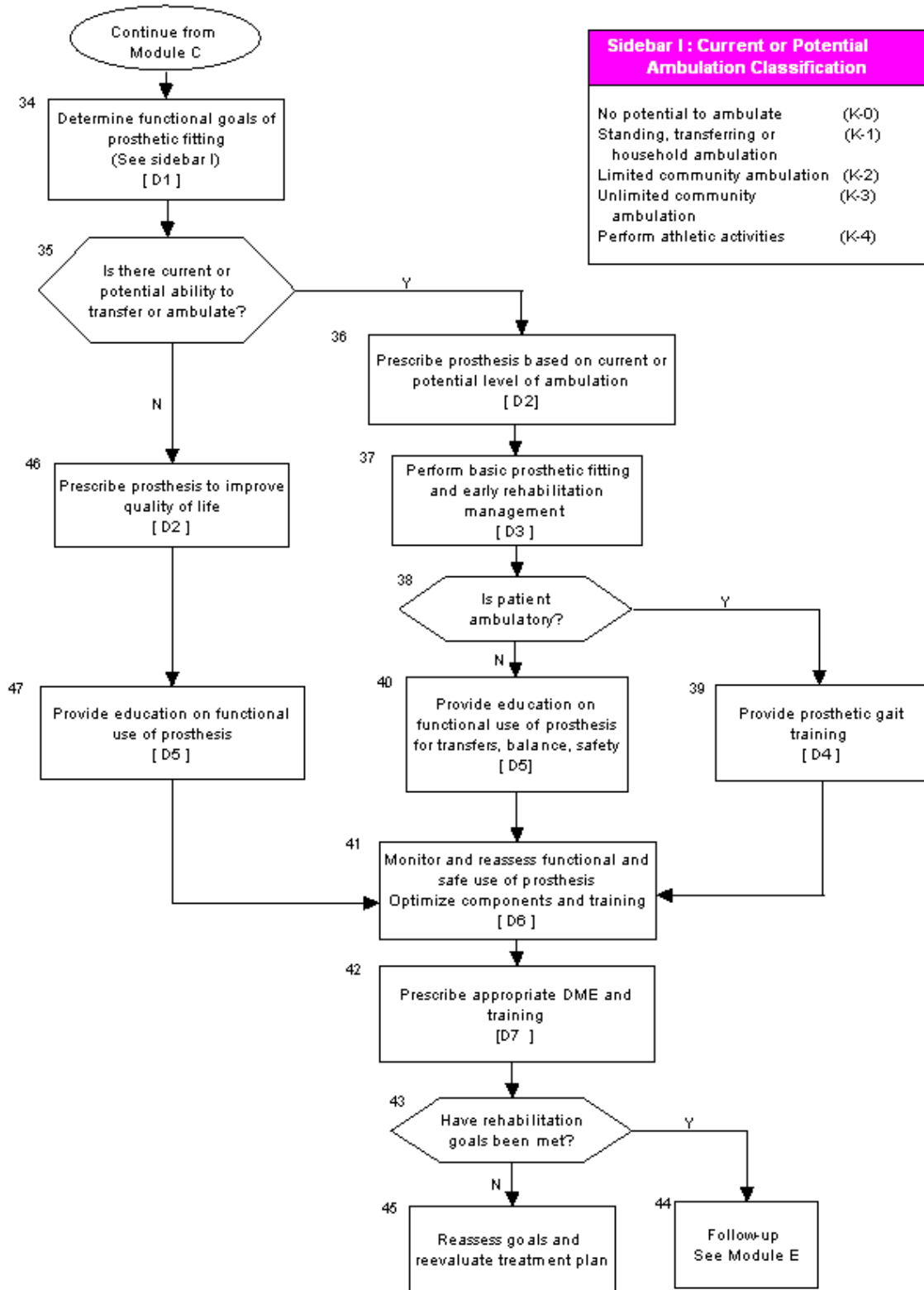
#### Algorithm

#### Annotations

- D-1: Determine Functional Goals of Prosthetic Fitting**
- D-2: Prescribe the Prosthesis Based on the Current or Potential Level of Ambulation**
- D-3: Perform Basic Prosthetic Fitting and Early Rehabilitation Management**
- D-4: Provide Prosthetic Gait Training**
- D-5: Provide Education on Functional Use of the Prosthesis for Transfers, Balance, and Safety**
- D-6: Monitor and Reassess Functional and Safe Use of the Prosthesis; Optimize Components and Training**
- D-7: Prescribe Appropriate Durable Medical Equipment (DME) and Training**

**VA/DoD Clinical Practice Guideline for  
Rehabilitation of Lower Limb Amputation  
Module D: Prosthetic Training**

**D**



Sidebar I: Current or Potential Ambulation Classification	
No potential to ambulate	(K-0)
Standing, transferring or household ambulation	(K-1)
Limited community ambulation	(K-2)
Unlimited community ambulation	(K-3)
Perform athletic activities	(K-4)

**Module D: ANNOTATIONS**

**D-1. Determine Functional Goals of Prosthetic Fitting**

BACKGROUND

A patient with a lower limb amputation will have wide ranging personal, social, and professional demands. Their ability to meet these demands will be mediated by several factors, including residual limb characteristics, overall health, fitness, and other medical conditions. Based upon these factors, a best estimate of future activities needs to be made so that the patient may get the most appropriate prosthetic prescription.

The Centers for Medicare and Medicaid Services (CMS), formerly known as Health Care Financing Administration (HCFA), requires a determination of functional level with certificates of medical necessity for a prosthesis. These are known as “K” levels (see [Table 10. Centers for Medicare and Medicaid Services Functional Levels](#)).

**Table 10. Centers for Medicare and Medicaid Services Functional Levels**

Level of Function	Description of Ambulation Level
<b>K 0:</b>	The patient does not have the ability or potential to ambulate or transfer safely with or without assistance and the prosthesis does not enhance his/her quality of life or mobility.
<b>K 1:</b>	The patient has the ability or potential to use the prosthesis for transfers or ambulation on level surfaces at fixed cadence - typical of the limited and unlimited household ambulator.
<b>K 2:</b>	The patient has the ability or potential for ambulation with the ability to traverse low-level environmental barriers such as curbs, stairs, or uneven surfaces - typical of the limited community ambulator.
<b>K 3:</b>	The patient has the ability or potential for ambulation with variable cadence - typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion.
<b>K 4:</b>	The patient has the ability or potential for prosthetic ambulation that exceeds basic ambulation skills, exhibiting high impact, stress, or energy levels - typical of the prosthetic demands of the child, active adult, or athlete.

ACTION STATEMENT

Determine current and prospective functional needs of the patient.

## RECOMMENDATIONS

1. Patients at K level "0" are not recommended for prostheses for ambulation or transfers.
2. Patients at K level "1" are recommended for prostheses that meet the functional goals of limited and unlimited household ambulation.
3. Patients at K level "2" are recommended for prostheses that meet the functional goals of limited community ambulation.
4. Patients at K level "3" are recommended for prostheses as community ambulators with the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion.
5. Patients at K level "4" are recommended for prostheses at the highest level of functioning typical of the child, active adult, or athlete.
6. Prosthetic fittings typically should not begin until the suture line has completely healed, although in unusual circumstances prosthetic fitting and limited ambulation may start with a clean non-infected wound with granulation tissue.

## DISCUSSION

Prostheses are described at this phase as either preparatory (preliminary) or definitive. The preparatory prosthesis is fitted while the residual limb is still remodeling. This allows the patient to commence the rehabilitation program of donning and doffing, transfer training, building wear tolerance, improving balance, and ambulating with the prosthesis several weeks earlier. A preparatory prosthesis often allows a better fit in the final prosthesis as the preparatory socket can be used to decrease edema and shape the residual limb.

### **D-2. Prescribe the Prosthesis Based on the Current or Potential Level of Ambulation**

#### BACKGROUND

The final prescription must come from the Amputation Clinic Team. Hip-disarticulation, transpelvic, and translumbar amputations are not addressed here; they are deferred to the knowledge and expertise of the Amputation Clinic Team.

#### RECOMMENDATIONS

1. The prescription for a patient with a transmetatarsal amputation should include:
  - a. Toe filler/arch support
  - b. Custom/prefabricated Ankle-foot orthosis (AFO) with toe filler:
  - c. Assessment adequate shoe fit
2. The prescription for a patient with a transtibial/transfemoral amputation should include:
  - a. Socket
  - b. Socket interface

- c. Suspension mechanism
- d. Pylon
- e. Knee joint
- f. Foot/ankle.

(See [Appendix C](#) for a listing of specifications.)

### **D-3. Perform Basic Prosthetic Fitting and Early Rehabilitation Management**

#### BACKGROUND

The socket design prescribed for the prosthesis requires anthropometric measurements and possibly a negative impression or digital image of the residual limb. The (test) diagnostic socket is the first step in fabricating a prosthetic socket. This is a clear plastic material that allows direct visualization of the residual limb and assessment of mechanical loading of the residual limb. It can be applied directly to the residual limb without a foot/pylon system, or it can be used with a foot pylon system to establish a preliminary alignment. The assembled static prosthetic system is fit to the patient and dynamically aligned during the initial gait training phase by the physiatrist and prosthetist. Throughout the gait training phase, the prosthetic prescription is evaluated and either validated or modified.

An individual with a lower extremity amputation must bear full body weight on soft tissues not designed for that function. The socket must be designed such that these forces are distributed as much as possible and as evenly as possible over pressure-tolerant areas. These include the patellar tendon, the pretibial muscles, the residual posterior muscles, the medial flare of the tibia, and the lateral fibula. The presence of ongoing pain, skin breakdown, change in the ability to don and doff the prosthesis, and change in the number of sock plies indicates that the prosthesis needs to be modified. Erythema normally appears within a few minutes after removing the prosthesis and should fade quickly. Erythema that is present upon removing the prosthesis or that does not completely resolve within 20 minutes is of concern and need to be evaluated.

#### ACTION STATEMENT

Fabricate, dynamically align, adjust, and modify the prosthesis, and instruct the patient on the use of a prosthesis when appropriate.

#### RECOMMENDATIONS

1. Initiate physical and functional interventions for prosthetic training as appropriate for the patient's functional goals:
  - a. Residual limb management (donning and doffing of prosthesis, gel liners or socks as appropriate)
  - b. Range of motion (ROM)
  - c. Strengthening
  - d. Cardiovascular fitness and endurance

- e. Balance
  - f. Mobility
  - g. Functional activities and activities of daily living (ADL)
  - h. Equipment
  - i. Driver's training
  - j. Home evaluation
  - k. Home exercise program
  - l. Community integration.
2. A two-phase process may be considered for prosthetic fitting and training:
    - a. Phase One: Preparatory (preliminary) prosthesis
    - b. Phase Two: Definitive prosthesis.
  3. If only a definitive prosthetic is to be fitted, the fitting for the socket should be delayed until the residual limb is fully mature (usually three to four months) or until general stabilization occurs in the patient's weight and residual limb volume.

#### **D-4. Provide Prosthetic Gait Training**

##### BACKGROUND

Patients after amputation have altered balance and need assistance re-learning ambulation and mobility skills with the prosthesis. Prosthetic gait training is necessary to maximize the quality of the gait, to conserve energy, and provide the patient with the opportunity to resume his/her previous social roles.

##### ACTION STATEMENT

Prosthetic gait training must be performed for the patient to safely ambulate on all surfaces with or without adaptive equipment.

##### RECOMMENDATIONS

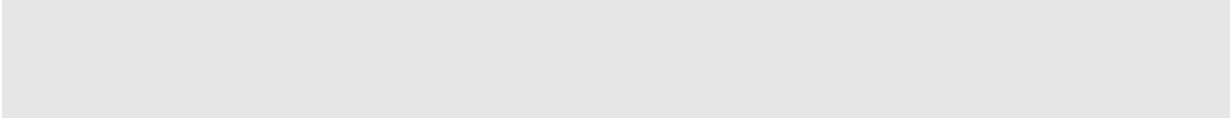
1. Once basic prosthetic management has been completed, the focus should move to weight bearing with the prosthesis, standing balance, weight shifts, and equalization of step length.
2. Once the patient has mastered prosthetic ambulation with a walker or other assistive device, training on stairs, uneven surfaces, and ramps/inclines are recommended.
3. Prosthetic gait training should incorporate aspects related to the patient's home, work, and/or recreational environments.

**D-5. Provide Education on Functional Use of the Prosthesis for Transfers, Balance, and Safety**

BACKGROUND

The use of the prosthesis to facilitate transfers in a non-ambulatory patient may be appropriate. However, for non-ambulatory patients with a lower limb amputation, a cosmetic or passive prosthesis may enable the patient to maximize their function postoperatively by restoring body image and self-confidence.

ACTION STATEMENT



RECOMMENDATIONS

1. Initial patient education in the use of a prosthetic lower limb should include:
  - a. Demonstration and training in donning and doffing the prosthesis (dependent upon the type of prosthesis provided)
  - b. Initial training in how to start ambulation (dependent upon the type of prosthesis provided)
  - c. Instruction in accomplishing safe transfers taking in consideration the home environment
  - d. Instruction in how to fall safely and get back up
  - e. Instruction in daily self inspections of the residual limb for excessive tissue loading; if erythema is present upon removing the prosthesis and does not completely resolve in 20 minutes, the patient should be instructed to report it immediately
  - f. Basic residual limb and prosthetic hygiene.
2. If appropriate, the patient's caregiver should also be instructed in management and care of the prosthesis, proper transfer technique and safety.

**D-6. Monitor and Reassess Functional and Safe Use of the Prosthesis; Optimize Components and Training**

BACKGROUND

The daily use of the prosthesis may have an effect on the patient's activity level and their ability to perform various activities of daily living. The prosthesis does not have to be used all the time; a functional user may use the prosthesis for part of the day or only for certain functions, such as to facilitate a transfer. This may change with time and need reevaluation by the rehabilitation team.

ACTION STATEMENT



components and training at least throughout the first year post fitting.

#### RECOMMENDATIONS

1. Patients who were not prosthetic candidates or candidates for a transfer prosthesis should be evaluated periodically to determine if their functional goals may be expanded to include ambulation.
2. Patients with a prosthesis should be advised to report any of the following symptoms as they are signs that the prosthesis needs to be modified:
  - a. Ongoing pain
  - b. Skin breakdown
  - c. Change in the ability to don and doff the prosthesis
  - d. Change in the number of sock plies
  - e. Change in the pattern of usage
  - f. Change in functional needs or goals.
3. The prosthesis should be assessed at least once within the first year of prosthetic use to address:
  - a. Stability
  - b. Ease of movement
  - c. Energy efficiency
  - d. Appearance of the gait to determine the success of fitting and training.
4. Patients presenting with dermatologic problems require assessment and intervention:
  - a. Contact dermatitis: assess the hygiene of the liner, socks, and suspension mechanism
  - b. Cysts and sweating: assess for excessive shear forces and improperly fitted components
  - c. Scar management: requires massaging and lubricating the scar to obtain a well-healed result without dog ears or adhesions
  - d. Superficial fungal infections are common and will require topical anti-fungal agents for resolution.

### **D-7. Prescribe Appropriate Durable Medical Equipment (DME) and Training**

#### BACKGROUND

Patients after amputation will need to develop new ways to perform various activities in their daily lives. To this end, a prosthetic limb alone may not be enough to allow the patient to fully return to daily activities. Patients who have not been deemed candidates for prosthetic prescription will also need DME to maximize their functional status. If the patient has reached a plateau in their functional status, additional DME may be required to assist these patients in their daily activities.



#### ACTION STATEMENT

Consider durable medical equipment (DME) prescription (e.g., wheelchair, walker, cane, crutches, shower chairs).

#### RECOMMENDATIONS

1. Additional equipment to facilitate mobility and activities of daily living (ADL) should be provided after lower extremity amputation with or without a prosthesis.
2. The type of equipment should be based on the current and anticipated functional status.

#### DISCUSSION

In order to provide functional mobility in a variety of environments, participating in different activities, and during times of repair of lower limb prostheses, additional equipment is needed for mobility. DME includes such items as manual or power wheelchairs, crutches (auxillary, forearm), and canes .

Bilateral lower limb amputations necessitate a manual or power wheelchair for mobility, regardless of the status of the prostheses, due to the increased energy expenditure and decreased likelihood of ambulation with bilateral lower limb amputations.

Complicated unilateral lower limb amputations may require the use of assistive devices for mobility (to include a wheelchair), if a compromised contralateral limb or compromised cardiovascular status prevents using the prosthesis to its full potential.

Uncomplicated unilateral lower limb amputations require an appropriate assistive device if necessary or for use during periods of limb changes, pain, changes in prosthesis or fit, or skin breakdown.

Home modifications are required for individuals who have not been issued a prosthesis or have difficulty with transfers or stairs. Modifications may include the installation of ramps, stair lifts, grab bars, handheld showers, mechanical lifts, bedside commodes, tub transfer benches, tub seats or benches, and shower seats or benches. Usage of durable medical equipment requires training for the individual to gain maximum benefit. For example, manual wheelchair skills such as wheelie's, curb climbing, curb-descent, ramps and uneven terrain should be mastered.

## **Module E: Rehabilitation and Prosthesis Follow-Up**

### **Summary**

Algorithm E commences at the point that the initial rehabilitation goals have been met with or without a prosthesis. The patient schedules at least one appointment within the first year after discharge to assess the prosthetic fit and function (in prosthetic users), need for DME, goals, and health status. Treatment is provided as needed to optimize health and functional status; meet new goals; provide, replace, or repair DME; and prevent a secondary amputation.

Life-long care will be provided to monitor risk factors for chronic diseases or psychosocial illnesses.

