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# Pre and post-amputation mobility of trans-tibial amputees: correlation to medical problems, age and mortality

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**Abstract**

This retrospective study compares pre and post-amputation mobility and the influence of age and associated medical problems. Data from the charts of 120 male patients who underwent unilateral trans-tibial (below-knee) amputation at the Dallas Veteran's Administration Hospital between June, 1983 and October, 1991, were collected and analyzed. Mobility was assessed with a six level scale developed by Volpicelli *et al.* (1983). The presence of cardiac disease, pulmonary disease (COPD), peripheral vascular disease (PVD), diabetes mellitus, degenerative joint disease, blindness, cerebral vascular accident (CVA), and age are correlated with changes in mobility after amputation. Older patients had more medical problems and lower post-amputation scores. Individual medical problems did not influence mobility scores, but the presence of COPD and PVD lowered pre-amputation mobility scores. Cardiac disease and diabetes mellitus influenced post-amputation mobility scores by lowering them, either together or individually. Regardless of age, however, patients with more medical problems were poor ambulators. The cause of amputation *per se* did not influence mobility scores.

## Introduction

The majority of amputations performed in the United States are a result of vascular disease or diabetes mellitus or both. Amputation surgery not only removes the pathology but also reconstructs the limb, to allow for prosthetic fitting and subsequent ambulation. Often the medical problem that leads to amputation may influence post-amputation mobility, morbidity and patient mortality. Medical problems unrelated to the cause of amputation may influence mobility and ambulation. Awareness of those conditions which affect patient mobility, are important in the evaluation of the patient's potential ability to use a prosthesis.

The purpose of this retrospective study is to evaluate pre-amputation and post-amputation mobility in unilateral trans-tibial amputees and its association with age and the presence of medical problems. Although several studies have evaluated amputee mobility, most of these have looked at the level of amputation, with no correlation to the concomitant medical problems (Brodzka *et al.*, 1990; Durance *et al.*, 1989; Pohjolainen *et al.*, 1990; Siriwardena and Bertrand, 1991; Steinberg *et al.*, 1985). It has been shown that the more distal the amputation, the greater the likelihood of the patient being a prosthetic user.

## Methods

Data was collected retrospectively from the charts of 120 male patients who underwent unilateral trans-tibial amputation at the Dallas Veteran's Administration Hospital between June, 1983 and October, 1991. The information included age at amputation, number and types of medical problems, cause of amputation, pre-amputation mobility scores and post-amputation mobility scores. Mobility scores were assigned according to the six level scale developed by Volpicelli *et al.* (1983) (Table 1). This tool for evaluating mobility was selected because it contained specific objective criteria for the assignment of scores. The categories used were unlimited or limited community and household ambulator, wheelchair ambulator or bedridden. Other activity scores such as developed by Day

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Table 1. Volpicelli ambulatory status scale

| | | |
|---|---|---|
| Grade I | Wheelchair Ambulator | 1. uses wheelchair at all times;<br>2. able to transfer with prostheses and to propel wheelchair. |
| Grade II | Supervised household ambulator | 1. blind;<br>2. needs supervision during limited household ambulation. |
| Grade III | Limited household ambulator | 1. walks less than 100 feet (30.5 metres) with prostheses in the house;<br>2. uses wheelchair for longer distances outside the house, may use cane, crutches, or walker; and<br>3. able to negotiate indpendently on stairs with rails, carpets, and chairs. |
| Grade IV | Unlimited household ambulator | 1. walks at least 100 feet (30.5 metres) with prostheses in the house;<br>2. uses wheelchair for longer distances outside the house, may use cane, crutches, or walker; and<br>3. able to negotiate independently on stairs with rails, carpets, and chairs. |
| Grade V | Limited community ambulator | 1. walks one to five blocks with prostheses;<br>2. uses wheelchair for longer distances, may use cane or crutches; and<br>3. able to negotiate independently on stairs without rails, kerbs, rough terrain, and public transportation. |
| Grade VI | Unlimited community ambulator | 1. walks at least five blocks with prostheses;<br>2. uses wheelchair for longer distances, may use cane or crutches; and<br>3. able to negotiate independently on stairs without rails, kerbs, rough terrain, and public transportation. |

(Volpicelli *et al.*, 1983)

(1981) were not used because of the availability of the simplified system by Volpicelli *et al.* (1983). Scores were recorded by either the therapist who was following the patient during in-patient or out-patient therapy or by the physician director of the amputation programme.

