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Center for International Rehabilitation Research Information and Exchange (CIRRIE)
515 Kimball Tower
University at Buffalo, The State University of New York
Buffalo, NY 14214
E-mail: ub-cirrie@buffalo.edu
Web: http://cirrie.buffalo.edu

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Amputation

Jibby E. Kurichi, MPH
Project Manager
Center for Clinical Epidemiology and Biostatistics
University of Pennsylvania School of Medicine
Philadelphia, PA, USA

Barbara E. Bates, MD, MBA
Associate Chief of Staff for Quality Management, VAMC Albany, NY
Assistant Professor, Physical Medicine and Rehabilitation, Albany Medical College
Albany, NY, USA

Margaret G. Stineman, MD
Professor of Physical Medicine and Rehabilitation and Epidemiology
Department of Physical Medicine and Rehabilitation
Senior Scholar Center for Clinical Epidemiology and Biostatistics
University of Pennsylvania School of Medicine
Philadelphia, PA, USA

Background

Limb loss is one of the most physically and psychologically devastating events that can happen to a person. Not only does lower limb amputation cause major disfigurement, it renders people less mobile and at risk for loss of independence (Gitter and Bosker 2005). Yet with appropriate rehabilitation, many people can learn to walk or function again and live high quality lives. Despite advances in medicine and surgery, amputation continues to be a large problem in the world, predominantly for older adults. It has been estimated that there were 664,000 persons living with major limb loss in the United States in 2005 and more than 900,000 with minor limb loss (Ziegler-Graham et al. 2008). "Major" limb loss is defined as amputation above the elbow, below the elbow, above the knee, below the knee, or the foot. "Minor" limb loss is defined as amputation of the hand or digits (fingers or toes) (Tseng et al. 2007). Lower limb amputations are much more frequent than upper limb and are most commonly the result of disease followed by trauma. This article focuses on lower limb amputation with emphasis on studies particularly within the United States because of the comprehensive databases that are available.

Worldwide prevalence estimates of amputation is difficult to obtain, mainly because amputation receives very little attention and resources in countries where survival is low (Aleccia 2010). The overall rates of amputation due to trauma or malignancy are decreasing while the incidence of dysvascular amputations is rising (Dillingham et al. 2002). Amputations due to dysvascular disease accounts from roughly 54% of limb loss cases in the United States, while traumatic amputations account for 45% of loss (Aleccia 2010). The number of lower limb amputations is expected to increase in the United States to 58,000 per year by 2030 (Cutson and Bongiorni 1996; Fletcher et al., 2002), with nearly 75% occurring in those aged 65 and older (Clark et al. 1983).

The United States has a higher lower limb amputation rate compared to other developed countries (Renzi et al. 2006). The Marshall Islands have been identified to also have a very high rate of lower limb amputation, by world standards (Harding 2005). From 1991-2000, rates of diabetes related to lower extremity amputations decreased in The Netherlands (van Houtum et al. 2004). In a World Health Organization multinational study of vascular disease in diabetes, the results showed that the incidence of lower limb amputation was higher in the American Indian centres than in the East Asian centres (Chaturvedi et al. 2001). Moreover, the earthquake that shook Haiti in 2010 ranks among the largest ever loss of limbs in a single natural disaster (Aleccia 2010).

Amputation Etiology

Limb loss can be the result of trauma, malignancy, disease, or congenital anomaly. Vascular disease is the most common cause of limb loss overall, with the rate of dysvascular amputation being nearly 8 times greater than the rate of trauma related amputations, the second leading cause of limb loss (Amputee Coalition of America 2010). Diabetes mellitus is also present in almost half of all cases, and people with diabetes mellitus have a 10 times higher risk of amputation (Carmona et al. 2005). Cancer related amputations are a rare cause for lower limb amputation (Dillingham et al. 2002).