### **Table of Contents**

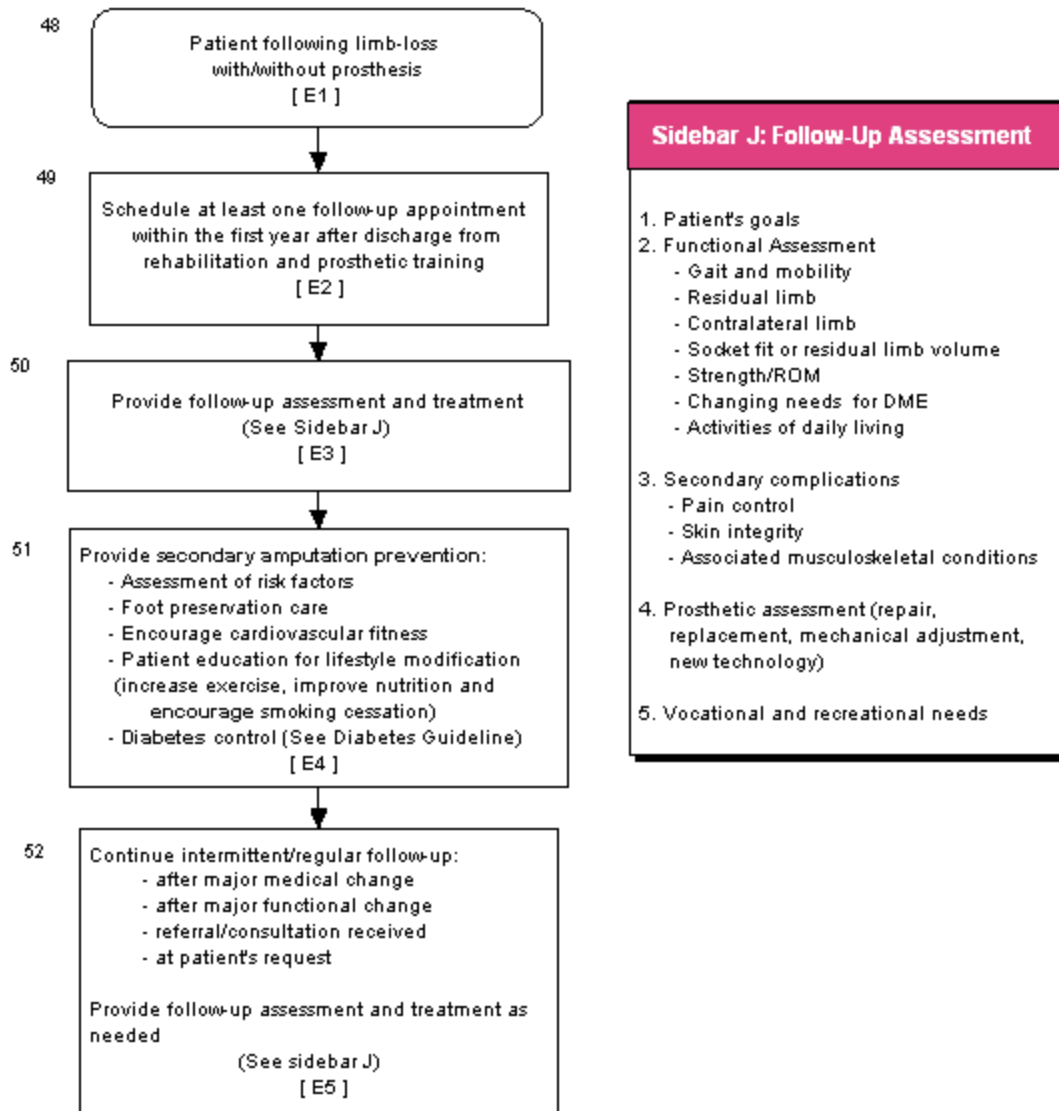
#### **Algorithm**

#### **Annotations:**

- E-1: Patient Following Limb-Loss With or Without Prosthesis**
- E-2: Schedule At Least One Follow-up Appointment within the First Year after Discharge From Rehabilitation and Prosthetic Training**
- E-3: Provide Follow-Up Assessment and Treatment**
- E-4: Provide Secondary Amputation Prevention**
- E-5: Continue Follow-Up as Needed**

VA/DoD Clinical Practice Guideline for  
Rehabilitation of Lower Limb Amputation  
Module E: Rehabilitation and Prosthesis Follow-up

**E**



4/16/2007

## Module E: ANNOTATIONS

### E-1. Patient Following Limb-Loss With or Without Prosthesis

#### BACKGROUND

Follow-up for all patients with amputations is needed to ensure continued optimal function in the home and community. The long-term follow-up will be a dynamic process, as the patient's needs may change with time. Reassessment of the available advancements in medical science and prosthetic technology will continue for the patient's lifetime.

#### DEFINITION

The follow-up algorithm applies to a patient with limb-loss who has achieved maximal functional potential with or without a prosthesis. The patient may begin long-term follow-up when the following goals are met:

- Prosthetic fit is appropriate
- Patient incorporated the prosthesis into his/her lifestyle and is satisfied with the outcome
- Patient function is maximized per the goals set up at the initial rehabilitation process.

### E-2. Schedule At Least One Follow-Up Appointment Within the First Year after Discharge From Rehabilitation and Prosthetic Training

#### BACKGROUND

There are many reasons to justify at least one follow-up appointment, including:

- Patients with amputations are at risk for secondary complications in the residual and contralateral limb as well as the upper extremities
- Patients with dysvascular amputations are at risk of losing the contralateral limb
- The residual limb of a patient with an amputation will change over the life of the patient
- The prosthesis must be updated to meet those changes
- A prosthesis has a limited life expectancy and needs to be evaluated on a regular basis
- As a patient's function changes, the prosthesis needs to match the ability of the user
- As technology changes, the prosthetic user may benefit from these advances.

#### ACTION STATEMENT

All patients with amputations should have at least one scheduled follow-up appointment, within the first year after discharge, to evaluate the quality and comfort of the prosthetic fit and the patient's health status and function.

#### RECOMMENDATIONS

1. Patients with a prosthesis should visit the Amputation Clinic Team for an initial comprehensive visit to address any change in the condition of the residual limb.
2. Patients with minor repairs or adjustments to the prosthesis should visit a prosthetic laboratory.
3. Patients with a change in their medical condition should be seen by a primary care provider or physiatrist, in addition to their comprehensive follow-up with the Amputation Clinic Team.
4. A follow-up appointment should be made at the time of the comprehensive visit with the appropriate clinic or provided at the patient's request, after a major medical or functional change, or after a referral/consultation is received.
5. Patients with a lower limb amputation who are not prosthetic users should be seen by their primary care provider to manage comorbidities, evaluate medical risks, and maintain the health of the residual and contralateral extremity.
6. If the function of a non-prosthetic user changes and he/she becomes a prosthetic candidate, an appointment should be made with the Amputation Clinic Team for consideration of prosthetic restoration.

#### DISCUSSION

Without scheduled follow-ups, patients with amputations may become lost in the system and may develop problems. They may not recognize problems with the fit of their prosthesis, a change in their gait pattern, or changes in their contralateral or residual limb. As a result, major or minor secondary complications may arise.

In addition, the level of independent walking decreases with the passage of time; one third of persons who were young at the time of amputation and were successfully rehabilitated may have limitations in mobility in later life. Reevaluations should be conducted to assess the need for modification of the prosthesis more appropriate to the patient's new functional status (Burger et al., 1997).

Modification of the prosthesis as well as adaptations to the home environment should be assessed by the rehabilitation team to help the patient maintain the highest possible level of independence and psychosocial integration throughout the lifespan.

### E-3. Provide Follow-Up Assessment and Treatment

#### BACKGROUND

A follow-up assessment provides the best information to recognize changes and associated needs and minimize the risk of complications. The residual limb is dynamic and its shape will change over the life of the patient. As a result, function may be affected and the prosthesis may need to be adapted. Non-prosthetic users may also have a change in function and must be assessed to determine the medical and rehabilitative management that will provide the best quality of life.

#### ACTION STATEMENT

The long-term follow-up should include assessment of the patient's goals, function, secondary complications, and the condition of the prosthesis. Treatment should also be provided as indicated.

#### RECOMMENDATIONS

1. The follow-up assessment for a prosthetic user should include:
  - a. Patient's goals (i.e., new recreation, vocation, or community requirements)
  - b. Functional assessment:
    - Gait and mobility
    - Residual limb health
    - Contralateral limb
    - Socket fit or residual limb volume
    - Strength and range of motion (ROM)
    - Changing needs for durable medical equipment (DME)
    - Activities of daily living (ADL)
  - c. Secondary complications as a result of prosthetic use:
    - Pain control
    - Skin integrity
    - Associated musculoskeletal conditions (e.g., back pain and knee pain).
  - d. Prosthetic assessment (repair, replacement, mechanical adjustment, new technology)
  - e. Vocational and recreational needs.
2. The follow-up assessment for a non-prosthetic user should include:
  - a. Patient's goals
  - b. Functional assessment
    - Residual limb health
    - Range of motion (ROM)

- Strength
  - Gait and mobility
  - Changing needs for durable medical equipment (DME)
  - Activities of daily living (ADL)
- c. Secondary complications in the residual and contralateral limb:
- Pain control
  - Skin integrity
  - Associated musculoskeletal conditions (e.g., back and knee pain)
- d. Vocational and recreational needs.

#### **E-4. Provide Secondary Amputation Prevention**

##### BACKGROUND

The key to amputation prevention in non-traumatic amputations is to identify high-risk patients, make an early diagnosis, and provide interdisciplinary intervention. This process should ideally begin in the office of the primary care provider. Risk factors affecting the residual and contralateral limbs should be identified. Then, a strategy of patient education, patient self-care, and referral to foot care providers are instituted to prevent foot ulceration, infection, gangrene, and ultimately amputation.

The VA program titled, “Prevention-Amputation Care and Treatment” (PACT) focuses on prevention of amputation by identifying veterans who are at risk and providing them with education and appropriate footwear.

Cardiovascular fitness is an important component to maintain the increased metabolic expenditure of ambulation.

##### ACTION STATEMENT

Identify high-risk patients and provide patient education to minimize the potential for secondary amputation.

##### RECOMMENDATIONS

1. Long-term follow-up should include an assessment and management of risk factors for secondary amputation including: peripheral vascular disease, diabetes, peripheral neuropathy or nerve injury, skin integrity, foreign bodies, bony deformities including heterotopic ossification, and a history of foot ulcers.
2. For the patient with vascular disease or diabetes, long-term follow-up should include appropriate foot care and patient education at every patient visit (see the [VA/DoD Clinical Practice Guideline for Diabetes Mellitus](#) - Module F: Foot Care).
3. Patients identified to be at risk for limb-loss should be referred to an appropriate specialist.

4. Encourage cardiovascular fitness to compensate for the increased metabolic cost of ambulation post-amputation.
5. Provide patient and family education regarding risk-modification to encourage a healthy lifestyle through increased exercise, improved nutrition, and smoking cessation (see [Appendix D: Foot Care Interventions for Patients with Amputation](#)).

## E-5. Continue Follow-Up as Needed

### BACKGROUND

Given the importance of optimal socket fit, the patient must also be monitored for volumetric and anatomical changes, alignment adjustments, component replacement and continuing education. The patient may be referred to the Amputation Clinic Team for rehabilitation concerns and evaluation, secondary complications, other medical issues, socket replacement or prosthesis replacement, upgrades, and recreational prostheses.

A life-long consultation to other healthcare providers regarding the interaction between other disease processes and the function of patients with a lower limb amputation may be required.

### ACTION STATEMENT

A patient with a lower limb amputation should receive life-long care to maintain the quality and functionality of the prosthetic limb and the patient's abilities, goals, and quality of life.

### RECOMMENDATIONS

1. Intermittent/regular follow-up should be provided to assess the patient's current needs, abilities, and goals.
2. Life-long care should include monitoring the patient for psychosocial adjustment, skin disorders of the residual limb, pain, musculoskeletal impairments, cardiovascular disease, other chronic diseases, and the health of the contralateral limb and provision of appropriate foot wear for the contralateral foot.
3. A follow-up appointment should also be provided at the patient's request, after a major medical or functional change, or after a referral/consultation is received.
4. For the prosthetic user, life-long care should also include surveillance for and management of secondary impairments associated with limb-loss; i.e., cardiovascular disease, accelerated degenerative joint disease of other joints, functional losses due to aging, and complications of prosthetic use.
5. For the prosthetic user, new technology should be considered but must be matched to the patient's function and goals, and followed with an additional period of gait training to help the patient learn to use new components. The latest technology is not always the best choice for the patient.



## DISCUSSION

There are no clinical trials that provide evidence for the need for life-long care. Patients need to have access to primary care and an amputation team, but there is no evidence to indicate how often that follow-up should occur. However, as a patient's age advances follow-up visits to assess and modify the prosthesis become important due to changes that occur in a patient with an amputation in the aging process (Frieden, 2005).

Patients with amputations are not exempt from acquired chronic diseases and loss of social support associated with aging. Their ability to adapt may be limited and as a result, a minor problem may have a tremendous impact on their function (Flood & Saliman, 2002). For example, a significant relationship has been found between combat-related amputation and cardiovascular disorders. Due to the increase in energy cost of ambulation with a prosthesis, heart disease may have a profound impact on function (Hrubec & Ryder, 1979). Likewise, loss of social support with aging can have an impact on psychosocial adjustment and function in the home and community.

The loss of a limb provides ongoing stress to other areas of the body. Musculoskeletal problems may arise in the residual and contralateral limb, spine, and upper extremities.

Approximately 65 percent of the amputations in people over age 50 are due to vascular disease or the effects of diabetes. Of this population, 30 percent will lose a second limb to the same disease. Therefore, as much emphasis should be placed on the contralateral limb as there is on recovering from the amputation (Jefferies, 1996).

Changes associated with aging, changes with the residual limb, the wearing out of the prosthetic components, and new technologies are all reasons to order a new prosthesis. As the technology changes, components are more responsive and materials are lighter, resulting in an increased ability of the older patient with an amputation to remain mobile.

## **APPENDICES**

- Appendix A: Guideline Development Process
- Appendix B: Supporting Evidence for Pain Management
- Appendix C: Prosthetic Prescription
- Appendix D: Foot Care Interventions for Patients with Amputation
- Appendix E: Pre-Surgical Educational Interventions
- Appendix F: Acronym List
- Appendix G: Participant List
- Appendix H: Bibliography

## APPENDIX A

### Guideline Development Process

The development process for the VA/DoD Clinical Practice Guideline for Rehabilitation of Lower Limb Amputation followed the steps described in "Guideline for Guidelines," an internal working document of VHA's National Clinical Practice Guideline Council, which requires an ongoing review of the work in progress. The Working Group of the VHA/DoD was charged to provide evidence-based action recommendations whenever possible.

The initial literature search revealed limited research specific to rehabilitation following lower limb amputation, with randomized controlled trials (RCT) noticeably absent. The search did not identify any published clinical practice guidelines or standard protocols that address lower limb amputation rehabilitation. Published literature consisted primarily of epidemiologic surveys, cross section descriptive studies, clinical commentaries, single-group cohort studies, and case studies. Recognizing these limitations, the actual literature review for this guideline (covering the period 1996 – 2006) focused on three specific questions: the management of pain control, the strategy of postoperative residual limb management (e.g., post operative dressing), and behavioral health interventions throughout the rehabilitation process. Original articles of clinical trials and empirical data evaluating efficacy and harm of intervention in these three areas, that met the inclusion criteria, were evaluated.

#### Development Process

The Offices of Quality and Performance and Patient Care Services, in collaboration with the network Clinical Managers, the Deputy Assistant Under Secretary for Health, and the Medical Center Command of the DoD identified clinical leaders to champion the guideline development process. During a preplanning conference call, the clinical leaders defined the scope of the guideline and identified a group of clinical experts from the VA and DoD that formed the Rehabilitation of Lower Limb Amputation Working Group. Working Group members included representatives of the following specialties: physical medicine, surgery, physical and occupational therapy, psychology, vocational rehabilitation, prosthetics, nursing, pharmacy, and health care systems management and policy. Working Group members also received input from several clinical directors of amputation clinics in the VHA and DoD.

As a first step, the guideline development groups defined a set of clinical questions within the area of the guideline. This ensured that the guideline development work outside the meeting focused on issues that practitioners considered important and produced criteria for the search and the protocol for systematic review and, where appropriate, meta-analysis.

The Working Group participated in an initial face-to-face meeting to reach consensus about the guideline algorithm and recommendations and to prepare a draft document. The draft continued to be revised by the Working Group at-large through multiple conference calls and individual contributions to the document. Following the initial effort, an editorial panel of the Working Group convened to further edit the draft document.

Experts from the VA and DoD in the areas of physical medicine and rehabilitation in particular reviewed the final draft and their feedback was integrated into the final draft document. This document will be updated every three years, or when significant new evidence is published to ensure that Department of Veterans Affairs (VA) and Department of Defense (DoD) healthcare delivery remain on the cutting edge of the latest medical research.

This Guideline is the product of many months of diligent effort and consensus building among knowledgeable individuals from the VA, DoD, academia, as well as guideline facilitators from the private sector. An experienced moderator facilitated the multidisciplinary Working Group. The list of participants is included in Appendix G.

### **Formulating of Questions**

The Working Group developed researchable questions and associated key terms after orientation to the scope of the guideline and to goals that had been identified by the Working Group. The questions specified (adapted from the Evidence-Based Medicine (EBM) toolbox, Center for Evidence-Based Medicine, (<http://www.cebm.net>):

- **Population** – Characteristics of the target patient population
- **Intervention** – Exposure, diagnostic, or prognosis
- **Comparison** – Intervention, exposure, or control used for comparison
- **Outcome** – Outcomes of interest.

These specifications served as the preliminary criteria for selecting studies. Research questions focused on the following areas of inquiry: pain control, postoperative dressing, behavioral health and support, effect of co-morbidity and rehabilitation interventions and outcomes.

### **Selection of Evidence**

The evidence selection was designed to identify the best available evidence to address each key question and ensured maximum coverage of studies at the top of the hierarchy of study types. Evidence-based guidelines, meta-analyses, systematic reviews of published, peer-reviewed randomized trials and single randomized controlled trials were considered to constitute the strongest level of evidence in support of guideline recommendations. This decision was based on the judgment that RCTs provide the clearest, scientifically sound basis for judging comparative efficacy. The Working Group made this decision recognizing the limitations of RCTs, particularly considerations of generalizability with respect to patient selection and treatment quality. When available, the search sought out critical appraisals already performed by others that described explicit criteria for deciding what evidence was selected and how it was determined to be valid. The sources that have already undergone rigorous critical appraisal include Cochrane Reviews, Best Evidence, Technology Assessment, and EPC reports.

The search was performed using the National Library of Medicine's (NLM) Medline database. The terms "amputation," "traumatic amputation," and "limb-loss" were used together with the following Boolean expressions and terms:

- Pain control
- Outcome
- Rehabilitation
- Behavior therapy.

In addition to Medline/PubMed, the following databases were searched: Database of Abstracts of Reviews of Effectiveness (DARE) and Cochrane Central Register of Controlled Trials (CCTR). For Medline/PubMed searches, limits were set for language (English), date of publication (1996 through 2006) and type of research (RCT, systematic reviews and meta-analysis).

As a result of the literature reviews, articles were identified for possible inclusion. These articles formed the basis for formulating the guideline recommendations. The following inclusion criteria were used for selecting randomized controlled trial studies:

- Articles published between 1996 and 2006
- English language only
- Full articles only
- Age limited to adults greater than 18 years
- Randomized controlled trials or prospective studies
- Focus on amputation or traumatic amputation of lower extremities
- Key outcomes cited (function, HRQOL, pain).

### **Preparation of Evidence Tables (Reports) and Evidence Rating**

The results of the search were organized and evidence reports. Copies of the original studies were provided to the Working Group upon request. Each reference was appraised for scientific merit, clinical relevance, and applicability to the populations served by the Federal health care system. Recommendations were based on consensus of expert opinions and clinical experience only when scientific evidence was unavailable.