Data were analyzed using the Statistical Analysis System (SAS) software by an independent statistician who was not involved with data collection. The Spearman rank correlation was used to determine linear relationships between pre and post-amputation mobility scores, number of medical problems, and age at amputation.

Paired multiple conclusions using the Krushkal-Wallis analysis were performed and significance was determined by the Student-Newmans-Keuls procedure. Association between mobility scores and presence or absence of each medical problem was determined with Mantel-Haenszel test.

Table 2. Age, mean number of medical problems, mean mobility scores

| Age | Number | Number of medical problems | Mean mobility score | |
|---|---|---|---|---|
| | | | pre-amputation | post-amputation |
| 20-29 | 1 | 0 | * | 5 |
| 30-39 | 8 | 0.75 | 6 | 5.87 |
| 40-49 | 17 | 1.17 | 4.9 | 5.47 |
| 50-59 | 28 | 1.78 | 4.71 | 4.96 |
| 60-69 | 46 | 1.95 | 4.63 | 4.34 |
| 70-79 | 17 | 2.17 | 4.63 | 4.0 |
| 80-89 | 3 | 1.66 | * | 2.0 |
| 20-49 | 26 | 1.04 | 5.2 | 5.6 |
| 70-89 | 20 | 2.1 | 4.6 | 3.7 |

*none recorded

Table 3. Individual correlation of medical problems, age and mobility scores

| Variable | Spearman correlation coefficient (p value) |
|---|---|
| Age, number of medical problems | +0.28 (p=0.002) |
| Age, post-amputation score | -0.46 (p=0.0001) |
| Number medical problems, post-amputation score | -0.23 (p=0.01)* |
| Pre, post-amputation score | +0.52 (p=0.0001) |
| Age, pre-amputation | -0.25 (not significant)** |
| Number medical problems, pre-amputation score | -0.18 (not significant) |

*N=54, **N=120

## Results

Ages of the veterans in this study ranged between 25 and 89 years, with a mean age of 58 years and a standard deviation of 11 years (Table 2). Age at amputation and number of medical problems were correlated with an r value of +0.28 (p=0.002) indicating that as patients grow older, they have greater numbers of medical problems.

A negative correlation was found between age at amputation and post-amputation mobility score (r-value of -0.46, p=0.0001), indicating that elderly patients did poorer in terms of ambulation than younger patients (Table 3). In the multiple correlation analysis, age at amputation influenced post-amputation mobility scores, decreasing scores by 0.04 for each year over age 25. Age and pre-amputation scores were correlated with an r-value of -0.25, but this did not reach statistical significance. Reasons for the lack of significant correlation between age and pre-amputation mobility score may be that older patients may have greater morbidity or mortality due to the amputation surgery itself.

## Number of medical problems

The number of medical problems ranged from zero to four, with a mean of 1.75. Table 4 lists the number of patients with zero, one, two, three, or four medical problems, their mean age, and mean post-amputation scores. The average age of patients without medical problems is 42 years, compared to 60 years in patients with one, two, or three medical problems, and 66 years in patients with four medical problems. Pre and post-amputation scores in the zero medical problem group were at least one grade higher than all other groups. Mean post-amputation score for patients with one, two or three medical problems was the same, 4.5. The Spearman correlation coefficient of number of medical problems and post-amputation mobility scores had an r value of -0.23, p=0.01. A negative but not significant correlation (r=0.18) was found for the number of medical problems and pre-amputation mobility score. In multiple regression analysis, the number of medical problems was not an independent predictor of post-amputation mobility score (Table 5).

