

Amputation surgery in the lower extremity—part II

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Introduction

Part I of this contribution was published in the last issue of "Prosthetics and Orthotics International" (Vol. 1, No. 2). This part presents the application of the techniques and considerations previously discussed in a variety of special circumstances.

Vascular disease

Vascular disease has played an increasingly important role in the field of amputation. Atherosclerosis is widespread in Northern Europe, North America and elsewhere in the world and several publications (Hansson, 1965 and Robinson, 1976) demonstrate that over 80 per cent of primary amputations are now performed on patients with vascular disease and this despite a number of significant advances in vascular surgery. Our experience in the Tayside area of Scotland with a very stable population, indicates a figure of 86 per cent (Murdoch *et al*, 1977).

Typically, these patients are elderly and subject to other handicaps which are often multiple (Troup, *et al*, 1973). Mazet *et al* (1959) and Olejniczak (1967) indicate that as recently as twenty years ago some 90 per cent of these patients had above-knee amputations performed.

One event focused attention on the lot of the amputee—the advent of immediate post-surgical fitting of prostheses. Following the first report of Berlemont (1961) experience in a variety of places, notably that of Burgess and Romano (1968)¹ and Sarmiento *et al* (1970), has underlined that a high proportion of these patients can be rehabilitated following successful fitting with a prosthesis. While the emphasis on immediate post-surgical fitting itself has now

diminished a number of centres around the world have achieved similar success. Our own studies have demonstrated that close to 90 per cent can be returned, independent in some degree, to a home environment. We also know that this rehabilitation need take no more than forty or fifty days. However, to achieve this kind of result an integrated programme of rehabilitation with a properly co-ordinated management of concurrent handicaps is required. Moreover, the knee joint should be saved when possible and to achieve this, the accuracy of level selection and the success of surgery are critical. Should level assessment be in error or the surgery fail for any reason the rehabilitation time is doubled.

Once presented for possible amputation the dysvascular patient must be aggressively investigated as every day lost causes deterioration with increasing depression, muscle wasting, the development of flexion contractures and a variety of systemic changes due to inadequate fluid intake. The assessment must be of the patient as a whole and of the vascular tree in particular to decide whether vascular surgery can offer a solution. This usually involves arteriography which, however, is not in itself of particular value in determining any proposed level of amputation (Murdoch, 1967; Burgess *et al*, 1971; Burgess and Romano, 1971). The clinical appearances of the limb remain important providing information about peripheral pulses, frank gangrene or partial ischaemia and particularly the state of the skin. The surgeon need not be put off the lower levels of amputation by hairless, thin, inelastic skin but he will certainly have doubts where there are frank ischaemic ulcers or a severe temperature drop is noted.

For a number of years a variety of ancillary methods of investigation have been available and all provide information of value although, even at this date, one cannot make categorical decisions on the basis of any single technique.

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These methods include plethysmography, skin blood flow and skin blood pressure estimations (Browse, 1973; Lassen and Holstein, 1974), the use of the Doppler ultrasound in providing information about the total blood flow (Barnes *et al*, 1976) and thermography (Murdoch, 1975). Significantly useful results have been claimed for each of these methods. However it is necessary that work continues so that not only the crude level of amputation, for example, above-knee or below-knee, is selected but also in the case of possible below-knee amputation, the precise state of each of the tissues involved can be determined permitting the surgeon to fashion skin flaps appropriate to the individual case, according to the state of the pathology and, if need be, to excise muscle groups which are likely not to survive the assault of the operation. Many of the successes reported in this field have been dependent on the ability to achieve amputation at below-knee level and there is the suggestion that the employment of the posterior flap operation has also contributed (Burgess and Romano, 1968²; Burgess *et al*, 1969; Murdoch, 1970). When it is considered that below-knee amputation is not feasible, and perhaps the final decision should be made only at operation, through-knee amputation, supracondylar amputation such as the Gritti-Stokes and above-knee amputations are all available. Several publications testify to good results from the through-knee amputation (Howard *et al*, 1969; Newcombe and Marcuson, 1972) and similarly good results with supracondylar amputation (Weale, 1969; Martin *et al*, 1967; Middleton and Webster, 1962). However, these publications do not include the composite view of the patient's life after amputation nor, in some instances, indicate on what basis these other levels of amputation have been selected. Whatever technique is employed one must pay respect to the importance of attachment of the muscles to the bone end, sculpturing of the bone end where the bone is divided, high division of the nerve, adequate haemostasis and proper abutment of the skin edges without tension.

In summary, the level of amputation selected should be based on as much information as possible, bearing in mind the value of the knee joint in the rehabilitation of the patient and in the quality of his life thereafter. The surgeon should have some knowledge of the prostheses available and confidence in his prosthetists to

fit the patient competently. The surgery and prosthetic fitting should take place in an environment which ensures the proper treatment of concurrent handicaps, stimulates motivation and assures the patient an adequate follow-up in the fullest terms.

