Major Lower Extremity Amputation

Outcome of a Modern Series

Bernadette Aulivola, MD; Chantel N. Hile, MD; Allen D. Hamdan, MD; Malachi G. Sheahan, MD; Jennifer R. Veraldi, BA; John J. Skillman, MD; David R. Campbell, MD; Sherry D. Scovell, MD; Frank W. LoGerfo, MD; Frank B. Pomposelli, Jr, MD

Hypothesis: Major lower extremity amputation results in significant morbidity and mortality.

Design: Retrospective database query and medical record review for January 1, 1990, to December 31, 2001. Mean follow-up was 33.6 months.

Setting: Academic tertiary care center.

Patients: Nine hundred fifty-nine consecutive major lower extremity amputations in 788 patients, including 704 below-knee amputations (BKAs) (73.4%) and 255 above-knee amputations (AKAs) (26.6%).

Main Outcome Measures: Patient survival, cardiac morbidity, infectious complications, and subsequent operation.

Results: Overall 30-day mortality was 8.6%, worse for AKA (16.5%) than BKA (5.7%) patients (P<.001). Thirty-day mortality for guillotine amputation for sepsis control was 14.3% compared with 7.8% for closed amputation (P=.03). Complications included cardiac (10.2%), wound infection (3.5%), and pneumonia (4.5%). Twelve AKA (4.7%) and 129 BKA (18.4%) limbs required subsequent operation. Only 66 BKAs (9.4%) required conversion to AKA (average, 77.1 days postoperatively). Overall survival was 69.7% and 34.7% at 1 and 5 years, respectively. Survival was significantly worse for AKAs (50.6% and 22.5%) than BKAs (74.5% and 37.8%) (P<.001). Survival in patients with diabetes mellitus (DM) was 69.4% and 30.9% vs 70.8% and 51.0% in patients without DM at 1 and 5 years, respectively (P=.002). Survival in end-stage renal disease patients was 51.9% and 14.4% vs 75.4% and 42.2% in patients without renal failure at 1 and 5 years, respectively (P<.001).

Conclusions: Major amputation continues to result in significant morbidity and mortality. Survivors with BKA require revision or conversion to AKA infrequently. Long-term survival is dismal for patients with DM and end-stage renal disease and those undergoing AKA.

Arch Surg. 2004;139:395-399

Major lower extremity amputation is still a commonly performed operation, even in hospitals that emphasize aggressive revascularization for limb salvage. Although some reports document decreasing major amputation rates during the past decade, possibly as a result of increased aggressiveness in revascularization and endovascular intervention, other reports do not demonstrate this relationship in patients with peripheral vascular disease. Major amputation is a commonly performed procedure that is indicated in patients with failed attempts at revascularization, comorbidity or anatomic factors precluding revascularization efforts, and extensive tissue loss or infection. An underlying goal in the care of the patient who requires amputation is to retain the knee joint if possible given its contribution to more efficient ambulation with a prosthesis, requiring less energy expenditure. Multiple studies have documented the increased rehabilitation rate in below-knee amputation (BKA) vs above-knee amputation (AKA) patients, with more than 65% of BKA patients ambulating with prostheses. In contrast, less than one third of AKA patients are likely to rehabilitate with the use of a prosthesis. Likely due to the significant comorbidities of patients undergoing amputation for ischemic disease, perioperative mortality rates range from 0.9% to 14.1% for BKA patients and are significantly worse for AKA patients at 2.8% to 33%. Given that major amputation is an unavoidable component of the practice of any surgeon caring for patients with peripheral vascular disease, we attempted to gain a better understanding of the pa-
patient population that required major lower extremity amputation, including comorbid diseases, revascularization history, and indications for amputation. We also aimed to assess the morbidity and mortality rates associated with major lower extremity amputation at a high-volume tertiary care institution in relation to amputation level and patient-related factors such as comorbid conditions.

**METHODS**

**DESIGN**

Using a computerized vascular registry, a retrospective review of all major lower extremity amputations performed between January 1, 1990, and December 31, 2001, at a single academic tertiary care center was conducted. Our registry contains prospectively accumulated data on patient demographics, comorbid conditions, and indications for surgery. The registry also contains postoperative follow-up information, including complications and the need for subsequent operations. Database and medical record reviews were performed. Dates of death were determined or confirmed using the online Social Security Death Index. Survival was analyzed using Kaplan-Meier analysis. Patient survival, morbidity associated with surgery, and success or failure of the amputation were recorded and analyzed. Assessment of morbidity associated with surgery included stroke, cardiac morbidity (arrhythmia, congestive heart failure, or myocardial infarction), pneumonia, renal failure, and sepsis. Of note, postoperative electrocardiograms, echocardiograms, and cardiac enzyme analysis were not performed routinely but were obtained based on the clinical scenario. Morbidity specific to the amputation site included hemorrhage, hematoma, wound infection, and failure to heal. Failure of the amputation was defined as the need for conversion to a higher level. Demographic data and comorbidities included patient age and sex, DM, ESRD, coronary artery disease, history of myocardial infarction, and history of previous revascularization procedure on the amputated limb. These factors were evaluated in relation to the previously mentioned outcome measures to identify factors associated with increased morbidity and mortality in this patient population. Outcomes were also analyzed with relation to the level of amputation.

