Original article

Surgical experience and supervision may influence the quality of lower limb amputation

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Aim: Only half of those patients undergoing major lower limb amputations for peripheral vascular disease (PVD) are likely to mobilise on a prosthesis. This study aimed to determine whether a surgeon's experience influenced the quality of the residual limb and thus the likelihood of the stump being suitable for a prosthesis.

Methods: All patients undergoing major lower limb amputations for PVD were recruited prospectively, between August 1992 and July 1996. Following surgery, patients were categorised, by a consultant in rehabilitation medicine, as potentially suitable (group I) or unsuitable (group II) for rehabilitation. Patients in group I were further assessed by prosthetists for limb fitting.

Results: A total of 217 patients underwent 260 amputations for PVD between 1992 and 1996: trans-femoral (TFA) 131, trans-tibial (TTA) 127, and through-knee (TKA) in 2. The 30-day mortality was 12% ($n = 27$). Following surgery, 109 patients were assigned to group I (51%), and 81 patients to group II (37%). The proportion of junior surgeons performing surgery was similar for patients in both groups. Twenty-three amputation stumps (9%) required revision or conversion to a higher level within 30 days. Revisions or conversions were significantly more frequent where the original operation had been performed by an unsupervised junior surgeon rather than a senior surgeon ($P = 0.009$). The rate of defective amputations compromising limb fitting also reached significance when unsupervised junior and senior surgeons were compared ($P = 0.04$).

Conclusions: Rehabilitation of the relatively few amputees who reach the stage of limb fitting is hindered by poor surgical technique in a large proportion of cases. Patients operated on by a more experienced surgeon had a better chance of mobilising without revision or conversion surgery.

Key words: Amputation – Supervision – Quality

It is estimated that only 50% of patients undergoing a major lower limb amputation for peripheral vascular disease (PVD) will become ambulatory after surgery.¹ The relatively short life-span following amputation² makes delay in rehabilitation undesirable. Previous studies have shown that successful rehabilitation of the amputee on a prosthetic limb depends on stump quality,³ but the reported incidence of stump defects that preclude limb

fitting may be as high as 50%.⁴ Surgical trainees do perform major lower limb amputations unsupervised, and a causal relationship between surgical inexperience and defective stump healing has been cited.⁵

This study was designed to determine whether a surgeon's experience influenced the likelihood of a stump being suitable for a functional prosthesis in patients undergoing lower limb amputation for PVD.

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Patients and Methods

Between August 1992 and January 1996, patients undergoing major lower limb amputation for PVD in our unit were prospectively recruited to the study. A consultant vascular surgeon decided the level and timing of the amputation. Senior surgeons were defined as consultants, senior registrars and Calman trainees years 3–6; junior surgeons were Calman registrars, years 1 and 2, and senior house officers. Trainee surgeons were assessed as competent by their respective consultants prior to performing a major lower limb amputation unsupervised. Junior grade surgeons were considered to be supervised if a senior surgeon was present in theatre, either assisting or giving guidance.⁶

Following surgery, patients were categorised as potentially suitable (group I), or unsuitable (group II) for limb fitting by a consultant in rehabilitation medicine. Group I patients were referred to the Disablement Services Centre, Plymouth (DSC), where their stumps were assessed by prosthetists. Stump defects were identified and documented as type A or type B. Type A defects were attributed to poor surgical technique: excess soft tissue, stump too short, stump too long, inadequate myoplasty resulting in a prominent bony 'high spot'. Type B were defects not attributable directly to surgical technique, and included: adherent scar, sepsis, oedema, flexion contracture of the knee greater than 5°. The χ^2 -test ($P < 0.05$) was used to determine any significance between the grade of operating surgeon and the prevalence of type A or type B stump defects.

Results

A total of 217 patients were recruited to the study: 124 men (57%), and 93 women (43%), median age 75 years (range, 31–94 years). Patients who underwent operation by surgeons in the senior and junior groups were comparable for age, sex and prevalence of diabetes. In the patient group, 260 amputations were performed: 131 TFAs (51%), 127 TTAs (48%) and 2 (1%) TKAs. Sixty-five (30%) patients were diabetic. Sixty-one amputations (23%) followed failed vascular reconstruction.