Diagnoses likely contributing to limb loss can be grouped into related categories (Dillingham et al. 2002; Dormandy et al. 1999; Ebskov 1992; Mayfield et al. 2000; Stroke Unit Trialists' Collaboration 2002) according to International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code specifications. Common etiologies of lower limb amputation include: chronic osteomyelitis, congenital deformities, device infection, diabetes mellitus type I or type II, local significant infection, lower extremity cancer, previous amputation complications, skin breakdown, peripheral circulation problems, trauma, and systemic sepsis (Bates et al. 2006). Table 1 shows one classification scheme of how contributing etiologies for lower limb amputation are expressed from ICD-9-CM codes. In actuality, limb loss is often multi-factorial since patients may have evidence of one or more of the following contributing categories of conditions.

Table 1. Conditions Contributing to Etiology of Lower Limb Amputation

Diagnostic Description	**ICD-9-CM Codes**
Chronic Osteomyelitis: chronic osteomyelitis of pelvic region and thigh, lower leg, ankle, and foot	730.15-730.17
Congenital Deformity: transverse deficiency of lower limb, longitudinal deficiency of lower limb	755.31-755.39
Device Infection: vascular device, internal orthopedic device, tissue graft, joint prosthesis	996.1, 996.4, 996.52, 996.62, 996.66, 996.67, 996.69, 996.7, 996.74
Diabetes Mellitus: diabetes mellitus type I with and without manifestations, diabetes mellitus type II with and without manifestations	250-250.93
Local Significant Infection: gangrene, actinomycotic infections, cellulitis, pyogenic arthritis, infective myositis, necrotizing fasciitis	040.0, 395, 440.24, 681.10, 682.6-682.8, 711.06, 728.0, 728.86, 729.4, 785.4
Lower Extremity Cancer: malignant neoplasm of pelvic bones, sacrum, coccyx, long and short bones of lower limb, connective tissue of lower limb including hip, skin of lower limb including hip	170.6-170.8, 171.3, 172.7, 173.7
Previous Amputation Complication: infected amputation stump	997.62
Problems with Peripheral Circulation: atherosclerosis, aortic aneurysm, venous thrombosis, arterial stricture or stricture of graft, circulatory disease, venous insufficiency, organ or tissue replaced by blood vessel, gangrene, vascular complications of other vessels	440.0-441.9, 442.3, 443.1-443.9, 444.0, 444.81, 447.1, 453.8, 459.81-459.9, 557.1-557.9, 785.4, 997.79, 38.48 (procedure), 434 (procedure)
Skin Breakdown: ulcer or decubitus ulcer of lower extremity	440.23, 454.0, 454.2, 707.0, 707.10, 707.12-707.9
Systemic Sepsis: septicemia, gram negative septicemia, E.coli, other type of systemic sepsis, bacteremia	038.11, 038.40, 038.42, 038.8, 038.9, 790.7
Trauma: acute osteomyelitis, closed or open fractures to lower extremities, fracture of one or more phalanges of foot, trauma to AKA or BKA, open wound to lower limb, burns of lower limb, fracture of lower limb, open wound of lower limb, late effects of injuries, poisonings, toxic effects, and other external causes, crushing injury of lower limb	730.05-730.08; 820.8, 821.21, 821.23, 821.30, 823.82, 823.92, 824.1, 826.0, 837.0, 890.1-890.2, 891.1-891.2, 892.1-892.2, 893.1-893.2, 894.1-894.2, 897.0-897.2, 905.4, 928.0-928.8, 945.22, 945.25-945.26, 945.32-945.33, 959.6-959.7