**MAIN OUTCOME MEASURES**

Overall 30-day mortality rate was 8.6% for the series. Thirty-day mortality was significantly worse for AKA patients (16.5%) than for BKA patients (5.7%) (P<.001) (Figure 1). Guillotine amputation was required in 70 limbs for control of sepsis; 57 were performed at the below-the-knee level, whereas 13 were performed at the above-the-knee level. Thirty-day mortality was higher for this group of patients (14.3%) than for those undergo-

![Figure 1. Actuarial survival in below-knee amputation (BKA) patients vs above-knee amputation (AKA) patients (P<.001).](image-url)
Cardiac complications occurred in 10.2% and included arrhythmia in 25 cases (2.6%), congestive heart failure in 40 cases (4.2%), and myocardial infarction in 33 cases (3.4%). Systemic complications included pneumonia in 43 (4.3%), renal failure in 25 (2.6%), and stroke in 9 cases (0.9%). Renal failure was considered a complication when those with a creatinine level less than 2 mg/dL had an elevation to above this cutoff postoperatively or when patients with preexisting renal dysfunction had a clinically significant decline in renal function. Subsequent operation was required in 141 limbs (14.7%), including 129 (18.4%) of 704 BKA and 12 (4.7%) of 255 AKA limbs (P < .001).

Complications at the amputation site in BKA patients included hemorrhage or hematoma in 9 (1.3%), wound infection in 39 (5.5%), and failure to heal requiring further operative intervention in 93 limbs (13.2%). These operative interventions included split-thickness skin graft in 2 (0.3%), hematoma evacuation in 2 (0.3%), soft tissue debridement in 7 (1.0%), stump revision in 16 (2.3%), and conversion to AKA in 66 limbs (9.4%) an average of 77.1 days after initial amputation (range, 2-1076 days). Conversion of BKA to AKA was performed for failed BKA, defined as initial nonhealing or additional ulceration within 60 days of amputation, in 40 limbs and progression of ischemia in an additional 26 limbs. Knee salvage was achieved in 95.5% and 87.7% of BKA limbs at 1 and 5 years, respectively, reflecting the fact that most conversions occur early in the postoperative course. No difference was noted in BKA failure rate between DM and non-DM patients. Of BKA limbs, 7.6% of non-DM patients and 6.5% of patients with DM required conversion to AKA. Guillotine amputation was performed in 57 BKA limbs. Delayed closure of the open BKA stump was performed in 49 limbs (6.9%) an average of 6.4 days after initial amputation (range, 2-26 days). Conversion to AKA was performed in 2 and closure by secondary intention occurred in 1 limb. In addition, 2 limbs were not revised due to patient death within 6 days of surgery and 3 limbs were lost to follow-up.

Complications in AKA patients included hemorrhage or hematoma in 1 (0.4%), wound infection in 17 (6.7%), and failure to heal requiring further operative intervention in 10 limbs (3.9%). These included stump revision in 6 (2.4%), soft tissue debridement in 2 (0.8%), split-thickness skin grafting of a granulating open amputation stump in 1 (0.4%), and conversion to hip disarticulation in 1 limb (0.4%). Delayed closure of guillotine AKA stump was performed in 6 limbs (2.4%), an average of 8.5 days after initial amputation (range, 4-21 days), whereas 2 limbs were not closed secondary to patient death within 14 days of initial surgery. In addition, 3 open stumps underwent closure by secondary intention and 1 was lost to follow-up.

Actuarial overall survival was 69.7% and 34.7% at 1 and 5 years, respectively. Survival was not affected by patient sex, history of hypertension, or previous revascularization procedures. The BKA patients had significantly better survival outcomes than AKA patients with survival at 1 and 5 years of 74.5% and 37.8%, respectively, compared with 50.6% and 22.5% for AKA patients (P < .001) (Figure 1). Both DM and ESRD were significant predictors of decreased survival. Survival in patients with DM was 69.4% and 30.9% vs 70.8% and 51.0% in patients without DM at 1 and 5 years, respectively (P = .002) (Figure 2).