A group of research analysts read and coded each article that met inclusion criteria. The articles have been assessed for methodological rigor and clinical importance using the following criteria:

The information was synthesized and reported in a brief summary of the critical appraisal of each article that included the following components:

- Description of patient population
- Interventions
- Comparisons
- Outcomes
- Summary of results
- Analysis of findings
- Evidence appraisal
- Clinical significance.

Quality of evidence ratings were assigned for each source of evidence using the grading scale presented in Table A-1 [USPSTF, 2001). The Working Group received an orientation and tutorial on the evidence USPSTF 2001 rating process, reviewed the evidence and independently formulated Quality of Evidence ratings (see Table A-1), a rating of Overall Quality (see Table A-2), and a Strength of Recommendation (see Table A-3).

### Lack of Evidence – Consensus of Experts

Very few source documents that use an evidence-based approach were found in the searches. Therefore, while the Working Group utilized evidence-based sources wherever applicable, most of the recommendations in this guideline emerged through a discussion and consensus process.

<b>Table A-1: Quality of Evidence (QE)</b>	
<b>I</b>	At least one properly done RCT
<b>II-1</b>	Well-designed controlled trial without randomization
<b>II-2</b>	Well-designed cohort or case-control analytic study, preferably from more than one source
<b>II-3</b>	Multiple time series evidence with/without intervention, dramatic results of uncontrolled experiment
<b>III</b>	Opinion of respected authorities, descriptive studies, case reports, and expert committees

<b>Table A-2: Overall Quality</b>	
<b>Good</b>	High grade evidence (I or II-1) directly linked to health outcome
<b>Fair</b>	High grade evidence (I or II-1) linked to intermediate outcome; <i>or</i> Moderate grade evidence (II-2 or II-3) directly linked to health outcome
<b>Poor</b>	Level III evidence or no linkage of evidence to health outcome

<b>Table A-3: Net Effect of the Intervention</b>	
<b>Substantial</b>	More than a small relative impact on a frequent condition with a substantial burden of suffering; <i>or</i> A large impact on an infrequent condition with a significant impact on the individual patient level.
<b>Moderate</b>	A small relative impact on a frequent condition with a substantial burden of suffering; <i>or</i> A moderate impact on an infrequent condition with a significant impact on the individual patient level.
<b>Small</b>	A negligible relative impact on a frequent condition with a substantial burden of suffering; <i>or</i> A small impact on an infrequent condition with a significant impact on the individual patient level.
<b>Zero or Negative</b>	Negative impact on patients; <i>or</i> No relative impact on either a frequent condition with a substantial burden of suffering; or an infrequent condition with a significant impact on the individual patient level.

<b>Table A-4: Final Grade of Recommendation</b>				
	<i>The net benefit of the intervention</i>			
<i>Quality of Evidence</i>	<b>Substantial</b>	<b>Moderate</b>	<b>Small</b>	<b>Zero or Negative</b>
<b>Good</b>	A	B	C	D
<b>Fair</b>	B	B	C	D
<b>Poor</b>	I	I	I	I

<b>Table A-5: Strength of Recommendation Rating System</b>	
A	A strong recommendation that the clinicians provide the intervention to eligible patients. <i>Good evidence was found that the intervention improves important health outcomes and concludes that benefits substantially outweigh harm.</i>
B	A recommendation that clinicians provide (the service) to eligible patients. <i>At least fair evidence was found that the intervention improves health outcomes and concludes that benefits outweigh harm.</i>
C	No recommendation for or against the routine provision of the intervention is made. <i>At least fair evidence was found that the intervention can improve health outcomes, but concludes that the balance of benefits and harms is too close to justify a general recommendation.</i>
D	Recommendation is made against routinely providing the intervention to asymptomatic patients. <i>At least fair evidence was found that the intervention is ineffective or that harms outweigh benefits.</i>
I	The conclusion is that the evidence is insufficient to recommend for or against routinely providing the intervention. <i>Evidence that the intervention is effective is lacking, or poor quality, or conflicting, and the balance of benefits and harms cannot be determined.</i>

### Survey of Current Practice

A survey was also prepared and disseminated to practicing professionals within both the VA and DoD who work directly with patients who have had lower limb amputations. An effort was made to reach a maximum number of individuals from the various disciplines that provide care and services to this population. These professional staff members were queried as to care in all phases of rehabilitation of patients with amputation. In addition, they were asked to share testing techniques and approaches that they have found to be especially successful in working with patients with lower limb amputations. The results of the survey were kept from the Working Group to avoid creating bias and were compared to the final list of recommendations that emerged from the group discussions. The summary table ([Table 2. Summary of Interventions in Rehabilitation Phases](#)) was compared and consolidated with the results of the survey.

### Algorithm Format





The goal in developing the guideline for lower limb amputation was to incorporate the information into a format which would maximally facilitate clinical decision-making. The use of the algorithm format was chosen because of the evidence that such a format improves data collection, diagnostic and therapeutic decision-making and changes patterns of resource use. However, few guidelines are published in such a format.



The algorithmic format allows the provider to follow a linear approach to critical information needed at the major decision points in the clinical process, and includes:

- An ordered sequence of steps of care
- Recommended observations
- Decisions to be considered
- Actions to be taken

A clinical algorithm diagrams a guideline into a step-by-step decision tree. Standardized symbols are used to display each step in the algorithm (Society for Medical Decision-Making Committee [SMDMC], 1992). Arrows connect the numbered boxes indicating the order in which the steps should be followed.

	Rounded rectangles represent a clinical state or condition.
	Hexagons represent a decision point in the guideline, formulated as a question that can be answered Yes or No. A horizontal arrow points to the next step if the answer is YES. A vertical arrow continues to the next step for a negative answer.
	Rectangles represent an action in the process of care.
	Ovals represent a link to another section within the guideline.

A letter within a box of an algorithm refers the reader to the corresponding annotation. The annotations elaborate on the recommendations and statements that are found within each box of the algorithm. Included in the annotations are brief discussions that provide the underlying rationale and specific evidence tables. Annotations indicate whether each recommendation is based on scientific data or expert opinion. A complete bibliography is included in the guideline.

## REFERENCES

Cochrane Library. Cochrane Controlled Trials Register. Available at [http:// www.update-software.com/cochrane](http://www.update-software.com/cochrane)

Department of Veterans Affairs. VA 1996 External Peer Review Program. Contract No. V101(93) P-1369.

Gresham GE, Duncan PW, Stason WB, et al. Post-Stroke Rehabilitation. Clinical Practice Guideline, No. 16. Rockville, MD: U.S. Department of Health and Human Services. Public Health Service, Agency for Health Care Policy and Research. AHCPR Publication No. 95-0662. May 1995

- Harris RP, Helfand M, Woolf SH, Lohr KN, Mulrow CD, Teutsch SM, Atkins S; Methods Work Group, Third US Preventive Services Task Force. Current methods of the U.S. Preventive Services Task Force: a review of the process. *Am J Prev Med* 2001 Apr; 20 (3 Suppl): 21-35.
- Society for Medical Decision-Making Committee (SMDMC). Proposal for clinical algorithm standards, SMDMC on Standardization of Clinical Algorithms. *Med Decis Making* 1992; April-June 12(2): 149-54.
- United States Preventive Service Task Force (USPSTF). Guide to Clinical Preventive Services. 2<sup>nd</sup> edition. Washington, DC: Office of Disease Prevention and Health Promotion, U.S. Government Printing Office; 1996.
- Woolf SH. Practice guidelines, a new reality in medicine II. Methods of developing guidelines. *Arch Intern Med* 1992 May; 152(5): 946-52.
- Woolf SH. Manual for conducting systematic reviews. Rockville, MD: Agency for Health Care Policy and Research. Draft. August 1996.

## APPENDIX B

### Supporting Evidence for Pain Management

Our search of the literature identified one systematic review and 28 individual prospective controlled trials (total of 821 patients) investigating intervention for management of pain after amputation. Twelve of these studies have been included in the systematic review (Halbert et al., 2002). In addition, an excellent critical review of Chronic Pain after Lower Extremity Amputation, by Joseph Czerniecki and Dawn Ehde (2003), provided a comprehensive source of information as well as conceptual framework for organizing this summary.

The following summary of selected studies and available evidence for pain management addresses:

1. Residual limb pain (RLP)
2. Phantom limb sensation (PLS)
3. Phantom limb pain (PLP)
4. Musculoskeletal pain: low back pain (LBP), and knee pain.

### RESIDUAL LIMB PAIN

- The reported incidence of residual limb pain (RLP) after amputation is very variable, ranging from 1 to 76 percent (Bach et al., 1988; Ehde et al., 2000; Gallagher et al., 2001; Lambert et al., 2001; Smith et al., 1999; Wartan et al., 1997).
- Studies that have followed patients longitudinally from the time of amputation demonstrate that the greatest incidence of RLP is in the immediate postoperative period and that it subsequently decreases with time (Bach et al., 1988; Jensen et al., 1985; Lambert et al., 2001).
- RLP is an important problem and may be more disabling to patients with lower limb amputation than phantom limb pain (PLP) (Czerniecki & Ehde, 2003; Ehde et al., 2000; Gallagher et al., 2001; Marshall et al., 2002; Smith et al., 1999).
- The large variability in the incidence of RLP may be due to the prevalence of differing etiologies of amputation, the time since amputation, or the proportion of subjects using prosthetic limbs in each of the studies.
- The validity of the reported incidents of pain may be questioned due to variability in definitions of RLP and the way the questions were phrased in each study. Another factor that may explain the very high incidence in large surveys may be a sample bias, as individuals with pain are possibly more likely to respond to a survey than those without. It is unlikely, however, that these factors alone would explain all of the variance in the reported incidence of RLP after lower extremity amputation. This would suggest the need for further studies to elucidate the pathophysiology of pain associated with amputation.

- The specific factors that determine pain-related disability secondary to RLP are not known. For example, an individual with significant RLP may be unable to wear his/her prosthesis which may have a greater impact on his/her mobility, vocation, or avocational activities than someone with the same level of PLP that is unchanged with lower limb prosthetic use.

## PHANTOM LIMB SENSATION

- Phantom sensations occur commonly in patients who have experienced amputation as well as other clinical conditions. It is important to differentiate between phantom limb sensation (PLS) and phantom limb pain (PLP). In some cases there are overlapping sensory experiences that are difficult to classify. PLS can be defined as the presence of non-painful sensory experiences in the limb distal to the site of amputation.
- PLS is almost a universal experience after lower limb amputation. PLS is typically experienced almost immediately after surgical amputation and has been reported to occur in as much as 84 percent of patients (Jensen et al., 1983; Jensen et al., 1984). Patients should be educated to understand the types of sensations they might experience and the normalcy of these experiences. Educating the patient may alleviate or prevent experiences of anxiety or embarrassment in the early post-amputation period. In most patients, their intensity and frequency will diminish over time.
- The quality of the sensory experience is extremely variable. Jensen et al. (1984) developed an organizational structure for these experiences. They divided PLS into: kinesthetic sensations, which they defined as those of length, volume, or other spatial sensations; kinetic or movement sensations; and exteroceptive sensations, which are the perception that sensory stimuli are applied to the amputated extremity.
- The kinesthetic sensations are most common early after amputation and gradually diminish over time. The patient may feel that the amputated limb is still present with a normal shape and location, whereas in others, the phantom limb may present in a twisted or deformed orientation or may be perceived as having muscle cramps. Jensen et al. (1983) in a 2-year longitudinal study found that only 30 percent of patients noted telescoping (i.e., the length and volume of the phantom limb gradually foreshortens). In the remainder, there was a gradual reduction in the intensity of the perception of the phantom limb or that it occurred more intermittently.
- Kinetic sensations involve a perception of moving the phantom limb voluntarily or involuntarily. These sensations occur in about 30 percent of patients and do not change significantly, at least within 2 years of the amputation (Jensen et al., 1984).
- Exteroceptive sensations have a wide variety of characteristics and intensities. They have been described as itching, tingling, warmth, or cold. A small proportion of patients have only exteroceptive sensations. PLS can occur spontaneously; recent evidence also indicates that phantom sensory experiences can also be elicited by tactile stimuli applied to other intact body locations. Typically, sensory inputs to adjacent somatotopic areas can elicit and modify sensory experiences in the phantom limb. The observation that

sensory stimuli to the skin of body parts with somatotopic representation adjacent to the amputated extremity can elicit sensory experiences in the phantom, along with neurosources imaging studies, indicate that there is extensive neural reorganization that occurs after amputation or deafferentation of an extremity (Flor et al., 2000).

## PHANTOM LIMB PAIN

- Acute phantom limb pain (PLP) after amputation is a significant problem with a reported incidence in the first year following amputation as high as 70 percent (Lambert et al., 2001). Other epidemiological studies have reported variable incidence of chronic PLP, from 10 percent to 100 percent of cases. According to large studies, PLP probably affects between 67 percent and 79 percent of patients with amputation (Ehde et al., 2000, Jensen et al., 1985; Whyte et al., 2001). The quality and intensity of the pain experience are particularly variable.
- Ehde et al. (2000) assessed the disability caused by PLP using the Chronic Pain Grade (CPG) assessment tool. According to their study, 47 percent of patients were classified as low intensity and low disability (grade I); an additional 28 percent of patients were classified as having high intensity yet low disability (grade II), and 48 percent had a pain severity grade of greater than 5 out of 10 using the numerical pain rating scale. In another study, a large proportion of patients with PLP experienced severe pain (rating 7-10 on a pain scale) in the first 4 weeks after the surgery. Across all pain types, a quarter of those with pain reported their pain to be extremely bothersome (Ephraim, 2005).

### Causes and Mechanism of PLP

- The onset of PLP is usually within the first week of amputation (Jensen et al., 1985, Nikolajsen et al., 2000a). For those who will develop PLP, the pain typically starts within the first 4 days in 83 percent (Nikolajsen 2000). There is no significant difference in the incidence between 1 week, 6-month follow-up (Nikolajsen et al., 1997b), 2-year follow-up, and at least in one study, at 5-year follow-up (Steinbach et al., 1982). Most studies show a reduction in the frequency and duration of PLP during the first 6 months after amputation, however, there was no change in the intensity between one week and 6 months (Nikolajsen et al., 1997b).
- As with PLS, increasing evidence suggests a combination of alterations in peripheral sensory inputs in conjunction with neural reorganization play a causative role. Such a mechanism was demonstrated in animal experiments. It is not known whether these changes are induced by the chronic pain that occurs in many patients prior to amputation, or whether they are related to the nerve resection that occurs at the time of amputation. Retrospective data supports an association between the quality and location of phantom pain with pain prior to amputation (Katz & Melzack., 1990). However, Jensen et al. (1985) compared the severity of pain location and quality in the pre- and post-amputation phase. They found similar location and character in only 36 percent of patients who had pain early after the amputation, and only 10 percent were similar at the 2-year follow-up. The study also found that that PLP was more likely to develop when the duration of pre-

amputation pain was longer than 1 month. In a later study (Nikolajsen et al., 1997), a significant relationship between the presence of pre-amputation pain and the development of PLP at 1 week and 3 months was demonstrated, but not at 6 months. The intensity of pre-amputation pain, however, was not correlated with the development of PLP. Many individuals who have not had a history of chronic pain prior to their amputation develop phantom pain and sensations.

- In summary, most epidemiological studies demonstrate that the presence of pre-amputation pain and possibly a longer duration of pain prior to amputation may be associated with the development of PLP. It is uncertain whether pre-amputation pain intensity increases the risk for PLP. The studies also do not support the perception that the PLP experienced by patients is in a similar location and quality to pain prior to the amputation.

## **Treatment of PLP**

### **Preemptive Analgesia**

The neural changes associated with the deafferentation that occurs with amputation plus some of the early reports that suggested there were similarities between preamputation pain and PLP in patients with amputation lead to a number of investigations to evaluate whether or not the elimination of afferent nociceptive discharges prior to or at the time of amputation reduced the incidence or severity of PLP. This approach to the prevention of post-amputation pain has been termed preemptive analgesia. The 2 major strategies to eliminate nociceptive input prior to or during amputation have been perineural analgesia and epidural blockade. However, there is little support for the role of preemptive analgesia in the prevention of PLP after amputation. Neither perineural analgesia nor epidural blockade under the conditions used in the studies exhibited a beneficial effect.

### **Epidural Blockade**

- The first prospective randomized clinical trial to evaluate epidural blockade was performed by Bach et al. (1988). The study demonstrated that epidural blockade 3 days prior to and during the operation of individuals with a painful extremity prior to amputation, resulted in a significant 2-fold to 3-fold reduction in PLP immediately after amputation. At 6 months and one year after amputation all of the subjects (n=11) with epidural blockade were still pain free, whereas in the control group (n=14), 38 percent and 27 percent reported PLP at 6 months and 1 year after amputation.
- Another study (Jahangiri et al., 1994) also supported the benefit of epidural blockade in the perioperative period. Perioperative epidural infusion of diamorphine, clonidine and bupivacaine has shown to be safe and effective in reducing the incidence of phantom pain after amputation in the study group (n=13) at 6-month and 1-year follow-up assessment.
- A third study (Nikolajsen et al., 1997a) in a double-blind, randomized trial with 27 patients in the experimental group showed that epidural blockade can reduce preoperative ischemic pain and postoperative stump pain, but has no beneficial effect on the prevention of RLP or PLP after limb amputation. The inconsistency with the earlier smaller studies may be explained by the

shorter duration of epidural blockade, 18 hours in comparison with 72 hours in the previous studies. Jensen & Nikolajsen (2000) in an update review discuss the unlikelihood of admitting all patients for prolonged periods of pre-surgery epidural anesthesia before amputation.

### **Perineural Analgesia**

- In a different, but similar approach to preemptive analgesia studies have been performed to determine if blocking an afferent discharge from the cut end of a nerve using perineural analgesia will modify the postamputation pain experience. The procedure involves dissection of the major nerve (sciatic or tibial) during the amputation. The nerve is then infiltrated with 10 mL of 0.25 percent bupivacaine and then transected. A multi-port epidural catheter is brought into the wound away from the main incision and advanced approximately 10 cm into the nerve sheath. An infusion of bupivacaine 0.2 percent at a rate of 3–6 mL per hour is commenced immediately postoperatively. The catheter is kept in for five days and is removed with the first dressing change.
- The results of 5 studies (Elizaga et al., 1994; Enneking 1997; Fisher & Meller, 1991; Lennox, 2002; Pinzur et al., 1996) evaluating the effect of perineural analgesia on postamputation pain are similar. The use of perineural analgesia reduces pain in the postoperative period therefore decreasing the need for other parenteral and oral analgesics; however, there is no beneficial effect on either RLP or PLP in long-term follow-up. (Lambert et al., (2001) compared the relative efficacy of epidural analgesia with perineural anesthesia and demonstrated that the incidence of PLP and RLP was no different between the two groups at 3, 6 and 12 months after amputation. The perioperative epidural block 24 hours before the operation gave better relief of RLP in the immediate postoperative period. Hayes et al. (2004) evaluated the effect of adding ketamine perioperatively compared to placebo (saline) and found significant increase of RLP in the experimental group. Patient satisfaction, the consumption of morphine, and report of pain at 6 month were not different between the groups.
- With this approach, short-term pain relief was achieved; less morphine was used for 2 or 3 days, and opioid needs were decreased at 3 days postoperatively. Continuous perineural infusion of an anesthetic appears to be a safe, effective method for the relief of postoperative pain but it does not prevent RLP or PLP.