Mortality Following Lower Limb Amputation

Mortality following a lower limb amputation is quite high among those whose amputations are of a dysvascular or diabetic etiology. Thirty-day mortality rates range from 6.3 to 42.3 percent (Feinglass et al. 2001; Mayfield et al. 2001; Pohjolainen et al. 1989). One study reported that 25.5 percent of patients with lower limb amputations in Finland died within 2 months of the amputation and nearly 40 percent within 1 year (Pohjolainen et al. 1989). Studies in the United States show one year survival following lower limb amputation to range from 50-80% depending on the amputation level (Aulivola et al., 2004; Bates et al. 2007; Feinglass et al., 2001; Pohjolainen et al. 1989). Survival rates at 2 to 5 years are also poor, with over 50 percent of patients dying at 2 years and roughly 70 percent by 5 years (De Luccia et al. 1992; Feinglass et al. 2001; Mayfield et al. 2001; Nehler et al. 2003; Pohjolainen and Alaranta, 1998; Pohjolainen et al. 1989). Congestive heart failure, renal failure, and liver disease were significantly associated with mortality both in hospital, at 3 months, and at one year among veterans. Metastatic cancer was associated only at 3 months and 1 year (Bates et al. 2006).

Survival and Physical Independence

Stineman et al., in a study of veterans following major lower limb amputation for a variety of reasons, identified thresholds of physical independence achievement during rehabilitation associated with improved 6-month survival and compared other risk factors after removing the influence of the grade achieved (Stineman et al. 2009). Grades provide functional status thresholds based on motor Functional Independence Measure (FIM™) (Hamilton et al. 1994) item response profiles that can be clinically meaningful for projecting other outcomes. To be at a particular grade, a patient must be functioning at or above the level specified for each activity. The study found that the 6-month survival rate for those at grade 1 (total assistance) was 73.5%. With the increase of just grade 1 to grade 2 (maximal assistance), survival jumped to 91.1%. This led to the largest incremental improvement in prognosis with survival. In amputees who remained at grade 1, the 30 day hazards ratio for survival compared with grade 6 (independent) was 43.9, sharply decreasing with time. Whereas metastatic cancer and hemodialysis remained significantly associated with reduced survival, amputation level was not significant when rehabilitation discharge grade and other diagnostic conditions were considered, suggesting that the effects of amputation level on mortality is mediated in part through the functional status achieved (Stineman et al. 2009). Amputation level is also a reflection of the burden of underlying disease, particularly vascular, and those needing a higher amputation level probably have greater coronary disease, leading to earlier mortality.

Rehabilitation Following Lower Limb Amputation

Successful rehabilitation following amputation is complex and requires multiple medical, surgical, and rehabilitation specialties. Rehabilitation is important for enhancing the mobility of affected individuals and improving their health and vocational prospects (Pezzin, et al. 2000.

Rehabilitation can occur at several times, places, and consists of many interventions. The Time, Place, Type (TPT) Framework classifies the rehabilitation processes by their timing, place, and types of service (Stineman et al. 2008). "Time" of rehabilitation relates the initiation of rehabilitation to the onset of the disability and/or to the receipt of fundamental non-rehabilitative health care services, such as surgery in the case of amputation. Rehabilitation can begin before the onset of disability (for example in anticipation of disabling procedures such as surgical amputation), immediately after, or at some point in time distant to the onset of disability. For patients with amputation, rehabilitation may start preoperatively, with clinicians preparing patients psychologically for limb loss, supporting them, and explaining future services that can potentially benefit them. Immediate postoperative inpatient rehabilitation occurs directly after the surgical amputation while patients are still hospitalized. Rehabilitation, when applied early, can help avoid issues such as deconditioning or joint contractures. Late rehabilitation begins during a separate hospitalization or visit after discharge from the surgical hospitalization. With the late pattern, patients are discharged to another setting (home, extended care, or other) before beginning rehabilitation. Time is important in understanding how rehabilitation fits within the continuum of care along with medical, surgical, and other types of healthcare services.

"Place" reflects the setting where rehabilitation services are rendered, including inpatient, outpatient, nursing homes, or home (Shojania et al. 2001). Place is particularly relevant to the rehabilitation process and the capacity of that setting to produce a quality outcome. Even more important than to other healthcare fields, the environmental contexts, i.e., where rehabilitation occurs or awareness of the architectural characteristics of where the individual will be living, will determine how well the functional outcomes achieved generalize to the individual's eventual real world living circumstances. Consequently, it is essential to look beyond biomedical concepts towards an ecological framework which envisions how barriers and facilitators in the environment influence an individual's functioning and ability to participate meaningfully in life (Stineman 2001). Architectural modifications and accessibility targeted to barrier reduction can make the difference between people being able to live in their community and needing to go to an institution (World Health Organization, 2001).