In patients with ESRD, survival was 51.9% and 14.4% vs 80.4% and 61.1% in non-DM patients at 1 and 5 years, respectively (P < .001). The significant difference in survival with relation to diabetes or ESRD status persisted regardless of amputation level. In BKA patients with DM, survival was 72.5% and 35.0% vs 80.4% and 61.1% in non-DM patients at 1 and 5 years, respectively (P = .002).

### Table 1: Actuarial Survival According to Renal Function

<table>
<thead>
<tr>
<th>Time, d</th>
<th>At Risk</th>
<th>Nondiabetic</th>
<th>Diabetic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 y</td>
<td>144</td>
<td>67</td>
<td>41</td>
<td>2</td>
</tr>
<tr>
<td>5 y</td>
<td>644</td>
<td>238</td>
<td>89</td>
<td>6</td>
</tr>
</tbody>
</table>

### Table 2: Actuarial Survival According to Renal Function

<table>
<thead>
<tr>
<th>Time, d</th>
<th>At Risk</th>
<th>No Renal Dysfunction</th>
<th>Creatinine Level &gt;2 mg/dL</th>
<th>ESRD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 y</td>
<td>544</td>
<td>259</td>
<td>119</td>
<td>33</td>
</tr>
<tr>
<td>5 y</td>
<td>111</td>
<td>22</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

ESRD indicates end-stage renal disease. To convert milligrams per deciliter to micromoles per liter, multiply by 88.4.
In BKA patients with ESRD, survival was 54.6% and 16.0% vs 77.3% and 44.0% in non-ESRD patients at 1 and 5 years, respectively (P < .001). Similarly, in AKA patients with DM, survival was 48.0% and 17.6% vs 53.8% and 37.6% in non-DM patients at 1 and 5 years, respectively (P = .03). In AKA patients with ESRD, survival was 26.8% and 8.2% vs 54.4% and 25.4% in non-ESRD patients at 1 and 5 years, respectively (P < .001).

Patients who presented with sepsis requiring guillotine amputation had a significantly higher 30-day mortality rate of 14.3% compared with 7.8% in those undergoing elective, closed amputation (P = .03). Despite this significantly higher mortality rate, most survivors of guillotine amputation progressed to operative closure or healing by secondary intention at the level chosen at the initial amputation. Of 70 limbs undergoing guillotine amputation, only 2 (2.9%) required conversion from BKA to AKA.

Major amputation continues to result in significant perioperative morbidity and mortality in the patient population with peripheral vascular disease. The 30-day mortality rate of 8.6% in this series is consistent with that of previously reported data. Systemic complications encountered in this series approximated those documented in previously published reports. Not surprisingly, complications of cardiac nature, such as myocardial infarction, arrhythmias, and congestive heart failure, were the most common and were documented in 10.2% of cases. As has been noted by various other investigators, the increased operative mortality rate in AKA patients, compared with even BKA patients, may reflect their advanced degree of ischemia in combination with their poorer overall medical condition.

This is further reflected in the dismal 5-year survival rate of AKA patients, which was 22.5% in this study. In addition, long-term survival is dismal for amputees with DM or ESRD. Other investigators have documented the especially high operative mortality rates and poor long-term survival in ESRD patients who require major amputation. One such study found these patients to have mortality rates of 3 times higher than patients without renal failure. The current series not only confirms this observation but also extends these findings of poor survival after amputation to nondialysis patients with moderate renal dysfunction as evidenced by serum creatinine levels of greater than 2 mg/dL. Unpublished data from our institution have also demonstrated decreased amputation-free survival in patients with moderate renal dysfunction undergoing limb salvage revascularization procedures compared with those patients without renal insufficiency.

Up to one quarter of patients who require major amputation are not considered limb salvage candidates because of extensive tissue loss or infection present on initial evaluation by the vascular surgeon. This suggests that late referral to a vascular surgeon may play some role in the need for amputation. However, once committed to the decision for amputation, determination of the most likely level of healing plays a crucial role in operative planning. We found that patients undergoing BKA required revision or conversion to AKA infrequently (9.4%), even when the level was determined by the attending surgeons’ clinical assessment alone. This supports previous findings that objective data, such as Doppler systolic pressure measurements, transcutaneous oxygen measurement, fluorescein angiography, and skin thermometry, can supplement but not replace clinical judgment.