### **Postoperative Therapeutic Interventions**

- More than 60 different treatment strategies have been suggested as being effective in treating PLP, including a variety of medical, surgical, psychological, and alternative options (Sherman, 1994). Studies have been published supporting the use of conventional analgesic treatments such as opioids (Huse, 2001) as well as less conventional treatments using antipsychotic, anticonvulsants drugs, and other somatic treatments (TENS), such as therapeutic touch and electroconvulsive therapy. However, the success rates of these treatments have rarely exceeded the expected placebo response rate of 25 percent to 30 percent (Czerniecki & Ehde, 2003).

- A systematic review (Halbert et al., 2002) identified 12 RCTs of PLP, 8 of which examined only acute phantom pain. Much of what is prescribed for PLP is based on the efficacy of certain medications in the treatment of other types of neuropathic pain. The majority of studies have focused on pharmacological interventions; however, most of the studies are clinical commentaries, single-group studies, and case reports. The few RCTs reviewed, used small samples or suffer from significant methodological shortcomings.

### **Post-operative Anesthesia, Analgesics**

- Four randomized studies have evaluated the efficacy of narcotic analgesia. Dextromethorphan satisfactorily attenuated the phantom limb pain. A dosage of 90 mg BID significantly reduced PLP compared to placebo (Abraham et al., 2002).
- In a study (Wu et al., 2002) that was trying to demonstrate the different mechanisms that play a role in RLP vs. PLP, the researchers compared the effect of morphine and lidocaine on pain. The results showed that morphine reduced both RLP and PLP. In contrast, lidocaine decreased RLP ( $P < 0.01$ ), but not PLP. The changes in sedation scores for morphine and lidocaine were not significantly different from placebo. Compared with placebo, self-reported RLP relief was significantly greater for lidocaine ( $P < 0.05$ ) and morphine ( $P < 0.01$ ), while phantom pain relief was greater only for morphine ( $P < 0.01$ ).
- The efficacy of oral retarded morphine sulphate was tested against placebo in a double-blind crossover design in 12 patients (Huse et al., 2001). Pain intensity assessed during the 4-week treatment-free phase of the trial, and at two follow-ups (6 and 12 months) showed significant pain reduction during morphine but not during placebo treatment. Neuromagnetic source imaging showed initial evidence for reduced cortical reorganization under morphine concurrent with the reduction in pain intensity in three of the patients.
- Robinson et al., (2004) found that amitriptyline compared with an active placebo was not efficacious in treating chronic PLP in adults with lower and upper limb amputations. Wilder-Smith et al., (2005) comparing individually titrated doses of tramadol to treatment with amitriptyline have shown that both amitriptyline and tramadol provided excellent and stable phantom limb and stump pain control with no major adverse events.
- Three RCTs compared the effect of an anticonvulsant (gabapentine) to placebo. In two of the trials gabapentine did not reduce the incidence or intensity of post amputation pain (Smith et al, 2005; Nicolajsen et al, 2006). In a third small study, gabapentin monotherapy was significantly better than placebo in relieving postamputation phantom limb after 6 weeks of treatment (Bone et al, 2002). Bone et al. only studied PLP in patients with severe levels of pain, whereas Smith et al., included participants with either PLP or RLP and their sample included a more moderate pain level. Gabapentin may be more effective in patients reporting greater pretreatment pain intensities (moderate to severe) or in patients specifically with PLP than in patients with RLP or patients who experience only mild pain.



- Aggressive pain management may be introduced at a late stage, when pain is already entrenched. One trial of infused intravenous ketamine showed promising results by reducing phantom and residual pain (Nikolajsen, 1996). Calcitonin treatment compared to placebo has shown mixed results. Although there was no significant difference in PLP relief between treatment group and placebo, four patients remained pain free with out a second infusion, and 15 never experienced PLP again. At one year follow-up 8 out of 13 surviving had >75 percent PLP relief and at two years, 12 patients had >75 percent PLP relief (Jaeger & Mier, 1992).

## **TENS**

- A controlled trial of transcutaneous electrical stimulation (TENS) showed TENS to be ineffective in treating chronic PLP. Finsen et al. (1988) found no significant differences in the analgesic requirements or reported PLP between the treatment group and placebo.
- Another controlled crossover study compared the effect of low frequency and high intensity of TENS in patients with PLS, phantom pain and no pain (Katz & Melzack, 1991). Small, but significant reduction in the intensity of non painful PLS was found during the TENS treatments but not the placebo condition. After receiving auricular TENS, a modest, yet significant decrease in pain was measured in the PLP group.
- Lundeberg (1985) reported reduction in pain by 75 percent of the patients treated with vibratory stimulation as compared to 44 percent during placebo.(N=24). Depending on the phantom sensation, the best pain-reducing site was found to be either the area of pain or the antagonistic muscle. In 90 percent of the patients, the best pain-reducing effect was obtained when stimulation was applied with moderate pressure over a large area.

## **NMDA-receptor antagonists**

- Three studies were undertaken to deduce if NMDA-receptor antagonists may be effective in patients with chronic PLP (Wiech et al., 2004). The drug memantine (NMDA-receptor antagonist ) was compared to placebo. Although one of the studies (Maier et al., 2003) reported significant decline in PLP in comparison with the baseline in both experimental and control arms, both trials failed to demonstrate a significant clinical benefit of the NMDA-receptor antagonist memantine in chronic PLP. In a third controlled trial, Schwenkreis and colleagues (2003) were trying to determine the relationship between intracortical inhibition (ICI) and intracortical facilitation (ICF) and phantom pain intensity. Memantine was able to significantly increase the reduced ICI and to normalize the enhanced ICF in patients with amputation at the hemisphere contralateral to the amputation. Neither a correlation between the amount of phantom pain reduction and the changes of one of the electrophysiological parameters, nor between the amount of phantom pain and the excitability parameters themselves could be observed, leading to the assumption that both phenomena might be considered independently of each other (Schwenkreis et al., 2003).

### **Farabloc™**

- Farabloc is a product promoted for the relief (not cure) of intermittent PLP. It is a linen fabric with ultrathin steel threads to be worn over the residual limb and claimed to shield nerve endings from external electrical and magnetic fields. In a double blind, cross-over design, 34 subjects reported their pain relief level during a pretreatment period, Farabloc or placebo treatment period, a no-treatment or "washout" period for the control of any carry-over effect, and an alteration of treatment period. The results were statistically significant ( $p < .001$ ) in favor of the Farabloc period. Of the 34 subjects, 21 reported their greatest pain relief during Farabloc intervention. However, the clinical significance of the findings may be questioned since only two subjects reported complete or near complete pain relief with Farabloc, and the number of potential users is limited. Nevertheless, Farabloc is a relatively inexpensive alternative compared to other therapeutic measures currently available (Conine, 1993).

### **SUMMARY**

In addition to medication, psychological techniques such as biofeedback, hypnosis and progressive muscle relaxation can help manage phantom pain. Multidisciplinary pain strategies that are common in other chronic pain conditions are rarely prescribed for patients with PLP. Although the reasons for this are unknown, it may be because many individuals with amputation-related pain manage to function despite their chronic pain problem (Ehde et al., 2000). No research has been conducted on multidisciplinary pain programs in patients with amputation. It is clear that the gap between practice and research in the area of PLP is marked. Because of their low quality and contradictory results, the randomized and controlled trials to date do not provide evidence to support any particular treatment of PLP, either in the acute perioperative period or later. Patients with amputation require timely up-to-date information on phantom pain which sensitively addresses the variability of the experience and provides the foundation for ongoing pain management (Mortimer et al., 2002). Review of focus groups of health professionals have shown that information given to patients on phantom phenomena is inconsistent and insufficient. Possible solutions are the development of minimum standards of information and specifically targeted interprofessional education (Mortimer et al., 2004).

## MUSCULOSKELETAL PAIN

### LOW BACK PAIN

- Low back pain (LBP) is reported in several epidemiological studies as a significant impairment that is prevalent in the majority of patients with lower limb amputations, and in a large percentage of patients it is considered more troubling than RLP and PLS. Patients with amputations, and especially those with transfemoral (TF) amputations should be assessed for LBP (Ehde et al., 2000; Ehde et al., 2001; Smith et al., 1999).
- The prevalence of LBP post-amputation has been reported to be 71 percent (Ehde et al., 2000; Smith et al., 1999). This prevalence was similar to that of participants reporting non-painful PLS (75.7%) and RLP (76.1%) (Smith, 1999). In a sample of young patients living moderately active lives with trauma or tumor related lower extremity amputations, serious LBP (i.e., frequent or permanent LBP) was reported in 26.3 percent of the participants (Stam et al., 2004). No relationship was found between LBP and years since amputation, or physical activity. Although there is some disagreement as to whether amputation level influences the incidence of back pain, patients with TF amputation had a significantly greater incidence, severity, and pain-related disability than patients with transtibial (TT) amputation (Smith et al., 1999).
- Of those with LBP, over half rated it as either moderately or severely bothersome, and 25 percent reported that it significantly interfered with their daily, social, family, and work activities (Ehde et al., 2001).

#### Causes of LBP

The causes of LBP in patients with TF amputation have not been systematically studied. Leg length discrepancy, excessive lumbar lordosis, and/or excessive trunk motion are frequently cited causes of LBP in the general population and may play a role in back pain after TF amputation (Czerniecki & Ehde, 2003).

- Friel et al. (2005), reported significant differences in back extensor muscle strength and endurance between two groups with lower limb amputation; with or without low back pain. In this study, patients with TF amputation exhibited greater strength but less endurance than those with TT amputation. In general, individuals with a TF amputation have lower levels of activity than people with TT amputation, and this may explain the differences in back extensor muscle endurance between the two groups. With respect to back extensor muscle strength, the back extension and hip-hiking used to advance the limb during gait with a TF prosthesis may explain the greater strength of these muscles in those patients compared with patients who received TT amputation.
- Rabuffetti et al. (2005) identified motor strategies adopted by patients with TF amputations to compensate for the constraints of hip motion induced by the interference of the socket with the pelvis and, particularly, with the ischial tuberosity. The authors interpret study results as a combination of

mechanical constraints and compensatory actions. They found that reduced prosthetic hip extension is determined by the mechanical constraint involved in the pelvis-socket interference; and that increased pelvis tilt and sound hip flexion occurring at the same time are compensating strategies that are adopted by the patients with lower extremity amputation in order to obtain a functional step length and symmetrical thigh inclinations. Those factors determine a gait pattern which is functional, only slightly slower than normal gait, and without any perceivable alterations. On the other hand, the authors show that the increased pelvic tilting necessary overloads the lumbar tract of the spine and may be related to the frequent occurrence of LBP, despite the positive functional gait recovery.

- Some researchers (Friberg, 1984) suggest that the prosthetic leg length of a patient with TF amputation depends not only on the physical length of the prosthesis, but also on the relationship of the residual limb to the prosthetic socket. Increased volume due to weight gain, edema, and prosthetic socks may act to displace the residual limb from its socket, thereby increasing the total prosthetic limb length. Similarly, a decrease in volume causes the residual limb to rest more deeply in the socket, thereby decreasing the total prosthetic limb length. Friberg (1984) found that patients with lower extremity amputations who experienced LBP had significantly greater leg length discrepancies than those without pain.
- Because it is present to some degree in all humans, the role of leg length discrepancy in low back pain remains controversial. While some studies found no relationship between leg length discrepancy and LBP in patients with lower extremity amputations, they have shown not only that a relationship exists, but that back pain improves with leg length discrepancy correction ( Czerniecki & Ehde, 2003).
- In several specialized populations, lordosis has been correlated with increased LBP. The extent of lumbar lordosis associated with LBP has not been evaluated in patients with lower extremity amputation. However, it appears that circumstances with poor prosthetic fit e.g., a prosthetic socket that is not adequately flexed (aligned in 5 degrees), or in which the amount of socket flexion does not accommodate a patient's hip flexion (contracture), can result in excessive lumbar lordosis.
- Other studies have investigated abnormal kinematics of the lumbar spine and support the clinical observation that increased and/or abnormal motion of the lumbar spine leads to injury and pain. Studies have also demonstrated that there is increased lateral bending toward the prosthetic side during stance phase. No attempt has been made to correlate this finding with LBP.
- Not surprisingly, the use of a prosthetic device alters the biomechanics of gait. Its effects on lower extremity kinematics in patients with TF amputation include decreased walking speed, asymmetrical swing and stance phases, larger stride width, and changes in hip and knee flexion throughout the gait cycle (Czerniecki & Ehde, 2003)

Abnormal stress-strain distributions may be a factor in the development of degenerative joint disease (DJD). Although speculative, when viewed in this context, the process by which leg length discrepancy, excessive lumbar lordosis,

and excessive motion of the lumbar spine result in LBP is essentially mechanical. These conditions produce abnormal spinal loads, which in turn produce abnormal stress distributions in the tissues (Czrniecki & Ehde, 2003).

### Treatment of LBP

In the absence of specific evidence guiding treatment of LBP in patients with lower extremity amputations, the routine management of LBP for any cause may be considered (see the [VA/DoD Guideline for Management of Low Back Pain](#)). Of importance, however, is the observation that the prevalence of LBP pain in lower extremity amputation is high and it may have the same or even greater impact on disability, function and outcome of rehabilitation as residual limb pain and phantom sensation. Thus, patients with lower extremity amputations should be specifically assessed for symptoms of LBP.

### KNEE PAIN

- The long-term use of a prosthetic device and the abnormal stress-strain distributions involved are thought to be the major etiologic factors associated with accelerated degenerative arthritis which causes knee pain. In addition, adaptations of gait imposed by walking with a prosthetic limb result in increased ground reaction forces, joint torques, and power outputs on the intact limb (Nolan & Lees, 2000).
- In spite of the use of a prosthetic device, the knee on the residual limb does not have an increased risk for degenerative arthritis. It is the knee of the intact contralateral limb that is likely to demonstrate accelerated degenerative arthritis (Burke et al., 1978; Lemaire & Fisher, 1994). The age and average weight-adjusted prevalence ratio of knee pain among Veterans Administration patients (male, unilateral traumatic amputation) with transtibial amputation was 1.3 (95% confidence interval [CI], 0.7-2.1) for the knee of the intact limb and 0.2 (95% CI, .05-0.7) for the knee of the amputated limb. The standardized prevalence ratio of knee pain in the intact limb and symptomatic osteo arthritis among patients with TF amputation, compared with nonamputees, was 3.3 (95% CI, 1.5-6.3) and 1.3 (95% CI, 0.2-4.8), respectively (Norvell et al., 2005). The period of partial and progressive weight bearing with gradual return to a higher activity level after a period of relative immobility may contribute to the higher risk of knee pain. Stresses on the contralateral knee may contribute to secondary disability. Possible explanations include gait abnormalities, increased physiologic loads on the knee of the intact limb, and the hopping and stumbling behavior common in many younger patients with amputations.
- During the postoperative stage, patients with lower limb amputation undergo a period of relative immobility followed by a period of partial and progressive weight bearing with gradual return to a higher activity level. During this period, there is a relatively reduced mechanical load to the articulations of the residual limb and relatively greater loading on the articulations of the contralateral limb.
- The incidence of osteoarthritis in patients with lower extremity amputation has been reported as 65.6 percent. (Melzer et al., 2001). Further, the risk for osteoarthritis appears to increase with lower extremity amputation level. Hungerford and Cockin (1975) found degenerative arthritis of the knee in 63

of patients with TF amputation, 41 percent of patients with TT amputation compared to 21 percent of matched controls. (These studies included only small select populations of patients with amputation or used less than optimally matched control groups [Czerniecki 2003]).

### Treatment of Knee Pain

- The magnitudes of the loads on the contralateral limb can be modified by the selection of the prosthetic foot type to be used. In particular, the use of the Flex foot seems to reduce abnormal loading on the intact limb (Powers et al., 1994; Snyder et al., 1995). In addition, optimizing prosthetic alignment may influence the loads experienced by the intact lower extremity (Pinzur et al., 1995).

### REFERENCES

- Abraham RB, Marouani N, Kollender Y, Meller I, Weinbroum AA. Dextromethorphan for phantom pain attenuation in cancer amputees: a double-blind crossover trial involving three patients. *J Clin J Pain* 2002; Sep-Oct; 18(5):282-5.
- Bach S, Noreng MF, Tjellden NU. Phantom limb pain in patients with amputation during the first 12 months following limb amputation, after preoperative lumbar epidural blockade. *Pain* 1988; 33:297–301.
- Bone M, Critchley P, Buggy DJ. Gabapentin in postamputation phantom limb pain: a randomized, double-blind, placebo-controlled, cross-over study. *Reg Anesth Pain Med* 2002; 27(5):481-6.
- Burke MJ, Roman V, Wright V. Bone and joint changes in lower limb patients with amputation. *Ann Rheum Dis* 1978; 37:252–254.
- Conine TA, et al., The efficacy of Farabloc in the treatment of phantom limb pain. *Can J Rehabil* 1993; 6: 155-61.
- Czerniecki J, Ehde D. Chronic Pain after Lower Extremity Amputation. *Critical Reviews in Phys and Rehabil Med* 2003; 15(3&4): 309–332.
- Ehde DM, Czerniecki JM, Smith DG, et al. Chronic phantom sensations, phantom pain, residual limb pain, and other regional pain after lower limb amputation. *Arch Phys Med Rehabil* 2000; 81:1039–1044.
- Ehde DM, Smith DG, Czerniecki JM, Campbell KM, Malchow DM, Robinson LR. Back pain as a secondary disability in persons with lower limb amputations. *Arch Phys Med Rehabil* 2001; 82: 731–734.
- Elizaga AM, Smith DG, Sharar SR, Edwards WT, Hansen ST Jr. Continuous regional analgesia by intraneural block: effect on postoperative opioid requirements and phantom limb pain following amputation. *J Rehabil Res Dev* 1994; 31: 179–187.
- Enneking FK, Morey TE. Continuous postoperative infusion of a regional anesthetic after an amputation of the lower extremity. A randomized clinical trial. *J Bone Joint Surg Am*. 1997 Nov; 79(11):1752-3.
- Ephraim PL, Wegener ST, MacKenzie EJ et al. Phantom pain, residual limb pain, and back pain in amputees: results of a national survey. *Arch Phys Med Rehabil* 2005; 86 (10):1910-9.
- Esquenazi A, DiGiacomo R. Rehabilitation after amputation. *J Am Podiatr Med Assoc* 2001; 91(1):13-22.