"Type" of rehabilitation approximates what is done for the patient. Getting reimbursement for essential environmental modifications can be problematic particularly in the private sector service system. Type can either focus on the detailed treatment components provided or center more broadly on the particular interdisciplinary service bundles or care patterns that are received.

The Veterans Health Administration (VHA) within the United States is one of the largest centralized and integrated health care systems in the world and provides a natural opportunity to compare the effectiveness of alternative care patterns. The population served primarily includes older veterans who have their amputation later in life, and not directly related to war-time traumatic amputations. There are 3 different patterns of rehabilitation care that can be provided to veterans during their hospitalizations for lower limb amputation when time is set to the immediate postoperative period and place to the inpatient setting. These patterns define 3 groups. The first group includes patients with no evidence of inpatient rehabilitation. The second group encompasses those who receive consultative rehabilitation while hospitalized for the surgical amputation, and the third group includes patients who receive rehabilitation on a specialized rehabilitation unit (SRU). Studying the effects of these alternative types of rehabilitation services can provide some insights into the effects of different levels of care in other systems.

In consultative rehabilitation, patients have one to several therapy sessions while hospitalized, therapy may vary from intermittent to regular sessions, and functional restoration is not typically the primary therapeutic focus because rehabilitation occurs on medical or surgical bed units. Alternatively, specialized rehabilitation on a SRU occurs in designated units, which consists of a cluster of beds located in a distinct area in the hospital specifically accredited for rehabilitation services by the Commission on Accreditation of Rehabilitation Facilities (CARF) International. CARF International is a nonprofit, independent accreditor of health and human services, and consists of a family of organizations, including CARF, CARF Canada, and CARF-Continuing Care Retirement Communities (Commission on Accreditation of Rehabilitation Facilities 2000). Specialized care on a SRU in the Department of Veterans Affairs (VA) is roughly comparable to treatment in an inpatient rehabilitation facility (IRF) in a non-VA setting. Restorative therapy occurs daily, and rehabilitation is the primary therapeutic focus. To achieve accreditation, SRUs must meet CARF's explicitly defined standards that are developed to ensure high quality and uniform services across the VA and private sector. To be designated as having a SRU, a Veterans Affairs Medical Center (VAMC) must meet these strict accreditation standards (Commission on Accreditation of Rehabilitation Facilities 2000), thus assuring availability of a specific bundle of highly coordinated multidisciplinary services. Some VAMCs have bed units, while others do not. Moreover, VAMCs with SRUs are known to have a wider constellation of rehabilitation services available.

Only a minority, about 17% of amputees within the VAMC, receive specialized services on a SRU. Amputees who receive specialized services on a SRU are more likely to be in the mid-range of physical and cognitive disabilities. Patients who receive consultation care only tend to have greater illness burden, profound physical and cognitive disabilities, and more serious conditions such as paralysis or renal disease which would logically impact their capacity to participate in the high intensity of care provided by SRUs (Bates et al. 2009). There are no recent estimates available regarding the proportion of lower limb amputees who receive IRF services in the private sector in the United States.

Does the presence of a SRU within the VAMC where surgery occurred, in addition to patient-level characteristics, influence access to rehabilitation services? No differences were found between patients treated at a facility with a SRU and those treated in a facility without SRU beds with respect to age, gender, marital status, living circumstance prior to hospital admission, or amputation level in one study (Bates et al. 2007). Patients with lower initial (admission) FIM™ scores are more likely to be treated in facilities with SRUs, and have longer surgical amputation hospitalizations. Patients at facilities with a SRU compared to those without a SRU have comparable likelihoods of being seen for an initial rehabilitation consultation, but are more likely to be admitted for specialized rehabilitation on a SRU (Bates et al. 2007). The type of rehabilitation services provided appears to be driven in part by the type of services available locally. This has strong implication with regard to the equitability of service access. If a veteran receives an amputation in a VAMC without a SRU, he or she is far less likely to receive specialized care on a SRU. The availability of particular types of rehabilitation services within the hospital where the amputation occurred likely influences access to those services in other health systems in the United States and beyond.