## Mobility score

The mean pre-amputation mobility score was 4.61, tabulated for the 54 patients who had this score listed. The mean post-amputation mobility score was 4.65, but this was calculated using all 120 patients. Pre and post-amputation mobility scores were highly correlated, with an r value of +0.52, p=0.0001. This demonstrated that most patients were able to maintain or improve their mobility after amputation. (Table 2).

## Selected medical problems

Individual medical problems were analyzed

Table 4. Frequency of number of medical problems and means of age, post-amputation mobility scores

| Number medical problems | Number of patients | Age | Post-amputation mobility scores |
|---|---|---|---|
| Zero | 16 | 42.1 | 5.6 |
| One | 30 | 60.3 | 4.5 |
| Two | 44 | 60.1 | 4.5 |
| Three | 27 | 60.4 | 4.5 |
| Four | 3 | 66 | 3.0 |

Table 5. Medical problem and influence on post-amputation mobility score

| Medical problem | Influence on post-amputaion score |
|---|---|
| CAD | -1.26 |
| DM | -1.76 |
| PVD + DM | -0.96 |
| PVD + CVA | -4 |

Table 6. Numbers of patients with each medical problem

| Medical problem | Number of patients |
|---|---|
| Cardiac disease | 31 |
| COPD | 9 |
| PVD | 80 |
| Diabetes mellitus | 76 |
| Degenerative joint disease | 2 |
| Blindness | 2 |
| CVA | 10 |

for influence on either pre or post-amputation mobility scores, and on differences between the pre and post scores. Only two of the seven medical problems showed individual influence on mobility, and three other medical problems showed influence on mobility, and three other medical problems showed influence when in combination with other medical problems (Table 5). The number of patients with each medical problem is listed in Table 6. The total exceeds 120 because some patients had multiple medical problems.

*Cardiac disease*

Cardiac disease was listed as a medical problem for 31 patients. In multiple correlation analysis, this condition negatively influenced mobility, lowering the post-amputation scores by 1.26.

*Diabetes mellitus*

The presence of diabetes lowered post-amputation mobility scores by 1.76. Not surprisingly, the combination of cardiac disease and diabetes had a negative influence on mobility. An additive effect might have been expected, but the combination had nearly the same effect as having either diabetes alone or cardiac disease alone (r=-1.23, p=0.004).

*Cardiovascular accident (CVA)*

There was a significant difference in post-amputation mobility scores between patients with and without CVA. The mean score of patients with stroke was 3.3, while the mean score of patients without stroke was 4.8. The Mantel-Haenszel calculation shows a clear trend to higher scores among patients without CVA. In this calculation, 63% of patients with a score of one did not have CVA, whereas 96% of patients with score six were patients without CVA. No associations were noted between side of CVA and side of amputation or CVA prior to or following amputation among this patient population.

*Peripheral vascular disease (PVD)*

PVD alone had no demonstrable impact on ambulation. However, peripheral vascular disease and diabetes together reduced post-amputation scores by 0.96 (p=0.031). When analyzed in combination with CVA, PVD was shown to decrease mobility scores by more than four.

*Chronic obstructive pulmonary disease (COPD)*

Separately, COPD did not influence mobility scores. In the Mantel-Haenszel calculation a trend to lower scores was found in patients with COPD when compared to those without this disease. Among patients with pre-amputation mobility score 1, 67% were without COPD. Among patients with pre-amputation mobility score 6, 95% were without COPD. The validity and utility of this finding is unclear, since only 5 patients had the disease. An unexpected finding was that the combination of both peripheral vascular disease and COPD lowered the pre-amputation mobility scores.

## Cause of amputation

Chart data was summarized into four possible causes of amputation: trauma, peripheral vascular disease associated with or without diabetes, and infection. Table 7 tabulates the number of patients with each cause. The total is greater than 120 because some patients had multiple causes listed. All diabetic patients for whom infection was a stated cause of amputation were assumed to also have peripheral vascular disease and this cause was added to their data. Cause factors dropped out of the multiple correlation, showing no influence on mobility.