- Finsen V, Persen L, Lovlien M, et al. Transcutaneous electrical nerve stimulation after major amputation. *J Bone Joint Surg Br* 1988;70:109–112.
- Fisher A, Meller Y. Continuous postoperative regional analgesia by nerve sheath block for amputation surgery—a pilot study. *Anesth Analg* 1991;72:300–303.
- Flor H, Muhlnickel W, Karl A, et al. A neural substrate for nonpainful phantom limb phenomena. *Neuroreport* 2000;11:1407–1411.
- Friberg O. Biomechanical significance of the correct length of lower limb prostheses: a clinical and radiological study. *Prosthet Orthot Int* 1984;8:124–129.
- Friel K, Domholdt E, Smith DG. Physical and functional measures related to low back pain in individuals with lower-limb amputation: An exploratory pilot study. *J Rehabil Res Dev* 2005 Mar-Apr;42(2):155-66.
- Gallagher P, Allen D, Maclachlan M. Phantom limb pain and residual limb pain following lower limb amputation: a descriptive analysis. *Disabil Rehabil* 2001;23:522–530.
- Halbert J, Crotty M, Cameron ID. Evidence for the optimal management of acute and chronic phantom pain: a systematic review. *Clin J Pain* 2002;18:84–92.
- Hayes C, Armstrong-Brown A, and Burstal R. Perioperative intravenous ketamine infusion for the prevention of persistent post-amputation pain: a randomized, controlled trial. *Anaesthesia and Intensive Care* 2004;32(3):330-8.
- Hungerford DS, Cockin J. Fate of the retained lower limb joints in second world war amputees. *J Bone Joint Surg Br* 1975; 57–B:111.
- Huse E, Larbig W, Flor H, Birbaumer N. The effect of opioids on phantom limb pain and cortical reorganization. *Pain* 2001; 90:47–55.
- Jaeger H, Maier C. Calcitonin in phantom limb pain: a double-blind study. *Pain* 1992.48(1):21-7.
- Jahangiri M, Jayatunga AP, Bradley JW, Dark CH. Prevention of phantom pain after major lower limb amputation by epidural infusion of diamorphine, clonidine and bupivacaine. *Ann R Coll Surg Engl* 1994;76:324–326.
- Jensen TS, Krebs B, Nielsen J, Rasmussen P. Immediate and long-term phantom limb pain in patients with amputation: incidence, clinical characteristics and relationship to pre-amputation limb pain. *Pain* 1985;21:267–278.
- Jensen TS, Krebs B, Nielsen J, Rasmussen P. Non-painful phantom limb phenomena in patients with amputation: incidence, clinical characteristics and temporal course. *Acta Neurol Scand* 1984;70:407–414.
- Jensen TS, Krebs B, Nielsen J, Rasmussen P. Phantom limb, phantom pain and stump pain in patients with amputation during the first 6 months following limb amputation. *Pain* 1983;17:243–256.
- Jensen TS, Nikolajsen L. Pre-emptive analgesia in postamputation pain: an update. *Prog Brain Res* 2000; 129:493–503.
- Katz J, Melzack R. Pain “memories” in phantom limbs: review and clinical observations. *Pain* 1990;43:319–336.
- Katz J, Melzack R. Auricular transcutaneous electrical nerve stimulation (TENS) reduces phantom limb pain. *J Pain Symptom Manage* 1991;6(2):73-83.
- Lambert AW, Dashfield AK, Cosgrove DC, Wilkins DC, Walker AJ, Ashley S. Randomized prospective study comparing preoperative epidural and intraoperative perineural

- analgesia for the prevention of postoperative stump and phantom limb pain following major amputation. *Reg Anesth Pain Med* 2001; 26: 316–321.
- Lemaire ED, Fisher FR. Osteoarthritis and elderly amputee gait. *Arch Phys Med Rehabil* 1994; 75: 1094–1099.
- Lennox PH, Winkelaar GB, Umedaly H, Hsiang YN. A continuous perineural infusion of local anesthetic provides effective postoperative pain management after lower limb amputation. *Can J Anaesth.* 2002 Jun-Jul; 49(6): 639-40.
- Lundeberg T. Relief of pain from a phantom limb by peripheral stimulation. *J Neurol* 1985; 232(2): 79-82.
- Maier C, et al. Efficacy of the NMDA-receptor antagonist memantine in patients with chronic phantom limb pain-results of a randomized double-blinded, placebo-controlled trial. *Pain* 2003; 103(3): 277-83.
- Marshall HM, Jensen MP, Ehde DM, Campbell KM. Pain site and impairment in individuals with amputation pain. *Arch Phys Med Rehabil* 2002; 83: 1116–1119.
- Melzer I, Yekutieli M, Sukenik S. Comparative study of osteoarthritis of the contralateral knee joint of male patients with amputation who do and do not play volleyball. *J Rheumatol* 2001; 28: 169–172.
- Mortimer CM, MacDonald RJ, Martin DJ, McMillan IR, Ravey J, Steedman WM. A focus group study of health professionals' views on phantom sensation, phantom pain and the need for patient information. *Patient Educ Couns* 2004 Aug; 54(2): 221-6.
- Mortimer CM, Steedman WM, McMillan IR, Martin DJ, Ravey J. Patient information on phantom limb pain: a focus group study of patient experiences, perceptions and opinions. *Health Educ Res* 2002 Jun; 17(3): 291-304.
- Nikolajsen L, Iikjaer S, Christensen JH, Kroner K, Jensen TS. Randomised trial of epidural bupivacaine and morphine in prevention of stump and phantom pain in lower-limb amputation. *Lancet* 1997a; 350: 1353–1357.
- Nikolajsen L, Iikjaer S, Kroner K, Christensen JH, Jensen TS. The influence of preamputation pain on postamputation stump and phantom pain. *Pain* 1997b; 72: 393–405.
- Nikolajsen L, Staehelin Jensen T. Phantom limb pain. *Curr Rev Pain* 2000a; 4: 166–170.
- Nikolajsen L, et al. A randomized study of the effects of gabapentin on postamputation pain. *Anesthesiology*, 2006; 105(5): 1008-15.
- Nikolajsen L, et al. The effect of ketamine on phantom pain: a central neuropathic disorder maintained by peripheral input. *Pain* 1996; 67(1): 69-77.
- Nolan L, Lees A. The functional demands on the intact limb during walking for active transfemoral and trans-tibial patients with amputation. *Prosthet Orthot Int* 2000; 24: 117–125.
- Norvell DC, Czerniecki JM, Reiber GE, Maynard C, Pecoraro JA, Weiss NS. The prevalence of knee pain and symptomatic knee osteoarthritis among veteran traumatic amputees and nonamputees. *Arch Phys Med Rehabil* 2005 Mar; 86(3): 487-93.
- Pinzur MS, Cox W, Kaiser J, Morris T, Patwardhan A, Vrbos L. The effect of prosthetic alignment on relative limb loading in persons with trans-tibial amputation: a preliminary report. *J Rehabil Res Dev* 1995; 32: 373–377.



- Pinzur MS, Garla PG, Pluth T, Vrbos L. Continuous postoperative infusion of a regional anesthetic after an amputation of the lower extremity. A randomized clinical trial. *J Bone Joint Surg Am* 1996; 78: 1501–1505.
- Powers CM, Torburn L, Perry J, Ayyappa E. Influence of prosthetic foot design on sound limb loading in adults with unilateral below-knee amputations. *Arch Phys Med Rehabil* 1994; 75: 825–829.
- Rabuffetti M, Recalcati M, Ferrarin M. Trans-femoral amputee gait: socket-pelvis constraints and compensation strategies. *Prosthet Orthot Int*. 2005 Aug; 29(2): 183-92.
- Robinson LR, et al. "Trial of Amitriptyline for Relief of Pain in Amputees: Results of a Randomized Controlled Study." *Arch Phys Med Rehabil* 2004; 85(1): 1-6.
- Schwenkreis P, et al. NMDA-mediated mechanisms in cortical excitability changes after limb amputation. *Acta neurologica Scandinavica*, 2003; 108(3): 179-84.
- Sherman RA. Phantom limb pain. Mechanism-based management. *Clin Podiatr Med Surg* 1994; 11: 85–106.
- Smith DG, Ehde DM, Legro MW, Reiber GE, del Aguila M, Boone DA. Phantom limb, residual limb, and back pain after lower extremity amputations. *Clin Orthop* 1999; 29–38.
- Smith DG, et al. Efficacy of gabapentin in treating chronic phantom limb and residual limb pain. *J Rehabil Res Dev* 2005; 42(5): 645-54.
- Snyder RD, Powers CM, Fontaine C, Perry J. The effect of five prosthetic feet on the gait and loading of the sound limb in dysvascular below-knee patients with amputation. *J Rehabil Res Dev* 1995; 32: 309–315.
- Stam HJ, Dommissie AM, Bussmann HJ. Prevalence of low back pain after transfemoral amputation related to physical activity and other prosthesis-related parameters. *Disabil Rehabil*. 2004 Jul 8; 26(13): 794-7.
- Steinbach TV, Nadvorna H, Arazi D. A five year follow-up study of phantom limb pain in post traumatic patients with amputation. *Scand J Rehabil Med* 1982; 14: 203–207.
- Wartan SW, Hamann W, Wedley JR, McColl I. Phantom pain and sensation among British veteran patients with amputation. *Br J Anaesth* 1997; 78: 652–659.
- Whyte AS, Niven CA. Variation in phantom limb pain: results of a diary study. *J Pain Symptom Manage* 2001; 22: 947–953.
- Wiech K, et al. A placebo-controlled randomized crossover trial of the N-methyl-D-aspartic acid receptor antagonist, memantine, in patients with chronic phantom limb pain. *Anesth Analg* 2004; 98(2): 408-13, table of contents.
- Wilder-Smith CH, Hill LT, Laurent S. Postamputation pain and sensory changes in treatment-naive patients: characteristics and responses to treatment with tramadol, amitriptyline, and placebo. *Anesthesiology* 2005; 103(3): 619-28.
- Wu CL, et al. Analgesic effects of intravenous lidocaine and morphine on postamputation pain: a randomized double-blind, active placebo-controlled, crossover trial. *Anesthesiology* 2002; 96(4): 841-8.

## APPENDIX C

### Prosthetic Prescription

#### TRANSMETATARSAL PRESCRIPTION OPTIONS

1. The following should be included in a prescription for a patient with a transmetatarsal amputation:
  - o Toe filler/arch support: with this amputation, the foot tends to pronate, splay, and over time go into an equinus contracture. A supportive total contact foot orthotic with toe filler is recommended. The patient will lack push-off and may require a rocker sole.
  - o Ankle-foot orthosis (AFO) with toe filler: use of carbon fiber custom/prefabricated AFO combined with an arch support with toe filler will provide a more dynamic push off from midstance through toe-off. Care must be made to ensure an adequate shoe fit.

#### TRANSTIBIAL PRESCRIPTION OPTIONS

1. **Socket** — connection between the residual limb and the prosthesis. The socket is the primary means of weight transfer to the prostheses. The residual limb must be tolerant to pressure in weight bearing regions.
  - o PTB or PTB/TSB – Patella Tendon Bearing (PTB) sockets are modified to have intentional pressure on several areas of the limb including the patella tendon, pretibial musculature, popliteal fossa, fibular shaft, and medial tibial flare. Contact is maintained on all surfaces of the limb with pressure relief on the bony prominences. Total Surface Bearing (TSB) sockets are designed on a principle of hydrostatic support. There are no areas of concentrated pressure on the residual limb. An elastomeric gel liner is recommended to allow circumferential pressure on the residual limb.
2. **Suspension** — method of securing the prosthesis to the residual limb.
  - o Sleeve – A neoprene, silicone, or similar material suspension sleeve is placed on the proximal brim of the socket and is rolled onto the thigh.
  - o Pin/shuttle – The roll-on elastomeric gel liner has a serrated pin attached to the distal end. When fully donned, the pin inserts into a locking mechanism incorporated into the distal socket. A button accessible on the outside of the socket releases lock.
  - o PTS or PTS SC/SP– The socket is shaped to compress the tissue proximal to the medial femoral condyle (supracondylar) and often will include the patella (supracondylar [SC]-suprapatellar [SP]). This compression suspends the limb over the bony anatomy during swing phase.
  - o Suprapatellar Cuff Strap – The simplest of suspension, this strap is attached to the socket on medial and lateral pivot points and suspends proximal to the patella. A circumferential strap holds it in position.

Pistoning may be expected with this system. A waist belt is often added to eliminate pistoning.

- Suction – An airtight seal is maintained with a suspension sleeve over the socket and onto the thigh. A one-way expulsion valve allows air to be expelled on weight bearing but not back in during deweighting.
  - VASS – A pump is placed between the socket and the foot of the prosthesis. During ambulation, the pump compresses in a telescoping manner and maintains a constant vacuum on the residual limb.
3. **Socket Interface** — incorporated between the residual limb and the prosthetic socket. May be as simple as a sock or as complicated as a custom designed liner. It is intended to reduce the friction and shear associated with ambulation in a prosthesis.
- Hard socket (no interface) – The sock is the only interface between the residual limb and the socket. There is no shock absorbing characteristics. Very simple and a well-designed socket, which can be comfortable for low impact activities.
  - Soft liner – Shock absorbing materials are used to make a liner that is donned over the residual limb prior to donning the prosthesis. Most available materials will compress over time and do not have full recovery from deformation during the gait cycle. They are easily adjusted for incremental volume reductions of the residual limb.
  - Elastomeric gel liner – The gel liner is rolled onto the residual limb. The high surface tension allows the liner to stick to the residual limb skin, thus reducing friction and shear during ambulation. Most are highly compressible with rapid recovery once the load is removed. Gel liners add extra weight and expense, can be the source of skin rashes, do not permit the skin to breath, and must be washed daily to prevent additional skin irritation.
  - Gel sock – The prosthetic sock is impregnated with silicone gel. This sock will absorb shear and reduce incidence of skin breakdown due to friction. Extra measures need to be taken when worn full time with seamed interface liners as the silicone impregnates glued seams and causes them to fail.
4. **Foot /Ankle** — provides stable weight bearing surface, absorbs shock, replaces lost muscle function, replicates anatomic joint, and restores cosmetic purpose. There is a vast range of prosthetic feet available depending upon the patient's needs. Feet are generally prescribed by activity level.
- Solid Ankle Cushion Heel (SACH) – Light, simple and inexpensive. No moving parts. Usually indicated for general activity levels.
  - Single Axis – Allows plantarflexion and dorsiflexion around one axis in the ankle. Degree of motion and resistance can be adjusted. Particularly helpful when additional loading response knee stability is desired. The

rapid plantarflexion possible with this type of foot reduces the knee flexion moment and provides early knee stability.

- Flexible (elastic) keel – Has general flexibility in all three planes. Indicated for general community ambulation. Some variants of this foot are also more accommodating to slight changes in heel height.
  - Multiple Axis – Incorporates ability to move in sagittal, coronal, and transverse planes. Indicated for accommodation to uneven terrain.
  - Dynamic Response – This category is typically characterized to include a carbon fiber foot, ankle, and shin as a single unit. The long lever will deform significantly on weight bearing. Indicated for unlimited ambulation and some impact activity.
  - Running/specialty – The running foot does not use a heel and must be aligned within parameters that are specific to the activity. Running feet are usually not conducive to daily ambulation.
5. **Pylon** — can be endoskeletal which is a simple tube connected between the socket and the foot. The exoskeletal pylon is a rigid fiberglass shell that is continuous and cosmetically contoured from the socket to the prosthetic foot.
- Rigid – Most common materials are high-grade aluminum, or carbon fiber with stainless steel, titanium, or aluminum alignment/attachment fixture at the ends. The range of adjustment is less than 10 degrees at each fixture.
  - Shock – Indicated when the desired result is to minimize the effects of high vertical impact on the residual limb. They offer an adjustable degree of telescoping motion when loaded.
  - Torsion – Rotation on the transverse plane is allowed. They are often referred to as torque absorbers. Particularly indicated for activities such as golf that requires rotary motion about a fixed base of support.
  - Combination – The most common combination will incorporate both vertical shock and torsion. Note that excess motion in the foot/ankle can cause gait deviations that would otherwise not be present.
  - Positional rotator – Permits the patient with an amputation to passively position the lower part of the prosthesis for additional ADLs such as donning shoes.

## 6. Construction

- Endoskeletal – The weight bearing structure of the prosthesis is on the inside of the limb. The pylon can be cosmetically finished with a covering of soft or semi rigid foam if desired. This approach allows unlimited adjustments in alignment and interchanging of modular components.
- Exoskeletal – The structural strength is on the outside of the limb. A rigid plastic laminate is formed over a hollow wooden core or shaped urethane

foam. This can produce a lightweight transtibial prosthesis, but adjustments are problematic, and the ability of the area between the distal socket and prosthetic foot to store or absorb energy is lost. An ultra light prosthesis is fabricated in this manner when the inner core is totally removed.

## TRANSFEMORAL PRESCRIPTION OPTIONS

1. **Socket** — connection between the residual limb and the prosthesis. The socket is the primary means of weight transfer to the prostheses. The residual limb must be tolerant to pressure in weight bearing regions.
  - Quad or variant Socket shape has four distinct walls. An anterior indentation in the Scarpa's triangle provides a posteriorly directed force to maintain the ischial tuberosity on a posterior shelf.
  - Ischial containment – Socket brim is formed in an anatomical shape to accommodate contraction of the primary muscle groups about the hip. Ischial tuberosity is contained within the socket with a laterally directed force. A 3 point pressure system is utilized to aid in maintaining the femur in an anatomically adducted position.
2. **Suspension** — method of securing the prosthesis to the residual limb.
  - Pin/shuttle/lanyard - The roll-on elastomeric gel liner – has a serrated pin attached to the distal end. When fully donned, the pin inserts into a locking mechanism incorporated into the distal socket. A button accessible on the outside of the socket releases the lock. An alternate design eliminates the use of a pin and replaces it with a Velcro strap that exits the distal socket and loops onto itself for secure suspension. Consider implementing when limb volume fluctuates.
  - Suction socket – Has reduced circumferences producing an airtight seal maintain suction suspension. Ideally a true "suction socket" is maintained on the residual limb by active musculature usage. The socket circumferences are smaller than the limb by 1 – 5%. The limb is manually pulled into the socket and a valve is placed distally to maintain an airtight seal. Requires stable limb volume. An additional donning method for patients unable to perform the needed Valsalva maneuver, or those whom a suction socket is contradicted because of heart disease, is called a "wet fit." An evaporating lubricant is applied to the residual limb permitting it to slide into the socket.
  - Silesian Bandage – Is used as a primary suspension with a sock fitting or more commonly as an auxiliary suspension for higher activity. Will incorporate various methods of closure such as buckles or Velcro, depending on patient capabilities.
  - Hip joint/pelvic band – Should be restricted to specific indications for use. These include physical conditions related to poor control of the prosthesis such as short residual limb, weak abductors, or pathologic weakness.