Benefits of Inpatient Rehabilitation among Veterans with Lower Limb Amputation

Although the stroke literature documents the benefits of a standardized multidisciplinary high intensity approach to rehabilitation (Stroke Unit Trialists 1997), it has only been recently that comparative studies have been conducted on the benefits of inpatient rehabilitation following lower limb amputation. Two linked studies within the VHA in the United States were performed using an observational design which statistically reduced the clinical differences between groups making it possible to compare them (Rosenbaum 2002). The first study was to determine the benefits of having some form of acute immediate postoperative inpatient rehabilitation (treatment) over no evidence of inpatient rehabilitation (control). It was understood that through the TPT framework, there is great variability in providing rehabilitation services to veterans with lower limb amputation. The association of outcomes to rehabilitation treatment was studied in data limited to the immediate postoperative time period. This restricted "time" to the immediate postoperative period only and "place" to the inpatient setting. The "type" of rehabilitation services was allowed to vary.

After reducing selection bias, patients who received immediate postoperative inpatient rehabilitation compared to those with no evidence of inpatient rehabilitation were 1.5 times more likely to survival 1-year post amputation, and 2.6 times more likely to be discharged home after the surgical hospitalization. There was no difference in the receipt of a prescription for a prosthetic limb between these two groups (Stineman et al. 2008). These associations support the provision of consultation rehabilitation services in the immediate postoperative time period in a selected group of veteran lower limb amputees.

The second linked study determined if there were incremental benefits of specialized rehabilitation on a SRU over consultative rehabilitation services only among those who received inpatient rehabilitation during the immediate postoperative period. After applying propensity score risk adjustment, there was strong evidence that patients who received specialized rehabilitation on a SRU versus consultative rehabilitation were more likely to be discharged home, receive a prescription for a prosthetic limb, and improve physical functioning. Patients who received specialized rehabilitation on a SRU had higher 1-year survival, but the difference was not statistically significant. The sensitivity of the findings was also considered, and results demonstrated that the findings were unaffected by a moderately strong amount of unmeasured confounding (Kurichi et al. 2009). These findings support the provision of higher intensity comprehensive specialized rehabilitation on a SRU over and above consultation services in the immediate postoperative time period in selected groups of veterans with lower limb amputation.

Dillingham and colleagues applied Medicare claims data to compare IRF outcomes to those of other post acute care settings among dysvascular amputees receiving rehabilitation in the United States private sector (Dillingham and Pezzin 2008). After statistically controlling for initial patient characteristics, 1-year survival was significantly increased in those who received IRF care compared to those admitted to nursing homes or directly discharged home. Also, the number of non-amputation-related hospital admissions and re-amputations were reduced in patients discharged to IRFs relative to the other settings (Dillingham and Pezzin 2008). Among trauma-related amputees, typically a comparatively younger population, the number of nights in inpatient rehabilitation correlated with better vocational outcomes, improved role functioning, increased vitality, and decreased pain (Pezzin et al. 2000).

Prosthetic Prescription

The World Health Organization estimates that in Latin America, Africa, and Asia combined, almost 30 million people require prosthetic limbs, braces, or other devices, up from 24 million in 2006 (Aleccia 2010).

The range of prosthetic devices available following an amputation is extraordinary and varies from basic devices to technologically advanced microprocessor controlled joints. Patients with a new amputation will vary in their potential to benefit from the use of prosthesis. The most fundamental question when developing a prosthetic prescription for a patient is their need for a prosthesis and their ability to adapt to and use the prosthesis. Patient's health status and functional goals should determine the optimal prosthetic device, and the selection of the optimal components within a prosthetic limb must be as careful and driven by clinical characteristics as the selection of the most effective antibiotic for a patient with an infection.