## Discussion

It is well known that younger amputee

Table 7. Number of patients with each cause of amputation

| Cause of amputation | Number of patients |
|---|---|
| Trauma | 15 |
| Infection | 62 |
| PVD associated with diabetes | 79 |
| PVD not associated with diabetes | 14 |

patients ambulate better than the elderly. It is generally assumed that walking difficulties are due to increasing medical complications with ageing. Several reports have noted that increasing age adversely affects mobility (Durance *et al.*, 1989; Steinberg *et al.*, 1985; Siriwardena and Bertrand, 1991). Brodzka *et al.* (1990) noted that non-ambulatory patients had a large number of medical problems and that these were more likely than ageing, to have an effect on ambulation. This was true at all levels of amputation. In this study as age increased, so did the number of medical problems. Even though pre and post-amputation scores were positively correlated, it is the post-amputation score alone that showed statistical significance in relation to age and number of medical problems. It is probable that patients with lower pre-amputation scores have a higher mortality associated with their surgery.

Otteman and Stahlgren (1965) noted serious medical problems in 71% of the patients studied, and that they had a peri-amputation mortality double that of healthier subjects. Ambulation scores in the present study may be higher than expected since selection criteria for patients included referral for prostheses, thus omitting patients in poor health who were thought not to be potential ambulators.

There was no relationship between cause of amputation and the variables of age, number of medical problems, or mobility. The reason for this may be that the categories selected may be too broad, thus making the variability within each category too great for mobility trends to be found.

Several reports have found that coronary artery disease affects walking of amputees (Couch *et al.* 1977; Moore *et al.*, 1989; Reyes *et al.*, 1977; Steinberg *et al.*, 1985). A study of trans-femoral, trans-tibial and bilateral trans-tibial amputees, noted that the incidence of cardiac disease was nearly equal in ambulatory and non-ambulatory patients (Steinberg *et al.*, 1985). There was also an influence on ambulation among trans-femoral and bilateral trans-tibial amputees, but not on unilateral trans-tibial amputees. Weiss *et al.* (1990) reported that amputees with multiple diseases and extensive atherosclerosis were less likely to walk.

There has been no uniformity regarding functional success for prosthetic rehabilitation. Thornhill *et al.* (1986) defined success as prosthetic use three times per week whereas Couch *et al.* (1977) regarded successful prosthetic rehabilitation as prosthetic wear greater than 25% of waking hours.

One of the difficulties of evaluating groups of patients from the literature is that most studies have included bilateral amputees as well as trans-femoral and trans-tibial amputee patients. However, in most of the studies where concomitant medical problems are documented, the reasons for failure to use a prosthesis include debility, dementia, stroke and cardiac problems.

It is well accepted that traumatic amputees in general have better functional outcome. Moore *et al.* (1989) noted that non-ambulatory patients were 15 years older than prosthetic users who were 57.1 years on average. Patients who were regarded as prosthetic failures were much older. In their study only two-thirds of the trans-tibial amputees were prosthetic users.

Some reports have not found an association between diabetes mellitus and the ability of the amputee to walk. The patients in the study reported here showed significantly decreased ambulation in the presence of diabetes mellitus. The combination of diabetes with cerebrovascular accident or peripheral vascular disease was associated with lower mobility scores. One explanation would be that these diabetic patients were poorly controlled or had complications from the diabetes that negatively influenced there ability to walk.

There are conflicting reports about the influence of stroke on patient mobility. However, it would appear that if the amputee patient was ambulatory before the stroke, then continued mobility was possible (Siriwardena and Bertrand, 1991; Varghese *et al.*, 1978; O'Connell and Gnatz, 1989). No trends were noted in patients in this study, most probably due to the low number of strokes in this group.

Chronic obstructive airway disease alone did not appear as an influence on mobility, in the multiple correlation analysis. Patients with pulmonary disease did show a trend toward lower ambulation scores when compared to patients without COPD.