3. **Knee Joint** — fulfills three functions: support during the stance phase of ambulation, smooth control during the swing phase, and maintenance of unrestricted motion for sitting and kneeling.
  - Manual locking knee – Can be locked when in full extension and unlocked for sitting. This knee should be limited to use when maximum stability is needed to prevent unwanted knee flexion.
  - Single axis constant friction – Is indicated when the patient is unable or uninterested in ambulation at varied cadence. Friction is set at one level for efficiency at a single ambulation speed. It is a simple and durable design and most appropriate for limited mobility.
  - Weight activated stance control – This knee incorporates a friction braking mechanism that limits or greatly reduces knee flexion when weight is applied. It is typically a single axis constant friction knee with this feature added. It is indicated for limited community ambulation where an additional safety factor to prevent unwanted knee flexion is desired.
  - Polycentric (multiple) axis – Is most commonly recommended for knee disarticulation to improve cosmetic appearance when sitting. It is available in geometric designs that offer stance phase stability for the weak or short residual limb, or efficiency as in the strong, longer limb.
  - Hydraulic/Pneumatic (stance, swing or combination, stance flexion) – The primary indication for hydraulic/pneumatic swing control is ambulation at a varied cadence. The hydraulic/pneumatic unit allows the swing phase rate of knee flexion and extension to adjust to variations in cadence and allow gait smoothness otherwise unattainable. Some hydraulic units offer a locked setting.
  - Microprocessor (swing and/or stance, locking, stance flexion) – In most microprocessor knees, the swing and stance phase are controlled. The swing rate is constantly adjusted at every step. A primary benefit of this knee is the ability to fully load the prosthesis when the knee is in flexion. This is most useful when descending stairs and inclines. A difference is noted in the ability to descend these barriers in a step over step manner.
  
4. **Foot** — provides stable weight bearing surface, absorbs shock, replaces lost muscle function, replicates anatomic joint, and restores cosmetic purpose. There is a vast range of prosthetic feet available depending upon the patient's needs. Feet are generally prescribed by activity level.
  - SACH
  - Single axis
  - Flexible keel
  - Multi axis
  - Energy storage

- Dynamic Response
  - Running/specialty.
5. **Pylon** — can be endoskeletal which is a simple tube connected between the socket and the foot. The exoskeletal pylon is a rigid fiberglass shell that is continuous and cosmetically contoured from the socket to the prosthetic foot.
- Rigid
  - Shock
  - Torsion
  - Combo.

**6. Construction**

- Endoskeletal
- Exoskeletal.

**Table C-1: Prosthesis Prescription Components Based on the Type of Ambulation Required**

Functional Level	TRANSTIBIAL PRESCRIPTION	TRANSFEMORAL PRESCRIPTION
<b>Unlimited household ambulatory (K 1)</b>	Patella tendon bearing (PTB) or total surface bearing (TSB) Sleeve or pin/shuttle Soft foam or gel liner Flexible keel foot Endoskeletal or exoskeletal pylon	Modified quadrilateral (quad) (improve sitting comfort) Silesian/pin/ shuttle/lanyard/total elastic suspension (TES) Gel liner or frame socket Knee systems * Flexible keel or single axis foot Endoskeletal pylon
<b>Limited community ambulatory (K 2)</b>	PTB or TSB Sleeve or pin/shuttle or suction Soft foam or gel liner or hard socket Flexible keel, multi-axial, or energy storage foot Endoskeletal or exoskeletal pylon	Quad, modified quad or ischial containment Pin/shuttle/lanyard/silesian/suction/TES Gel liner or frame socket Knee systems * Flexible keel or single axis foot Endoskeletal pylon
<b>Community ambulatory (K 3)</b>	PTB or TSB Sleeve, pin/shuttle, suction, or vacuum Soft foam or gel liner or hard socket Flexible keel, multi-axial foot Torsion and/or vertical shock pylon Endoskeletal or exoskeletal pylon	Quad, modified quad or ischial containment Pin/shuttle, suction, silesian/suction/TES Gel liner or frame socket Knee systems * Flexible keel, multi-axial or energy storage foot Torsion and/or vertical shock pylon Endoskeletal pylon
<b>Exceeds basic ambulation (K 4)</b>	PTB or TSB Pin/shuttle/sleeve/suction Soft foam or gel liner Flexible, multi-axial, or energy storage foot Specialty foot (running) Torsion and/or vertical shock pylon Endoskeletal or exoskeletal pylon	Ischial containment Suction/pin/shuttle/silesian/suction/combo Gel liner or frame socket Knee systems * Quad, modified quad Flexible keel or specialty foot (running) Torsion and/or vertical shock pylon Endoskeletal pylon

- *The specifications for knee systems are too varied to be presented in this table.*



**Table C-2: Specialty Prosthesis**

<b>Function Level</b>	<b>TRANSTIBIAL PRESCRIPTION</b>	<b>TRANSFEMORAL PRESCRIPTION</b>
Water limb	Patella tendon bearing (PTB) or total surface bearing (TSB) Sleeve and/or cuff and waist belt Hard socket or gel liner Water resistant foot Endoskeletal or hollow core	Quad, modified quad or ischial containment Pin/shuttle/lanyard/silesian/total elastic suspension (TES) Water resistant foot Waterproof single axis knee Endoskeletal or hollow core
Cycling	PTB or TSB with low posterior brim Pin/shuttle/sleeve/cuff Hard socket or soft foam or gel liner Dynamic Response Foot (consider direct pedal attachment) Endoskeletal or exoskeletal	Quad, modified quad or ischial containment Pin/shuttle/lanyard/TES Dynamic Response Foot (consider direct pedal attachment) Endoskeletal
Snow skiing/ boarding	PTB or TSB Pin/shuttle (add external brace for snow skiing) Gel liner Dynamic Response Specialty Foot for skiing (eliminate boot) foot for boarding Endoskeletal	Prosthesis not recommend for snow skiing Quad, modified quad or ischial containment Pin/shuttle/lanyard/silesian/TES Dynamic Response Foot for boarding Endoskeletal
Water skiing/ boarding	PTB or TSB Suction (add external brace for skiing) Gel liner Water resistant energy storage foot Endoskeletal or exoskeletal	Prosthesis not recommend for water skiing

**APPENDIX D**

**Foot Care Interventions for Patients with Amputations**

***Referral to a foot care specialist should include but not be limited to:***

***Patient specific education for foot care should include:***

Level 0 (Low-Risk)	Level 1 (Low-Risk)
<p><b>Level 0</b> Provide basic foot care education by primary healthcare provider and/or diabetes educator.</p>	
<p><b>Level 1</b> Consult to foot care specialist for a more in-depth evaluation of the foot's circulation and sensation.</p>	
<p><b>Level 2</b> Consult to foot care specialist for more in-depth evaluation of the foot's circulation and sensation and need for therapeutic footwear.</p>	
<p><b>Level 3</b> Consult to foot care specialist for more in-depth evaluation of the foot's circulation and sensation and evaluation of appropriate therapeutic footwear and ulcer management/care.</p>	
<ul style="list-style-type: none"> <li>• Glycemic control</li> <li>• Smoking cessation</li> <li>• Daily foot checks</li> <li>• Daily foot hygiene-bathing with complete drying</li> <li>• Return demonstration on how to do foot check</li> <li>• Overview of ulcers that can lead to gangrene and amputation</li> <li>• Use of clean, non-restrictive socks/stockings</li> <li>• Signs and symptoms of foot problems</li> <li>• When to seek evaluation of foot problems</li> <li>• Non-weight bearing whenever lesion is present</li> </ul>	<ul style="list-style-type: none"> <li>• Glycemic control</li> <li>• Smoking cessation</li> <li>• Do not walk barefoot</li> <li>• Types of shoe style and fit</li> <li>• Daily foot checks</li> <li>• Daily foot hygiene: bathing with complete drying</li> <li>• Return demonstration on how to do foot check</li> <li>• Overview of ulcers that can lead to gangrene and amputation</li> <li>• Use of clean, non-restrictive socks/stockings</li> <li>• Signs and symptoms of foot problems</li> <li>• When to seek evaluation of foot problems</li> <li>• Non-weight bearing whenever lesion is present</li> </ul>

Level 2 (Moderate-Risk)	Level 3 (High-Risk)
<ul style="list-style-type: none"> <li>• Glycemic control</li> <li>• Smoking cessation</li> <li>• Do not walk barefoot</li> <li>• Require therapeutic footwear and orthosis</li> <li>• Regular preventive foot care</li> <li>• Daily foot checks</li> <li>• Daily foot hygiene: bathing with complete drying</li> <li>• Return demonstration on how to do foot check</li> <li>• Overview of ulcers that can lead to gangrene and amputation</li> <li>• Use of clean, non-restrictive socks/stockings</li> <li>• Immediate follow-up of any foot injuries/ulcers</li> <li>• Non-weight bearing whenever there are lesions present</li> </ul>	<ul style="list-style-type: none"> <li>• Glycemic control</li> <li>• Smoking cessation</li> <li>• Do not walk barefoot</li> <li>• Require extra depth footwear with soft molded inserts</li> <li>• More frequent clinic visits</li> <li>• Regular preventive foot care and footwear modifications</li> <li>• Daily foot checks</li> <li>• Daily foot hygiene: bathing with complete drying</li> <li>• Return demonstration on how to do foot check</li> <li>• Overview of ulcers that can lead to gangrene and amputation</li> <li>• Use of clean, non-restrictive socks/stockings</li> <li>• Immediate follow-up of any foot injuries/ ulcers</li> </ul>

## APPENDIX E

### Pre-Surgical Educational Interventions

Pre-surgical educational interventions designed to prepare patients for amputation and rehabilitation are, among other purposes, aimed at decreasing the patient's fear, anxiety, and distress and improve his/her recovery. Utilizing an interdisciplinary team approach to patient education improves patient recovery and outcomes.

Ideally, information should include, but not be limited to: coping methods, equipment needs, pain control, positioning, prevention of complications, prosthetic timeline, rehabilitation progress, residual limb care, and safety. These issues are described below.

#### ***Coping methods***

- Address body image and limb-loss as a grieving process
- Identify and include support system in the process
- Buddy system or bedside visit to provide the patient the chance to meet and speak with others who have undergone lower limb amputation
- Local resources for patients with an amputation
- Refer more complex cases to the psychologist

#### ***Equipment needs***

- Wheelchair with mobility training (propulsion on different surfaces; indoors and out; maneuvering in narrow/small places), wheelchair maintenance and parts
- Assistive devices
- In-home needs upon discharge

#### ***Pain control***

- Surgical pain requires short term narcotics (IV initially)
- Phantom sensation requires no medication (provide reassurance that this is normal)
- Phantom pain may require medication; try to avoid narcotics

#### ***Positioning***

- Positioning is essential to prevent adaptive shortening of soft tissue as well as prevention of joint contracture
- Patients need to comply with recommended posture and exercises to maintain residual limb full mobility

#### ***Prevention of complications***

- **Immediate:** infection, secondary hemorrhage: preventable by control of infection and technique in suturing; incentive spirometry; tobacco cessation; nutrition; bowel/bladder management; deep vein thrombosis (DVT) prevention; contracture prevention; pressure ulcer prevention/skin care; and edema control of residual limb

- **Later:** stump neuroma: bulbous swelling at the cut nerve end; tender and causes pain on weight bearing; local hydrocortisone injection or ultrasonic therapy may help
- **Phantom limb:** Patient feels the limb is present and may feel sensation or pain. Assurances, analgesics, residual limb exercises, and regularity in use of prosthesis all may help.
- **Contractures:** Appropriate positions and exercises
- **Contralateral limb care:** includes skin disorders, musculoskeletal complications, and appropriate foot wear

### ***Prosthetic timeline***

- Measuring for temporary prosthesis occurs when the residual limb has healed and is relatively stable in size and shape; about six weeks postoperatively assuming there have been no complications
- The temporary prosthesis will be used through the interim shaping period: three to six months post surgery.
- Timing, fitting, and delivery of final prosthesis
- Factors affecting successful prosthesis use
- Care of prosthesis

### ***Rehabilitation progress***

- Acute hospital stay
- Inpatient rehabilitation/pre-prosthetic training
- Outpatient rehabilitation/prosthetic training

### ***Residual limb care***

- Shaping/shrinking, soft tissue
- Soft tissue mobilization and scar management
- Desensitization
- Sock management if appropriate

### ***Safety***

- Fall prevention is essential. Complications due to falls may result in significantly increased healing time, may cause the need for additional surgeries, may lead to other injuries and result in increased hospitalization. Strategies involving a pylon and foot system and 'limb-loss' reminders (a chair by the side of the bed to remind the patient to be careful) may help.
- Thorough training in all aspects of self-sufficiency, mobility, transfer, gait, home equipment, and prosthetics
- Stairs, ramps, curbs, elevators
- Falling "safely" techniques
- Driving

## APPENDIX F

### Acronym List

ACA	Amputee Coalition of America
ADL	Activities of Daily Living
AFO	Ankle-Foot Orthosis
AMP	Amputee Mobility Predictor
ATA	Absolute Atmospheres in Pressure
CARF	Rehabilitation Accreditation Commission
CBC	Complete Blood Count
CBT	Cognitive Behavioral Therapy
CMS	The Centers for Medicare and Medicaid Services
CPG	Clinical Practice Guideline
CV	Cardiovascular
DM	Diabetes Mellitus
DME	Durable Medical Equipment
DVT	Deep Vein Thrombosis
FIM	Functional Independence Measure
HAD	Hospital Anxiety and Depression Scale
HBO	Hyperbaric Oxygen Therapy
HCFA	Health Care Financing Administration
HEP	Home Exercise Program
HO	Heterotopic Ossification
HRQL	Health Related Quality of Life
IPOP	Immediate Postoperative Prosthesis
LBP	Low Back Pain
LE	Lower Extremity
NSAID	Non-Steroidal Anti-Inflammatory Drugs
NWB	Non-Weight Bearing
PACT	Preservation-Amputation Care and Treatment
PAOD	Peripheral Arterial Occlusive Disease
PCA	Patient Controlled Analgesia
PCL	Post-Traumatic Stress Checklist
PE	Pulmonary Embolism
PEQ	Prosthesis Evaluation Questionnaire
PIS	Pain Interference Scale
PLP	Phantom Limb Pain
PM&R	Physical Medicine & Rehabilitation
PTB	Patella Tendon Bearing
PTSD	Post-Traumatic Stress Disorder Symptoms

<b>PVD</b>	<b>Peripheral Vascular Disease</b>
<b>RCT</b>	<b>Randomized Controlled Trial</b>
<b>REALM</b>	<b>Rapid Estimate of Adult Literacy in Medicine</b>
<b>RLP</b>	<b>Residual Limb Pain</b>
<b>ROM</b>	<b>Range of Motion</b>
<b>RRD</b>	<b>Rigid Removable Dressing</b>
<b>SF-MPQ</b>	<b>Short Form McGill Pain Questionnaire</b>
<b>SSRI</b>	<b>Selective Serotonin Re-uptake Inhibitors</b>
<b>TAPES</b>	<b>Trinity Amputation and Prosthetic Experience Scales</b>
<b>TCA</b>	<b>Tricyclic Antidepressants</b>
<b>TENS</b>	<b>Transcutaneous Electrical Nerve Stimulation</b>
<b>TES</b>	<b>Total Elastic Suspension</b>
<b>TSB</b>	<b>Total Surface Bearing</b>
<b>TUG</b>	<b>Timed Up and Go Test</b>
<b>UE</b>	<b>Upper Extremity</b>
<b>VAC</b>	<b>Vacuum Assisted Closure Device</b>
<b>VAS</b>	<b>Visual Analog Scale</b>

## APPENDIX G

### Participant List

**Gary E. Benedetti, MD**  
**Lt Col, USAF, MC**  
3<sup>rd</sup> Medical Group  
Orthopedic Trauma Surgery  
5955 Zeamer Avenue  
Elmendorf Air Force Base, AK 99506  
Tel: (907) 580-1571  
Fax: (907) 580-1575  
gary.benedetti@Elmendorf.af.mil

**Donna J. Blake, MD**  
Chief, PMRS  
Denver VAMC and Eastern Colorado Health Care System  
1055 Clermont St.  
Denver, CO 80220  
Tel: (303) 399-8020 ext. 2289  
Fax: (303) 393-5220  
donna.blake@va.gov

**Steven M Brielmaier, MSPT**  
Physical Therapist  
Minneapolis VAMC  
One Veterans Drive  
Minneapolis, MN 55417  
Tel: (612) 467-3076  
Fax: (612) 727-5642  
Steven.Brielmaier@va.gov

**Carla Cassidy, CRNP, MSN**  
Director, Evidence-Based Practice Guideline Program  
Department of Veterans Affairs  
810 Vermont Avenue  
Washington, DC 20420  
Tel: (202) 273-6954  
Fax: (202) 273-9097  
Carla.cassidy@va.gov

**Linda A. Coniglio, MS, OTR**  
**LCDR, MSC, USN**  
Chief, Department of Occupational Therapy  
National Naval Medical Center  
8901 Wisconsin Ave  
Bethesda, MD 20889  
Tel: (301) 295-4866  
Fax: (301) 295-1768  
laconiglio@bethesda.med.navy.mil



**Joseph Czerniecki, MD**

Director, RCS  
Seattle VAMC  
Puget Sound HC System  
1660 S. Columbian Way  
Seattle, WA 98108-1597  
Tel: (206) 277-1812  
joseph.czerniecki@va.gov

**Martha D'Erasmus, MPH**

Independent Consultant  
4550 North Park Ave, Apt. 505  
Chevy Chase, MD 20815  
Tel: (301) 654-3152  
Marty@hqiinc.com

**John Ferguson, CPO**

Prosthetist  
Amputee Care Center  
Brooke Army Medical Center  
3851 Roger Brooke Drive,  
Fort Sam Houston TX 78234  
Tel: (210) 916-2948  
Fax: (210) 916-2485  
John.fergason@amedd.army.mil

**Rosalie Fishman, RN, MSN, CPHQ**

President  
Healthcare Quality Informatics, Inc.  
15200 Shady Grove Rd, Suite 350  
Rockville, MD 20850  
Tel: (301) 296-4542  
Fax: (301) 296-4476  
Rosalie@hqiinc.com

**Margaret A. Hawthorne, RN, MSN  
COL, AN, USA**

Chief, Evidence-Based Practice, SAMEDCOM  
2050 Worth Road, Suite 26  
Fort Sam Houston, TX 78234-6026  
Tel: (210) 221-8297 ext. 6527  
Margaret.Hawthorne@amedd.army.mil

**Scott W. Helmers, MD  
CDR, MC, USN**

Orthopedic Surgery  
Naval Medical Center  
348000 Bob Wilson Dr.  
San Diego, CA 92134-1112  
Tel: (619) 532-8427  
Fax: (619) 532-8467  
swhelmers@nmcsd.med.navy.mil

**Helene K. Henson, MD**  
Amputee Clinic Director  
Michael E. DeBakey VAMC  
2002 Holcombe  
Houston, TX 77030  
Tel: (713) 794-7114  
Fax: (713) 794-3671  
Henson.helenek@va.gov  
hhenson@houston.rr.com