Senior surgeons performed 35% of amputations ($n = 90$), with the remainder by junior surgeons ($n = 170$), supervised in 26% of cases. The grade of surgeon and level of amputation is shown in Table 1.

During the 30-day postoperative period, 9 stumps (6 TFA, 3 TTA) required surgical revision (*i.e.* local shortening) due to failure to heal, non-viability, or wound infection. Seven of these patients went on to be assessed for limb fitting, although 2 were complicated by non-surgical defects (*i.e.* oedema). One of these amputations was performed by a senior surgeon, eight by junior surgeons, five of which were unsupervised. No revised stump required conversion to a higher amputation level.

Table 1 Levels of lower limb amputations by grade of surgeon

Level of amputation	Grade of surgeon			Total
	Senior	Junior (super.)	Junior (unsuper.)	
TTA	46	22	59	127
TKA	0	0	2	2
TFA	44	23	64	131

super. = supervised; unsuper. = unsupervised

Table 2 Revisions and conversions to higher level by grade of surgeon

	Grade of surgeon		
	Senior	Junior (super.)	Junior (unsuper.)
Revisions (<i>i.e.</i> local shortening)			
TFA	1	0	3
TTA	0	2	3
Conversions (TTA to TFA)	3	1	10

super. = supervised; unsuper. = unsupervised

In addition, 14 (12%) amputations had to be converted from TTA to TFA within 30 days. Eight of these patients were assessed suitable for limb fitting following amputation to a higher level. Senior surgeons performed three of the original operations, the other eleven were carried out by junior surgeons, only one of which had been supervised.

There was no significant difference in the rate of revisions or conversions between senior surgeons and supervised junior surgeons, 4/39 (10%) against 3/23 (13%), respectively ($P = 0.74$), whereas unsupervised junior surgeons had significantly poorer results 16/47 (34%; $P = 0.0093$). The revisions and conversions by grade of surgeon performing the original operation are shown in Table 2.

The 30-day mortality rate was 12% (27 patients). There were 109 patients categorised to group I (47 TFAs and 62 TTAs). Significantly more TTA patients were suitable for limb fitting compared to TFA ($P = 0.035$). The 81 patients in group II were bilateral trans-femoral amputees, or had concurrent disease (predominately cardiac, respiratory or cerebrovascular) which precluded prosthetic rehabilitation. Neither of the through-knee amputations was performed with a view to limb fitting.

Of the group I amputees, 22 TFA (47%) and 38 TTA (61%) had defects that compromised limb fitting. Junior surgeons carried out 63% of these operations – 78% of them unsupervised. There was a statistically significant difference in the number of defective stumps following amputation between unsupervised junior surgeons and senior surgeons ($P = 0.04$). The difference in the defect rate between supervised junior and senior surgeons just failed to reach significance ($P = 0.052$); however, there was a striking difference between supervised and unsupervised junior surgeons ($P = 0.00024$). The number of defective amputations by grade of surgeon is shown in Table 3.

Table 3 Defective amputations by grade of surgeon

	Grade of surgeon			Total
	Senior	Junior (super.)	Junior (unsuper.)	
Total TFAs	15	12	20	47
Defective TFAs	8	3	11	22
Total TTAs	24	11	27	62
Defective TTAs	12	3	23	38

super. = supervised; unsuper. = unsupervised

Several stump defects were found to impede the fitting, and subsequent wearing of an artificial limb. A total of 24 defects were found in 22 TFAs; 87% of which were type A, a consequence of surgery. The most common fault was that the stump was too long. Faults were found in trans-femoral amputations performed by all grades of surgeon. Types of defects in TFAs are shown in Table 4.

Forty-eight defects were found in 38 TTAs, but type A defects were less common in these limbs. Of the type B defects (73%), flexion contracture was the most common fault, being present in 15 cases. Of the surgical defects, stump length was the most common fault in 70% of cases. Of the surgical defects, 62% were in cases operated on by unsupervised junior surgeons. Subsequently, 3 stumps required late revision or conversion to higher level due to technical defects. Unsupervised junior surgeons had performed all of these operations. Types of defects in TTAs are shown in Table 5.