Although this study did not address the presence or absence of psychological problems, it has been shown that patients with cognitive deficits or covert psychiatric illness are severely

hampered in the rehabilitation potential (Pinzur *et al.*, 1988).

## Conclusion

A retrospective chart review of the ambulation of 120 trans-tibial amputees, revealed several factors to be related to post-amputation walking. Older patients had more medical problems and poorer ambulation. Regardless of age, patients with more medical problems had poor ambulation. Coronary artery disease, diabetes mellitus, cerebrovascular disease, and the combinations of diabetes and cerebrovascular accident, diabetes and peripheral vascular disease, and cerebrovascular accident and peripheral vascular disease negatively influenced ambulation. The cause of amputation did not influence mobility scores.

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## REFERENCES

BRODZKA WK, THORNHILL HL, ZARAPKAR SE, MALLOY JA, WEISS L (1990). Long term function of persons with atherosclerotic bilateral below-knee amputation living in the inner city. *Arch Phys Med Rehabil 1990,* **71,** 895-900.

COUCH NP, DAVID JK, TILNEY NL, CRANE C (1977). Natural history of the leg amputee. *Am J Surg* **133,** 469-473.

DAY HJB (1981). The assessment and description of amputee activity. *Prosthet Orthot Int* **5,** 23-28.

DURANCE JP, WARREN WK, KERBEL DB, STROUD TWF (1989). Rehabilitation of below-knee amputees: factors influencing outcome and costs in three programmes. *Int Disabil Studies* **11,** 127-132.

MOORE TJ, BARRON J, HUTCHINSON F, GOLDEN C, ELLIS C, HUMPHRIES D (1989). Prosthetic usage following major lower extremity amputation. *Clin Orthop* **238,** 219-224.

O'CONNELL PG, GNATZ S (1989). Hemiplegia and amputation rehabilitation in the dual disability. *Arch Phys Med Rehabil* **70,** 451-454.

OTTEMAN MG, STAHLGEN LH (1965). Evaluation of factors which influence mortality and morbidity following major lower extremity amputations for arteriosclerosis. *Surg Gynaecol Obstet* **120,** 1217-1220.

PINZUR MS, GRAHAM G, OSTERMAN H (1988). Psychologic testing in amputation rehabilitation. *Clin Orthop* **229,** 236-240.

POHJOLAINEN T, ALARANTA H, KÄRKÄINEN M (1990). Prosthetic use and functional and social outcome following major limb amputation. *Prosthet Orthot Int* **14,** 75-79.

REYES RL, LEAHEY EB, LEAHY EB (1977). Elderly patients with lower extremity amputations: three year study in a rehabilitation setting. *Arch Phys Med Rehabil 1990* **58,** 116-122.

SIRIWARDENA GJA, BERTRAND PV (1991). Factors influencing rehabilitation of arteriosclerotic lower limb amputees. *J Rehabil Res Dev* **28,** 35-44.

STEINBERG FU, SUNWOO I, ROETTGER RF (1985). Prosthetic rehabilitation of geriatric amputee patients: a follow-up study. *Arch Phys Med Rehabil* **66,** 742-745.

THORNHILL HL, JONES GD, BRODZKA W, VANBOCKSTAELE P (1986). Bilateral below-knee amputations: experience with 80 patients. *Arch Phys Med Rehabil* **67,** 159-163.

VARGHESE G, HINTERBUCHNUR C, MONDALL P, SAKUMA J (1978). Rehabilitation outcome of patients with dual disability of hemiplegia and amputation. *Arch Phys Med Rehabil* **59,** 121-123.

VOLPICELLI LJ, CHAMBERS RB, WAGNER FWW (1983). Ambulation levels of bilateral lower-extremity amputees. J. Bone. *Joint Surg 1983* **65A,** 599-605.

WEISS GN, GORTON TA, READ RC, NEAL LA (1990). Outcomes of lower extremity amputations. *J Am Geriatr Soc* **38,** 877-883.