**Margaret J. Kent, PT**  
Physical Therapist  
Denver VA Medical Center (ECHCS)  
1055 Clermont St.  
Denver, CO 80220  
Tel: (303) 399-8020 ext. 3609  
Fax: (303) 394-5164  
Margaret.Kent@va.gov

**Joanne Marko, MS, SLP**  
Independent Consultant  
Olney, MD 20832  
301-774-5812  
Joanne@hqiinc.com

**Martin L. McDowell, BS, LPO, CPO**  
Chief, Outpatient Prosthetics Laboratory  
VA Puget Sound Health Care System  
1660 S. Columbian Way  
Seattle, WA 98108  
Tel: (206) 277-3604  
Fax: (206) 277-1243  
mlm@u.washington.edu

**Jennifer S. Menetrez, MD LTC, MC, USA**  
Chief, Physical Medicine Service  
Brooke Army Medical Center  
3851 Roger Brooke Drive  
Fort Sam Houston TX 78234  
Tel: (210) 916-0306  
Fax: (210) 916-0598  
jennifer.menetrez@amedd.army.mil

**Joseph A. Miller, MS CP**  
Deputy Chief Clinical Prosthetics Officer  
Prosthetic and Sensory Aid Service  
Department of Veterans Affairs  
1722 I Street  
Washington DC, 20307  
joseph.miller6@va.gov

**Lief Nelson, PT**

NYHHCS  
423 E. 23<sup>rd</sup> Street  
New York, NY 10010  
Tel: (212) 686-7500 x7734  
lief.nelson@va.gov

**Janet A. Papazis, MPT MAJ, SP, USA**

Chief, Physical Therapy  
Dewitt Army Healthcare Network  
9501 Farrell Road  
Fort Belvoir, VA 22060  
Tel: (703) 805-0008  
janet.papazis@na.amedd.army.mil

**Paul F. Pasquina, MD LTC, MC, USA**

Chief, Physical Medicine and Rehabilitation  
Walter Reed Army Medical Center  
6900 Georgia Ave  
Washington, DC 20307  
Tel: (202) 782-6369  
Fax: (202) 782-0970  
Paul.pasquina@na.amedd.army.mil

**Al Pike, CP**

Lead Prosthetist  
VAMC (121) - VA Polytrauma Center OEF/OIF  
One Veterans Drive - Minneapolis, MN 55417  
ABC Accredited O&P Facility  
Tel: (612) 467-2344  
Fax: (612) 727-5952  
Alvin.pike@va.gov

**Cindy E. Poorman, MS, PT**

Rehabilitation Planning Specialist  
National Rehabilitation Program Office  
1055 Clermont St.  
Denver, CO 80220  
Tel: (303) 399-8020 ext 3677  
Fax: (303) 393-5164  
Cindy.poorman@va.gov

**Mary C. Ramos, PhD, RN**

CPG Coordinator  
Evidence-Based Practice, US Army MEDCOM  
2050 Worth Rd, Suite 26  
Fort Sam Houston, TX 78234  
Tel: (210) 221-7281  
Fax: (210) 221-8478  
mary.ramos2@amedd.army.mil

**James F. Roper Jr., MD**

Chief, Physical Medicine and Rehabilitation  
Birmingham VA Medical Center  
700 South St.  
Birmingham AL 35233  
Tel: (205) 369-1794  
Fax: (205) 558-4812  
James.Roper@va.gov

**Sheila Saliman, PhD**

Denver VAMC (ECHCS)  
1055 Clermont St.  
Denver, CO 80220  
Tel: (303) 399-8020 ext.2182  
Fax: (303) 393-5220  
Sheila.Saliman@va.gov

**Barbara J. Sigford, MD**

Minneapolis VA Medical Center  
National Program Director, PM&R  
One Veterans Drive  
Minneapolis, MN 55417  
Tel: (612) 725-2044  
Fax: (612) 727-5642  
Barbara.sigford@va.gov

**Oded Susskind, MPH**

Medical Education Consultant  
Brookline MA 02446  
Tel: (617) 232-3558  
Fax: (775) 370-3470  
Oded@tiac.net

**Deborah J. Velez GNP, MN**

PACT Coordinator  
VA San Diego Health Care System  
3350 La Jolla Village Dr.  
San Diego, CA 92130  
Tel: (858) 552-8585 ext. 2781  
Fax: (858) 552-7422  
Deborah.Velez@va.gov

**Ramona Wallace, RN, MSN**

Project Manager  
Employee Education System  
St. Louis EERC  
1 Jefferson Barracks (14B/JB)  
St. Louis MO 63125  
Tel: (314) 894-6648 ext 3048  
Fax; (314) 894-6650  
Ramona.wallace@lrn.va.gov

**Marjory K. Waterman, RN, MN**  
Clinical Practice Guideline Coordinator  
Evidence Based Practice  
US Army Medical Command  
2050 Worth Rd  
Fort Sam Houston, TX 78234  
Tel: (210) 221-8658  
Fax: (210) 221-8478  
Marjory.waterman@amedd.army.mil

**Marilyn Weber, MD**  
Department of PM&R  
Director of Amputation and CVA Rehabilitation  
Minneapolis VAMC  
One Veterans Drive  
Minneapolis, MN 55417  
Tel: (612) 725-2000 ext. 2044  
Fax: (612) 727-5642  
Marilyn.weber@va.gov

**Robert J. Wilson, PsyD Lt Col, USAF, BSC**  
Assoc Dir Clin Serv/Deputy Director  
Walter Reed Army Medical Center (DHCC)  
6900 Georgia Ave, NW  
Building 2, Rm 3G04  
Washington, DC 20307-5001  
Tel: (202) 782-8946  
Fax: (202) 782-3539  
Robert.wilson@na.amedd.army.mil

## APPENDIX H

### Bibliography

- ACC/AHA 2006 guideline update on perioperative cardiovascular evaluation for noncardiac surgery: focused update on perioperative beta-blocker therapy: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Update the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery): developed in collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, and Society for Vascular Medicine and Biology. *Circulation* 2006 Jun 6;113(22):2662-74.
- Amputee Rehabilitation: Recommended Standards and Guidelines. A report by the Working Party of the Amputee Medical Rehabilitation Society, September 1992, Royal College of Physicians, London.
- Apelqvist J, Castenfors J, Larsson J, Stenstrom A, Agardh CD. Prognostic value of systolic ankle and toe blood pressure levels in outcome of diabetic foot ulcer. *Diabetes Care* 1989 Jun 12;(6):373-8.
- Bach JR. Physical medicine and rehabilitation principles and practice. 4<sup>th</sup> ed. Philadelphia: Lippincott Williams & Wilkins; 2005. Chapter 84, Rehabilitation of the patient with respiratory dysfunction. p.1843-66.
- Bach S, Noreng MF, Tjellden NU. Phantom limb pain in amputees during the first 12 months following limb amputation, after preoperative lumbar epidural blockade. *Pain* 1988 Jun;33(3):297-301.
- Baker WH, Barnes RW, Shurr DG. The healing of below-knee amputations: a comparison of soft and plaster dressing. *Am J Surg* 1977 Jun;133(6):716-8.
- Barber GG, McPhail NV, Scobie TK, Brennan MC, Ellis CC. A prospective study of lower limb amputations. *Can J Surg* 1983 Jul;26(4):339-41.
- Barnes RW, Shanik GD, Slaymaker EE. An index of healing in below-knee amputation: leg blood pressure by Doppler ultrasound. *Surgery* 1976 Jan;79(1):13-20.
- Bodeau VS. Lower limb prosthetics. Available from: <http://www.emedicine.com/pmr/topic175.htm> (Retrieved February 12, 2007).
- Boothby JL, Thorn BE, Stroud MW, Jensen MP. Coping with pain, In: Gatchel RF, Turk DC editors: *Psychosocial factors in pain*. New York; Guilford Press 1999; p. 343-59.
- Bosse MJ, MacKenzie EJ, Kellam JF, Burgess AR, Webb LX, Swiontkowski MF, Sanders RW, Jones AL, McAndrew MP, Patterson BM, McCarthy ML, Cyril JK. A prospective evaluation of the clinical utility of the lower-extremity injury-severity scores. *J Bone Joint Surg Am* 2001 Jan;83-A(1):3-14.
- Bosse MJ, McCarthy ML, Jones AL, Webb LX, Sims SH, Sanders RW, MacKenzie EJ; The Lower Extremity Assessment Project (LEAP) Study Group. The insensate foot following severe lower extremity trauma: an indication for amputation? *J Bone Joint Surg Am* 2005 Dec;87(12):2601-8.
- Boulias C, Meikle B, Pauley T, Devlin M. Return to driving after lower-extremity amputation. *Arch Phys Med Rehabil* 2006 Sep;87(9):1183-8.

- Burger H, Marincvek C, Isakov E. Mobility of persons after traumatic lower limb amputation. *Disabil Rehabil* 1997;19:272–277.
- Burgess EM, Matsen FA 3<sup>rd</sup>, Wyss CR, Simmons CW. Segmental transcutaneous measurements of PO<sub>2</sub> in patients requiring below-the-knee amputation for peripheral vascular insufficiency. *J Bone Joint Surg Am* 1982 Mar;64(3):378–82.
- Burke B, Kumar R, Vickers V, Grant E, Scremin E. Deep vein thrombosis after lower limb amputation. *Am J Phys Med Rehabil* 2000 Mar-Apr;79(2):145–9.
- Burke MJ, Roman V, Wright V. Bone and joint changes in lower limb amputees. *Ann Rheum Dis* 1978 Jun;37(3):252–4.
- Butler DJ, Turkal NW, Seidl JJ. Amputation: preoperative psychological preparation. *J Am Board Fam Pract* 1992 Jan-Feb;5(1):69–73.
- Cansever A, Uzun O, Yildiz C, Ates A, Atesalp AS. Depression in men with traumatic lower part amputation: a comparison to men with surgical lower part amputation. *Mil Med* 2003 Feb;168(2):106–9.
- Cederberg PA, Pritchard DJ, Joyce JW. Doppler-determined segmental pressures and wound-healing in amputations for vascular disease. *J Bone Joint Surg Am* 1983 Mar;65(3):363–5.
- Collin C, Collin J. Mobility after lower-limb amputation. *Br J Surg* 1995; 82:1010–1011.
- Czerniecki J, Ehde D. Chronic Pain After Lower Extremity Amputation *Critical Reviews in Physical and Rehabilitation Medicine*, 15(3&4):309–332 (2003)
- Dasgupta AK, McCluskie PJ, Patel VS, Robins L. The performance of the ICEROSS prostheses amongst transtibial amputees with a special reference to the workplace—a preliminary study. *Icelandic Roll on Silicone Socket. Occup Med (Lond)* 1997 May;47(4):228–36.
- Datta D, Harris I, Heller B, Howitt J, Martin R. Gait, cost and time implications for changing from PTB to ICEX Sockets. *Prosthet Orthot Int* 2004 Aug;28(2):115–20.
- Davidson JH, Jones LE, Comet J, Cittarelli T. Management of the multiple limb amputee. *Disabil Rehabil* 2002 Sept 10;24(13):688–99.
- Davis TC, Long SW, Jackson RH, Mayeaux EJ, George RB, Murphy PW, Crouch MA. Rapid estimate of adult literacy in medicine: a shortened screening instrument. *Fam Med* 1993(25):391–5.
- Deathe B, Miller WC, Speechley M. The status of outcome measurement in amputee rehabilitation in Canada. *Arch Phys Med Rehabil* 2002;83:912–918.
- Desmond DM, MacLachlan M. Psychosocial perspectives on post-amputation rehabilitation: a review of disease, trauma, and war related literature. *Crit Rev Phys Rehabil Med* 2004;81(2):77–93.
- Donovan-Hall MK, Yardley L, Watts RJ. Engagement in activities revealing the body and psychosocial adjustment in adults with a transtibial prosthesis. *Prosthet Orthot Int* 2002;26:15–22.
- Eneroth M, Apelqvist J, Larsson J, Persson BM. Improved wound healing in transtibial amputees receiving supplementary nutrition. *Int Orthop* 1997;21(2):104–8.
- Esquenazi A. Amputation rehabilitation and prosthetic restoration. From surgery to community reintegration. *Disabil Rehabil* 2004 July-Aug;26(14-15):831–6.

- Esquenazi A, Meier RH 3rd. Rehabilitation in limb deficiency. 4: limb amputation. *Arch Phys Med Rehabil* 1996; 77: S18–S27.
- Esquenazi A, DiGiacomo R. Rehabilitation after amputation. *J Am Podiatr Med Assoc* 2001 Jan; 91(1), 13-22.
- Finsen V, Svenningsen S, Harnes OB, Nesse O, Benum P. Transcutaneous electrical nerve stimulation after major amputation. *J Bone Joint Surg Br* 1988 Jan; 70(1): 109-12.
- Fitzgerald DM. Peer visitation for the preoperative amputee patient. *J Vasc Nurs* 2000 Jun; 18(2) 41-4; quiz 45-6.
- Flood K, Saliman S. VHI Traumatic Amputation and Prosthetics, Chapter 5: Long-term care of the amputee. Employee Education System. May 2002 pp 29-37.
- Frieden RA. The geriatric amputee. *Phys Med Rehabil Clin N Am* 2005 Feb; 16(1): 179-95.
- Fukunishi I. Relationship of cosmetic disfigurement to the severity of posttraumatic stress disorder in burn injury or digital amputation. *Psychother Psychosom* 1999 Mar-Apr; 68(2):82-6.
- Fukunishi I, Sasaki K, Chishima Y, Anze M, Saijo M. Emotional disturbances in trauma patients during the rehabilitation phase: studies of posttraumatic stress disorder and alexithymia. *Gen Hosp Psychiatry* 1996 Mar; 18(2) 121-7.
- Gagne RM, Driscoll M. Essentials of learning for instruction. 2<sup>nd</sup> ed. New Jersey: Prentice Hall College Div; 1988. 208p.
- Geertzen, JHB, Martina, JD, Rietman HS. Lower limb amputation Part 2: Rehabilitation – a 10 year literature review. *Prosthet and Orthot Int* 2001 Apr; 25(1): 14-20.
- Gerhard F, Florin I, Knapp T. The impact of medical, reeducational and psychological variables on rehabilitation outcome in amputees. *Int J Rehabil Res* 1987; 7: 379–88.
- Golbranson FL, Wirta RW, Kuncir EJ, Lieber RL, Oishi C. Volume changes occurring in postoperative below knee residual limbs. *J Rehabil Res Dev* 1988 Spring; 25(2): 11–8.
- Graf M, Freijah N. Early trans-tibial oedema control using polymer gel socks. *Prosthet Orthot Int* 2003 Dec; 27(3): 221-6.
- Granger CV, Ottenbacher KJ, Fiedler RC. The uniform data base system for medical rehabilitation. *Am J Phys Med Rehabil* 1995; 97: 62–66.
- Greenwell G, Pasquina P, Luu V, Gajewski D, Scoville C, Doukas W. Incidence of heterotopic ossification in the combat amputee. Poster/Abstract presented. Am Academy of PM&R Annual Meeting; Nov 2006; Honolulu, HI.
- Hanley M A, Jensen M P, Ehde DM, Hoffman A J, Patterson D R, Robinson LR. Psychosocial predictors of long-term adjustment to lower-limb amputation and phantom limb pain. *Disabil Rehabil* 2004 July 22-Aug 5; 26(14-15): 882-93.
- Heinemann AW, Linacre JM, Wright BD. Prediction of rehabilitation outcomes with disability measures. *Arch Phys Med Rehabil* 1994; 75: 133–143.
- Horgan O, MacLachlan M. Psychosocial adjustment to lower-limb amputation: a review. *Disabil Rehabil* 2004 July 22-Aug 5; 26(14-15): 837-50.
- Hrubec Z, Ryder RA. Report to the Veterans' Administration Department of Medicine and Surgery on service-connected traumatic limb amputations and subsequent mortality from cardiovascular diseases and other causes of death. *Bull of Prosthet Res* 1979 Fall; 16(2): 29-53.



- Huang CT, Jackson JR, Moore NB, Fine PR, Kuhlemeir KV, Traugh GH, Saunders PT. Amputation: energy cost of ambulation. *Arch Phys Med Rehabil* 1979 Jan; 60(1): 18-24.
- Huckabay, 1980 A strategy for patient teaching. *Nurs Adm Q*. 1980 Winter; 4(2): 47-54.
- Jahangiri M, Jayatunga AP, Bradley JW, Dark CH. Prevention of phantom pain after major lower limb amputation by epidural infusion of diamorphine, clonidine, and bupivacaine. *Ann R Coll Surg Engl* 1994 Sept; 76(5): 324-26.
- Jeffries GE. Aging americans and amputation. In *Motion* 1996 Apr-May; 6(2). Available online [http://www.amputee-coalition.org/inmotion/apr\\_may\\_96/aging\\_amputees.pdf](http://www.amputee-coalition.org/inmotion/apr_may_96/aging_amputees.pdf)
- Jelic M, Eldar R. Rehabilitation Following Major Traumatic Amputation of Lower Limbs A Review. *Physical and Rehab Med* 2003; 15(3&4): 235-52.
- Jensen MP, Ehde DM, Hoffman AJ, Patterson DR, Czerniecki JM, Robinson LR. Cognitions, coping and social environment predict adjustment to phantom limb pain. *Pain* 2002 Jan; 95(1-2): 133-42.
- Jensen MP, Smith DG, Ehde DM, Robinsin LR. Pain site and the effects of amputation pain: further clarification of the meaning of mild, moderate, and severe pain. *Pain* 2001; 91: 317-322.
- Jensen MP, Turner JA, Romano JM, Karoly P. Coping with chronic pain: a critical review of the literature. *Pain* 1991 Dec; 47(3): 249-83.
- Jensen TS, Krebs B, Nielson J, Rasmussen P. Immediate and long-term phantom limb pain in amputees: Incidence, clinical characteristics, and relationship to pre-amputation limb pain. *Pain* 1985 Mar; 21(3): 267-78.
- Jensen, MP, Nielson, WR, Kerns, RD. Toward the development of a motivational model of pain self-management. *J Pain* 2003 Nov; 4(9): 477-92.
- Jones L, Hall M, Shuld W. Ability or disability? A study of the functional outcome of 65 consecutive lower limb amputees treated at the Royal South Sidney Hospital in 1988-1989. *Disabil Rehabil* 1993 Oct-Dec; 15(4): 184-88.
- Koren D, Norman D, Cohen A, Berman J, Klein EM. Increased PTSD risk with combat-related injury: a matched comparison study of injured and uninjured soldiers experiencing the same combat events. *A J Psychiatry* 2005 Feb; 162(2): 276-82.
- Kostuik J. Indications, levels and limiting factors in amputation surgery of the lower extremity. In: Kostuik J, editor. *Amputation Surgery and Rehabilitation—The Toronto Experience*. New York, Churchill Livingstone, 1981: 17-25.
- Kulkarni J, Adams J, Thomas E, Silman A. Association between amputation, arthritis, and osteopenia in British male war veterans with major lower limb amputations. *Clin Rehabil* 1998 Aug; 12(4): 345-53.
- Lalka SG, Malone JM, Anderson GG, Hagaman RM, McIntyre K, Bernhard VM. Transcutaneous oxygen and carbon dioxide pressure monitoring to determine severity of limb ischemia and to predict surgical outcome. *J Vasc Surg* 1988 Apr; 7(4): 507-14.
- Lambert AW, Dashfield AK, Cosgrove C, Wilkins DC, Walker AJ, Ashley S. Randomized prospective study comparing preoperative epidural intraoperative perineural analgesia for the prevention of postoperative stump and phantom limb pain following major limb amputation. *Reg Anesth Pain Med* 2001 July-Aug; 26(4): 316-21.
- Lastoria S, Rollow HA, Yoshida WB, Giannini M, Moura R, Maffei FH. Prophylaxis of deep-vein thrombosis after lower extremity amputation: comparison of low molecular weight heparin with unfractionated heparin. *Acta Cir Bras* 2006 May-Jun; 21(3): 184-6.