A new study funded within the VA hopes to create biohybrid limbs that use lengthened bone, regenerated tissue, implantable sensors, and titanium prosthetics that will allow an amputee to use brain signals and nerves to move the leg. The goal is to provide veteran amputees, especially war veterans, more control of their limbs, better mobility, and reduce the infections and discomfort that are common with current prosthetics (Lawton 2004).

Prosthetic fitting rates following lower limb amputation ranges from 27-86%, depending on the population studied (De Luccia 1992; Fletcher et al. 2001; Fletcher et al. 2002; Houghton et al. 1992; Pohjolainen et al.1989; Rommers et al. 1996). Patients who undergo trans-tibial amputations compared to those who undergo trans-femoral amputation are more likely to receive a prosthesis, as are those who are younger (Fletcher et al. 2002). Patients with wound healing problems, oncological metastases (Rommers et al. 1996), dementia, and who are receiving renal dialysis (Cutson and Bongiorni 1996) are less likely to be fitted with a prosthetic limb.

Functional Outcomes and Quality of Life

Advanced age, the presence of many illnesses, and above knee amputation are known to retard functional recovery after amputation (MacKenzie et al. 2004; Nehler et al. 2003; Weiss et al. 1990).

In an earlier study of male veterans (median age 62), with amputations due to either critical limb ischemia or diabetes who underwent rehabilitation at 17 months follow-up, 29% were able to ambulate outdoors, 25% ambulated indoors only, and 46% were nonambulatory. Only 42% were using prosthetic limbs. Patients with major limb loss following rehabilitation often remain independent despite infrequent prosthetic usage. This highlights the importance of training for independence at the wheelchair level particularly among those who for various reasons are not considered to be prosthetic candidates (Nehler et al. 2003). In an exploratory analysis, subjective quality of life was rated high among amputees following rehabilitation for prosthetic fitting except in the area of physical functioning which continued to be seen as problematic through the rehabilitative and 3-month follow-up periods. Satisfaction with the prosthesis was strongly related to pain and body image (Zidarov et al. 2009).

Pain Management

Pain secondary to limb amputation is common (Ephraim et al. 2005) . Multiple factors may contribute to the presence and persistence of pain before and after lower limb amputation. Patients may experience immediate postoperative pain or may experience post-amputation pain including residual limb pain or phantom limb pain. In addition, patients with a lower limb amputation may have musculoskeletal pain (low back, hip, and knee pain) as a result of poor body mechanics or arthritis. Pain management strategies, including both pharmacological and non-pharmacological treatments, vary depending on the type and severity of pain.

Residual limb pain occurs in the part of the limb left after the amputation. This pain can be due to mechanical factors such as poor prosthetic fit, bruising of the limb, chafing, or rubbing of the skin. Pain in the residual limb can also be caused by ischemia, heterotopic ossification, or post amputation neuromas.

Phantom pain occurs in the missing or amputated part of the limb(s) or some part of it. Phantom pain was experienced by 42% in one study with over one third of their respondents noting constant or daily pain (Desmond and Maclachlan 2010). Phantom sensations, such as tingling, warmth, cold, cramping, or constriction in the missing portion of the limb, are likely to be experienced by most amputees and may be present throughout their entire life. Phantom sensation should be considered normal and treated only if it becomes disruptive to functional activities.

Conclusions

Amputation is a dramatic, life-altering event that typically results from either disease or trauma. The number of amputations appears to be on the rise despite advances in vascular surgery and diabetes management, and mortality following lower limb amputation is high.

Evidence among United States veterans with lower extremity amputation have shown that inpatient rehabilitation services provided immediately following the surgical amputation improves patient outcomes such as home discharge, survival, physical functioning, and receipt of a prescription for a prosthetic limb. Whiles these findings cannot be expected to completely generalize to non-veterans in the United States or people, who experience limb loss in other nations, we believe the prognostic factors discovered and the general findings related to expectations associated with various types of care provide important insights. Research beyond this population will be essential.

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