Other series have documented rates of conversion of BKA to AKA in the range of 18%. Our lower failure rate for BKA limbs may be partially attributable to the willingness to perform additional procedures, such as operative wound debridement, revision at the same level, or split-thickness skin grafting, in an attempt to salvage the knee joint at all costs. Knee salvage in this series was 95.5% and 87.7% at 1 and 5 years, respectively. Of 638 BKA limbs in which knee salvage was achieved, 29 (4.4%) required additional operative intervention to attain this outcome. In addition to meticulous postoperative wound care, good technical performance of the initial amputation with gentle handling of the tissues also plays a role in the ultimate healing of the amputation wound.

Despite the fact that 30-day mortality rates were significantly higher in the guillotine amputation group, overall outcome in this patient group in terms of amputation healing was higher than one might expect. Of 70 open amputations performed for sepsis, only 2 limbs (2.9%) required conversion to a higher level. The superiority of the 2-stage amputation for wet gangrene has been documented, including 1 randomized study demonstrating the rate of wound complications to be significantly higher when amputation with primary closure is attempted in this patient population.

In summary, major amputation procedures continue to result in significant perioperative morbidity and mortality, likely due to the presence of comorbid disease in the population at risk for amputation. In addition, these patients, especially those with DM and ESRD, have limited 5-year survival. Amputation level determination based on clinical judgment can be successful, especially when additional procedures short of revision to a higher level are performed to preserve the knee.

Accepted for publication December 22, 2003.

This paper was presented at the 84th Annual Meeting of the New England Surgical Society; September 19, 2003; Newport, RI; and is published after peer review and revision. The discussions that follow this article are based on the originally submitted manuscript and not the revised manuscript.

Corresponding author: Bernadette Aulivola, MD, Beth Israel Deaconess Medical Center, 110 Francis St, Suite 5B, Boston, MA 02215 (e-mail: baulivo@caregroup.harvard.edu).

REFERENCES

William F. Flynn, Jr, MD, Arlington, Mass: The data clearly show that patients with major amputations do a lot worse than those with bypass. I am not sure I heard you say this, but intuitively I think that would be simply a statement of the fact that the people who have amputations are sicker than those who have bypass and therefore don’t get offered it or are too far advanced for it. In my practice within the last couple of months I have heard on rounds advocacy of data such as yours as a reason to take an individual high-risk patient and do a bypass rather than amputation because a bypass was safer. That isn’t what you are trying to say, is it, or is it?

Dr Aulivola: That is not what I am trying to say. I agree that the patients who are assessed to be in need of amputation are intuitively sicker than those who are able to undergo revascularization. Another factor that may play a role in the poorer outcomes in the amputation population is the fact that we tend to do quite a bit more preoperative cardiac workup on patients undergoing lower extremity revascularization. Although I don’t have specific data on this, patients undergoing lower extremity revascularization tend to undergo a more extensive cardiac workup and are more likely to have Swan-Ganz catheter monitoring intraoperatively and subsequent monitoring in an ICU setting postoperatively. I think all of these factors may have some contribution to the outcome, and this is an area that should be studied in the future.

Edward M. Kwasnik, MD, Waterbury, Conn: This is certainly a challenging group of patients for those of us who take care of primarily diabetics by choice or by default. Recently, we have incorporated a lot of the newer wound healing techniques such as the VAC [vacuum-assisted closure] device. I know your series spanned about 10 years, the earlier part of which this device was not available, but I was wondering have you had experience with this, and do you think this has contributed to the excellent results you have presented?

Dr Aulivola: It may have. I don’t have data on this. We do use the VAC dressing, and we find it to be successful in many patients. I don’t have any information for you in terms of numbers and again this may have contributed to our good outcomes in terms of keeping the knee in these below-knee amputation patients with wound issues.

Robert Lowe, MD, Hartford, Conn: It is sometimes a very difficult decision to offer a patient either a bypass procedure as a third or fourth operation vs an amputation at that point. Is there anything in your database that would say that a failed redo amputation would lead to a higher-level amputation than what you would have hoped to have achieved if you had not tried one more bypass?

Dr Aulivola: I don’t have any data on whether failed redo revascularizations have impacted the level of subsequent amputation in this patient population; however, that is something that we may be able to look into in the future.

Nick P. Perencevich, MD, Concord, NH: Your paper alluded to some unpublished data about patients who get revascularized with creatinines greater than 2 but are not on dialysis. I was just curious whether you have looked at the amputation-free time in that group of patients vs those on dialysis.

Dr Aulivola: In the lower extremity revascularization populations, amputation-free survival in patients requiring dialysis is significantly worse than in nondialysis patients with creatinine greater than 2. However, both groups have significantly worse amputation-free survival rates than those with normal renal function. These data are in the process of being written up and published.