- Leonard JA. The elderly amputee. In: Felsenthal G, Garrison SJ, Stienberg FU, editors. *Rehabilitation of the Aging and elderly Patient*. Baltimore, MD: Williams & Wilkins, 1994:397–406.
- Livingston DH, Keenan D, Kim D, Elcavage J, Malangoni MA. Extent of disability following traumatic extremity amputation. *J Trauma* 1994;37:495–499.
- Livneh H, Antonak RF, Gehardt J. Psychosocial adaptation to amputation: the role of sociodemographic variables, disability-related factors and coping strategies. *Int J Rehabil Res* 1999 Mar; 22(1):21-31.
- MacKenzie EJ, Bosse MJ, Kellam JF, Pollak AN, Webb LX, Swiontkowski MF, Smith DG, Sanders RW, Jones AL, Starr AJ, McAndrew MP, Patterson BM, Burgess AR, Trivison T, Castillo RC. Early predictors of long-term work disability after major limb trauma. *J Trauma* 2006 Sep;61(3):688-94.
- MacKenzie EJ, Bosse MJ, Pollak AN, Webb LX, Swiontkowski MF, Kellam JF, Smith DG, Sanders RW, Jones AL, Starr AJ, McAndrew MP, Patterson BM, Burgess AR, Castillo RC. Long-term persistence of disability following severe lower-limb trauma. Results of a seven-year follow-up. *J Bone Joint Surg* 2005 Aug;87(8):1801-9.
- MacKenzie EJ, Bosse MJ, Castillo RC, Smith DG, Webb LX, Kellam JF, Burgess AR, Swiontkowski MF, Sanders RW, Jones AL, McAndrew MP, Patterson BM, Trivison TG, McCarthy ML. Functional outcomes following trauma-related lower-extremity amputation. *J Bone Joint Surg Am* 2004 Aug;86-A(8):1636-45.
- MacLean N, Fick GH. The effect of semi rigid dressings on below-knee amputations. *Phys Ther* 1994 74(7):668 -73.
- Management of Diabetes Mellitus. Washington, DC: VA/DoD Evidence Based Clinical Practice Guideline Working Group, Veterans Health Administration, Department of Veterans Affairs , and Health Affairs, Department of Defense, May 2003. . Office of Quality and Performance publication 10Q-CPG/DM. Available from: [http://www.oqp.med.va.gov/cpg/DM/DM\\_GOL.htm](http://www.oqp.med.va.gov/cpg/DM/DM_GOL.htm)
- Management of Major Depressive Disorder in Adults in the Primary Care Setting. Washington, DC: VA/DoD Evidence Based Clinical Practice Guideline Working Group, Veterans Health Administration, Department of Veterans Affairs , and Health Affairs, Department of Defense, May 2000. . Office of Quality and Performance publication 10Q-CPG/MDD. Available from: [http://www.oqp.med.va.gov/cpg/MDD/MDD\\_GOL.htm](http://www.oqp.med.va.gov/cpg/MDD/MDD_GOL.htm)
- Management of Post-Traumatic Stress. Washington, DC: VA/DoD Clinical Practice Guideline Working Group, Veterans Health Administration, Department of Veterans Affairs and Health Affairs, Department of Defense, December 2003. Office of Quality and Performance publication 10Q-CPG/PTSD-04. Available from: [http://www.oqp.med.va.gov/cpg/PTSD/PTSD\\_Base.htm](http://www.oqp.med.va.gov/cpg/PTSD/PTSD_Base.htm) 04
- Management of Acute Post Operative Pain. Washington, DC: VA/DoD Clinical Practice Guideline Working Group, Veterans Health Administration, Department of Veterans Affairs and Health Affairs, Department of Defense, October 2001. Office of Quality and Performance publication 10Q-CPG/Pain-01. Available from: [http://www.oqp.med.va.gov/cpg/PAIN/PAIN\\_base.htm](http://www.oqp.med.va.gov/cpg/PAIN/PAIN_base.htm)
- Management of Stroke Rehabilitation. Washington, DC: VA/DoD Clinical Practice Guideline Working Group, Veterans Health Administration, Department of Veterans Affairs and Health Affairs, Department of Defense, February 2003. Office of Quality and Performance publication 10Q CPG/STR-03. Available from: [http://www.oqp.med.va.gov/cpg/STR/STR\\_base.htm](http://www.oqp.med.va.gov/cpg/STR/STR_base.htm)

- Manella KJ. Comparing the effectiveness of elastic bandages and shrinker socks for lower extremity amputees. *Phys Ther* 1981 Mar; 61(3): 334-7.
- Mangano DT, Goldman L. Preoperative assessment of patients with known or suspected coronary disease. *N Engl J Med* 1996 Dec 28; 333(26): 1750-6.
- Marshall HM, Jensen MP, Ehde DM, Campbell KM. Pain site and impairment in individuals with amputation pain. *Arch Phys Med Rehabil* 2002 Aug; 83(8): 1116-9.
- Marzen-Groller K, Bartman K. Building a successful support group for post-amputation patients. *J Vasc Nurs* 2005 Jun; 23(2): 42-5.
- Matsen FA 3<sup>rd</sup>, Wyss CR, Pedegana LR, Krugmire RB Jr, Simmons CW, King RV, Burgess EM. Transcutaneous oxygen tension measurement in peripheral vascular disease. *Surg Gynecol Obstet* 1980 Apr; 150(4): 525-8.
- May CH, McPhee MC, Pritchard DJ. An amputee visitor program as an adjunct to rehabilitation of the lower limb amputee. *Mayo Clin Proc* 1979 Dec; 54(12): 774-8.
- McCullum PT, Spence VA, Walker WF. Arterial systolic pressures in critical ischemia. *Ann Vasc Surg* 1986 Nov; 1(3): 351-6.
- McQuay HJ, Tramer M, Nye BA, Carroll D, Wiffen PJ, Moore RA. A systematic review of antidepressants in neuropathic pain. *Pain* 1996 Dec; 68(2-3): 217-27.
- Melchiorre PJ, Findley T, Boda W. Functional outcome and comorbidity indexes in the rehabilitation of the traumatic versus the vascular unilateral lower limb amputees. *Am J Phys Med Rehabil* 1996; 75: 9-14.
- Miller WC, Deathe AB. A prospective study examining balance confidence among individuals with lower limb amputation. *Disabil Rehabil* 2004 Jul 22-Aug 5; 26(14-15): 875-81.
- Miller WR, Rollnick S. *Motivational Interviewing: Preparing People for Change, Second Addition*, New York: Guilford Press; 2002. 421p.
- Millstein S, Bain D, Hunter GA. A review of employment patterns of industrial amputees—factors influencing rehabilitation. *Prosthet Orth Int* 1985; 9: 69-72.
- Mooney V, Harvey P, McBride E, Snelson R. Comparison of postoperative stump management: plaster vs. soft dressings. *J Bone Joint Surg Am* 1971 Mar; 53(2): 241-9.
- Mueller M J. Comparison of removable rigid dressings and elastic bandages in preprosthetic management of patients with below-knee amputations. *Phys Ther* 1982 Oct; 62(10): 1438-41.
- Munin MC, Espejo-De Guzman MC, Boninger ML, Fitzgerald SG, Penrod LE, Singh J. Predictive factors for successful early prosthetic ambulation among lower-limb amputees. *J Rehabil Res Dev* 2001 Jul-Aug; 38(4): 379-84.
- Muecke L, Shekar S, Dwyer D, Israel E, Flynn JPG. Functional screening of lower limb amputees: a role in predicting rehabilitation outcomes. *Arch Phys Med Rehabil* 1992; 73: 851-858.
- Nawijn, SE, van der Linde H, Emmelot CH, Hofstad CJ. Stump management after trans-tibial amputation: a systematic review. *Prosthet Orthot Int* 2005 Apr; 29(1): 13-26.
- Nicholas GG, DeMuth WE Jr. Evaluation of use of the rigid dressing in amputation of the lower extremity. *Surg Gynecol Obstet* 1976 Sep; 143(3): 398-400.
- Nikolajsen L, Iikjaer S, Jensen TS. Effect of preoperative extradural bupivacaine and morphine on stump sensation in lower limb amputees. *British J Anaesthesia* 1998; 81(3): 348-54.

- Nissen SJ, Newman WP. Factors influencing reintegration to normal living after amputation. *Arch Phys Med Rehabil* 1992 Jun; 73(6):548-51.
- O'Halloran CM, Altmaier EM. The efficacy of preparation for surgery and invasive medical procedures. *Patient Educ and Couns* 1995 Feb; 25(1):9-16.
- Ostojic LJ, Ostojic Z, Rupcic E, Punda-Basic M. Intermediate rehabilitation outcome in below-knee amputations: descriptive study comparing war related with other causes of amputation. *Croat Med J* 2001; 42:535-8.
- Pandian G, Kowalske K. Daily functioning of patients with an amputated lower extremity. *Clin Orthop Rel Res* 1995; 361:91-7.
- Pell JP, Donnan PT, Fowkes FG, Ruckley CV. Quality of life following lower limb amputations for peripheral arterial disease. *Eur J Vasc Surg* 1993 Jul; 7(4):448-51.
- Pezzin LE, Dillingham TR, MacKenzie EJ. Rehabilitation and the long-term outcomes of persons with trauma-related amputation. *Arch Phys Med Rehabil* 2000; 81:292-300.
- Pinzur MS, Reddy N, Charuk G, Osteman H, Vrbos L. Control of the residual tibia in transtibial amputation. *Foot Ankle Int* 1996 Sep; 17(9):538-40.
- Pinzur MS, Sage R, Stuck R, Ketner L, Osterman H. Transcutaneous oxygen as a predictor of wound healing in amputations of the foot and ankle. *Foot Ankle* 1992 Jun; 13(5):271-2.
- Pitetti KH, Snell PG, Stray-Gundersen J, Gottschalk FA. Aerobic training exercises for individuals who had amputation of the lower limb. *J Bone Joint Surg Am.* 1987 Jul; 69(6):914-21.
- Potter BK, Burns TC, Lacap AP, Granville RR, Gajewski DA. Heterotopic ossification following traumatic and combat-related amputations. Prevalence, risk factors, and preliminary results of excision. *J. Bone Joint Surg Am* 2007 Mar; 89-A(3):476-486.
- Priebe M, Davidoff G, Lampman RM: Exercise testing and training in patients with peripheral vascular disease and lower extremity amputation. *West J Med* 1991 May; 154(95):598-601.
- Purpy NA, Hannon MA. How successful is below knee amputation for injury? *Injury* 1989; 20:32-35.
- Qaseem A, Snow V, Fitterman N, Hornbake ER, Lawrence VA, Smetana GW, Weiss K, Owens DK, Aronson M, Barry P, Casey DE Jr, Cross JT Jr, Fitterman N, Sherif KD, Weiss KB; Clinical Efficacy Assessment Subcommittee of the American College of Physicians. Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: A guideline from the American College of Physicians. *Ann of Intern Med* 2006; 144(8):575-80.
- Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology, Assessment: neuropsychological testing of adults. Considerations for neurologists; 1996.
- Robinson LR, Czerniecki JM, Ehde DM, Edwards WT, Judish DA, Goldberg ML, Campbell KM, Smith DG, Jensen MP. Trial of amitriptyline for relief of pain in amputees: results of a randomized controlled study. *Arch Phys Med Rehabil* 2004 Jan; 85(1):1-6.
- Rogers J, MacBride A, Whyllie B, Freeman SJ. The use of groups in the rehabilitation of amputees. *Int J Psychiatry Med* 1977-1978; 8(93):243-55.
- Royal College of Physicians, 1992 – see Amputee Rehabilitation: Recommended Standards and Guidelines.

- Rybarczyk BD, Nyenhuis DL, Nicholas JJ, Schulz R, Alioto RJ, Blair C. Social discomfort and depression in a sample of adults with leg amputations. *Arch Phys Med Rehabil* 1992 Dec; 73(12): 1169-73.
- Schon LC, Short KW, Soupiou O, Noll K, Rheinstein J. Benefits of early prosthetic management of transtibial amputees: a prospective clinical study of a prefabricated prosthesis. *Foot Ankle Int* 2002 Jun; 23(6): 509-14.
- Shah SK. *Physical Medicine and Rehabilitation Principles and Practice*, 4<sup>th</sup> Ed. Philadelphia: Lippincott Williams & Wilkins; 2005 Chapter 83, Cardiac Rehabilitation.
- Sherman RA, Sherman CJ, Parker L. Chronic phantom and stump pain among American veterans: results of a survey. *Pain* 1984; 18: 83-95.
- Smetana GW, Lawrence VA, Cornell JE; American College of Physicians. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med* 2006 Apr 18; 144(8): 581-95.
- Smith D. (Co chair) Clinical Standards of Practice (CSOP) consensus conference ; Assessing Outcomes and The Future JPO 2004, Vol 16, Num 3S. Available from: [http://www.oandp.org/jpo/library/index/2004\\_03S.asp](http://www.oandp.org/jpo/library/index/2004_03S.asp) (Accessed February 2007).
- Smith DG, McFarland LV, Sangeorzan BJ, Reiber GE, Czerniecki JM. Postoperative dressing and management strategies for transtibial amputations: a critical review. *J Rehabil Res Dev* 2003 May-Jun; 40(3): 213-24.
- Snow V, Aronson MD, Hornbake ER, et al. Lipid Control in the Management of Type 2 Diabetes Mellitus: A Clinical Practice Guideline from the American College of Physicians. *Ann Intern Med* 2004; 140: 644-49.
- Snow V, Barry P, Fitterman N, Qaseem A, Weiss K: Clinical Efficacy Assessment Subcommittee of the American College of Physicians. Pharmacologic and surgical management of obesity in primary care: a clinical practice guideline from the American College of Physicians. *Ann Intern Med* 2005 Apr 5; 142(7): 525-3.
- Snow V, Weiss KB, Mottur-Pilson C. Clinical Efficacy Assessment Subcommittee of the American College of Physicians. The evidence base for tight blood pressure control in the management of type 2 diabetes mellitus. *Ann Intern Med* 2003 Apr 1; 138(7): 587-92.
- Sullivan MJ, Thorn B, Haythornthwaite JA, Keefe F, Martin M, Bradley LA, Lefebvre JC. Theoretical perspectives on the relation between catastrophizing and pain. *Clin J Pain* 2001 Mar; 17(1): 52-64.
- Monage P, Chan A, Massiscotte P, Chalmers E, Michelson AD. Antithrombotic therapy in children: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest* 2004 Sep; 126(3 Suppl): 645S-687S.
- Turk DC, Okifuji A . Psychological factors in chronic pain: evolution and revolution. *J Consult Clin Psychol* 2002 Jun; 70(3): 678-90.
- Turner-Stokes L, Turner-Stokes T. The use of standardized outcome measures in rehabilitation centres in the UK. *Clin Rehabil* 1997; 11: 306-317.
- Turney BW, Kent SJ, Walker RT, Loftus IM. Amputations: no longer the end of the road. *J R Coll Surg Edinb* 2001 Oct; 46(5): 271-3.
- VATAP. A systematic review of clinical predictors of outcomes in adults with recent major lower limb amputation. 2005. Available from: [http://www.va.gov/VATAP/amputation\\_topic.htm](http://www.va.gov/VATAP/amputation_topic.htm) .

- Vigier S, Casillas JM, Dulieu V, Rouhier-Marcet I, D'Athis P, Didier JP. Healing of open stump wounds after vascular below-knee amputation: plaster cast socket with silicone sleeve versus elastic compression. *Arch Phys Med Rehabil* 1999 Oct;80(10):1327-30.
- Volpicelli LJ, Chambers RB, Wagner FW Jr. Ambulation levels of bilateral lower-extremity amputees. *J Bone Joint Surg* 1983 Jun;65(5):599-05.
- Wagner FW. Transcutaneous Doppler ultrasound in the prediction of healing and the selection of surgical level for dysvascular lesions of the toes and forefoot. *Clin Orthop Relat Res* 1979 Jul-Aug;(142):110-4.
- Wagner WH, Keagy BA, Kotb MM, Burnham SJ, Johnson G Jr. Noninvasive determination of healing of major lower extremity amputation: the continued role of clinical judgment. *J Vasc Surg* 1988 Dec;8(6):703-10.
- Waters RL, Perry J, Antonelli D, Bishop H. Energy cost of walking of amputees: the influence of level of amputation. *J Bone Joint Surg Am* 1976 Jan;58(1):42-6.
- Waters RL, Mulroy S. The energy expenditure of normal and pathologic gait, *Gait Posture* 1999 Jul;9(3):207-31.
- Weiss SA, Lindell B. Phantom limb pain and etiology of amputation in unilateral lower extremity amputees. *J Pain Symptom Manage* 1996 Jan;11(1):3-17.
- Williams RM, Ehde DM, Smith DG, Czerniecki JM, Hoffman AJ, Robinson LR. A two-year longitudinal study of social support following amputation. *Disabil Rehabil* 2004 Jul 22-Aug 5;26(14-15), 862-74.
- Wong CK, Edelstein JE. Unna and elastic postoperative dressings: comparison of their effects on function of adults with amputation and vascular disease. *Arch Phys Med Rehabil* 2000 Sep;81(9):1191-8.
- Woodburn KR, Sockalingham S, Gilmore H, Condie ME, Ruckley CV; Scottish Vascular Group; Scottish Physiotherapy Amputee Research Group. A randomised trial of rigid stump dressing following trans-tibial amputation for peripheral arterial insufficiency. *Prosthet Orthot Int* 2004 Apr;28(1):22-7.
- Yagura H, Miyai I, Suzuki T, Yanagihara T. Patients with severe stroke benefit most by interdisciplinary rehabilitation team approach. *Cerebrovasc Dis* 2005 Aug 22;20(4):258-63.
- Yeager RA, Moneta GL, Edwards JM, Taylor LM Jr, McConnell DB, Porter JM. Deep vein thrombosis associated with lower extremity amputation. *J Vasc Surg* 1995 Nov;22(5):612-5.