Discussion

The decision to amputate an ischaemic limb is never easy even though it may be inevitable. Most would agree that a consultant surgeon should make the decision, and then only after full consultation with the patient and their relatives. Ideally, a consultant in rehabilitation medicine should be closely involved from the outset and the combined skills of physical therapy, occupational therapy and social services should be freely available. There is increasing evidence that a multidisciplinary approach to rehabilitation of amputees is beneficial.^{7,8}

Optimal rehabilitation depends on good initial healing of the stump, which also needs to be of the correct length and shape. This can only be achieved by proper surgical technique. The question then arises whether it is appropriate to allow trainees to carry out the operation, and if so, under what degree of supervision. Other studies suggest that amputations performed for vascular disease by junior surgeons are associated with poorer outcomes.⁵ As surgeons in training currently perform the majority of amputations in this unit, we were prompted to analyse our own results.

Table 4 Type of defects in TFAs by grade of surgeon

Defect	Grade of surgeon			Total
	Senior	Junior (super.)	Junior (unsuper.)	
Type A				
Excess soft tissue	2	2	0	4
Too short	0	0	1	1
Too long	7	1	6	14
Prominent bone	1	1	0	2
Type B				
Adherent scar	0	0	0	0
Sepsis	0	0	0	0
Oedema	0	1	2	3

super. = supervised; unsuper. = unsupervised

Table 5 Types of defects in TTAs by grade of surgeon

Defect	Grade of surgeon			Total
	Senior	Junior (super.)	Junior (unsuper.)	
Type A				
Excess soft tissue	0	0	3	3
Too short	1	2	3	6
Too long	1	0	2	3
Prominent bone	0	1	0	1
Type B				
Adherent scar	4	1	1	6
Sepsis	0	0	0	0
Oedema	5	0	9	14
Flexion contracture	4	2	9	15

super. = supervised; unsuper. = unsupervised

In this study, a significant proportion of amputations required revision or conversion when unsupervised junior surgeons had performed them. This lengthened the hospital stay and delayed rehabilitation. In this series, unsupervised junior surgeons carried out 125/260 (48%) operations, and 77 (61%) of these were carried out as non-elective procedures. Improved results may result if trainee surgeons are more adequately supervised, although a large proportion of defective stumps could be avoided by improved surgical technique regardless of the grade of operating surgeon.

Not all defects have an equal impact on the outcome of prosthesis fitting. Incorrect stump length and stumps with excess tissue are significant and can have a permanent influence on the successful fitting of a prosthesis.⁴ With a short trans-tibial amputation, the energy expenditure level increases by 40%, and by 10% if it is too long.⁹ Excess tissue, particularly in the trans-tibial amputation, may cause problems when attaching the prosthesis, and also compromise the skin over the tibial shaft. In severe cases, the stump may require re-fashioning. Both defects occurred in this study.

The length of the stump affects the alignment of the prosthesis in trans-femoral amputees and determines the choice of prosthetic knee component. The increased energy requirement for a trans-femoral amputee is 20%, and this increases considerably if the limb is mal-aligned. These faults are potentially avoidable by close attention to surgical technique. An appreciation by the operating surgeon of the differing requirements of wheelchair-bound and ambulant patients is essential. The wheelchair-bound amputee requires a longer stump to provide stability when sitting and to act as an effective lever when transferring. Closer co-operation between surgeons and prosthetists should be encouraged to educate and re-inforce the desirable features of an amputation stump in different circumstances. Major lower limb amputation is relatively uncommon and not carried out very frequently by individual surgeons, even in a busy vascular unit. In this study, faults in stump length were common to all grades of surgeon. One explanation of this could be inadequate assessment or understanding of the requirements of amputation in individual cases. Technical defects necessitated more visits by the patients to the limb centre for adjustments by the prosthetists to ensure optimal limb fitting. Although these defects cause delay in early mobilisation, adequate prosthetic fitting can be achieved by alignment and modification of the socket. Ultimately, the majority of amputees can be fitted with an adequate prosthesis.

Conclusions

This study has confirmed the finding of others¹⁰ that approximately half of vascular amputees proceed to limb fitting. Referral rates for rehabilitation for vascular patients have been reported as 40–60%.^{11,12} Of these, approximately 65% of TFA and 82% of TTA amputees will regain mobility outside of their homes using a prosthetic limb.¹³ This study suggests that more experienced surgeons have a lower complication rate following lower limb amputation.

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