Diabetes

Depending on the population at risk, some 25-50 per cent presenting for amputation for vascular disease suffer from diabetes. The latter are often described as suffering from diabetic gangrene. There is no such single clinical entity. Meggitt (1973) emphasizes this in pointing out that the pathology can be the result of small vessel disease, major vessel occlusion as in atherosclerosis and in the absence of diabetes, neuropathy or infection to which diabetic tissue is more prone. Some or all of these factors may have an influence in a single case and thus each case must be assessed individually. Where there is no major vessel occlusion Meggitt has shown that some diabetic feet can be saved by careful surgery, excising all dead tissue, opening all infected areas and by careful pressure dressings (Figure 1). In some cases local toe amputations,



Fig. 1. Ischaemic and infected foot in diabetes. Wide exploration of tissues in sole of foot with excision of all dead and infected tissues. Sound healing achieved without amputation.

skin grafting and partial foot amputation such as the transmetatarsal procedure are appropriate. It has been shown by Meggitt and later by Wagner (1977) dealing with the same group of patients that Syme's amputation in the diabetic dysvascular patient is a useful procedure which can be performed with confidence provided level assessment has been carefully judged. Experience of the Syme's amputation in atherosclerosis without diabetes has been very variable and is not advocated. Where even a Syme's amputation is not deemed feasible the preponderance of major vessel occlusion in vessels below the knee rather than above the knee will normally permit a below-knee amputation.

Trauma

Amputation in the severe trauma resulting from road traffic accidents, war injuries and the like, can provide many serious but interesting problems. The long established principles will hold and the principal one to conserve all viable tissue should, in the initial operation, be mandatory. In a few cases in those regions where replantation teams have been organized and micro-surgical competence is established the completely severed limb with little local tissue damage should be presented with the patient as soon as possible in case replantation is feasible. (Chung-Wei, Che'en, 1962; Malt and McKhann, 1964). A considerable experience has been gained since these classic contributions although no conclusions can be reached (Editorial B.M.J., 1975; China Med. J., 1975).

The judgement as to whether a tissue is viable or not may be difficult but one should err on the side of conservation. Wounds should be closed when feasible. If there is much doubtful tissue destruction then open flaps should be employed. The contributions of Welch *et al* (1969), Mayfield *et al* (1972) and Brown (1970) suggest that skin traction has still an important part to play in this instance. By this approach and with the aid of plastic surgery joints can be saved and stump length maintained.

The problems that remain are clouded by a philosophical one, namely that given a well motivated patient and a skilled prosthetist even the most badly scarred stumps can be fitted well enough. However, the patients normally concerned have a life expectancy of 30, 40 or 50 years and accordingly the question of re-

construction of the stump when indicated must be formally presented to the patient at an early date. Stump reconstruction is often necessary to ensure that the stump will give the best service to the patient over the years and not interfere with his employment and social aspirations. The further possible procedures that may be discussed include excision of the fibula to increase load bearing area in very short stumps (Spira and Steinbach 1973), osteomyoplasty, scar excisions and mobilizations. Even if stump reconstruction is inconvenient at the time of consultation the patient must be informed of the long term implications of deficiencies in the stump so that he is in a position to make decisions regarding his future. The plastic surgeon in some instances should be consulted at this time to determine what role he may adopt.

Tumours

Osteosarcoma appears generally in the ages between 10 and 20 and continues to present horrifying decisions for the patients, parents and surgeons and, until recently, a five year survival rate of about 20 per cent was the common experience. Dahlin and Coventry (1967) confirmed the typical occurrence around the knee and the place of amputation in treatment. Radiotherapy has not significantly improved the patient's chances of survival although its application as recommended by Cade (1955), has spared many patients needless amputations by reserving the procedure for those most likely to survive. A series of publications since Jaffe's (1972) report on the use of high-dose methotrexate with citrovorum factor have awakened interest in chemotherapy because of the apparent improvement in survival rates. Marcove *et al* (1970) had shown the close relationship between the recognition of pulmonary metastases and death of the patient and so chemotherapy is now employed for treatment of the condition prior to the known existence of any pulmonary metastases and instituted at the time of amputation. Since then publications abound relating experience with a variety of drugs individually and in combination in differing doses (Sutow *et al*, 1974). They highlight in particular methotrexate in massive doses or adriamycin or combinations of both (Cortes *et al*, 1974). Jaffe and Watts (1976) in an editorial comment review the situation and point up some of the pathological and philo-

sophical problems. Much of the emphasis on chemotherapy is based on the view that the time interval between diagnosis of osteosarcoma and the appearance of lung metastases on radiological examination does not represent spread of the disease but rather the unveiling of disease which is already present. Jaffe points out further that while reports confirm that chemotherapy has substantially improved the prognosis in patients with osteosarcoma he wonders whether the results will stand up to the passage of time. Prior to chemotherapy if a patient survived two years he could be considered "cured". It is not possible to say this about the new treatments yet. These drug regimes also carry a high degree of toxicity. There is, therefore, a clear need for collaboration between centres as in the United Kingdom Medical Research Council trial to determine the efficacy of these drugs, their optimum dosage and the best ways of reducing toxic effects.

For the surgeon while chemotherapy slows down the healing of amputation wounds, it also permits amputation through the affected bone provided it is at least 70–100 mm above the most proximal area of bone reaction seen on bone scan. Amputation remains the main weapon of treatment but the way may now be open for resection of tumour rather than amputation in some cases. I wholly agree with Jaffe and Watts' plea for referral of patients to centres staffed by experts who can provide the best overall results.

Soft tissue sarcomas in the extremities

A report by Simon and Enneking (1976) regarding the management of soft tissue sarcomas of the extremities outline their approach and decision leading to radical local resection or amputation. They place particular emphasis on the value of angiography and bone-scanning. Any surgeon contemplating radical local resection should read this paper with care.

Chondrosarcoma

Chondrosarcoma is not normally amenable to radiation and is difficult to categorically exclude in any individual case of chondroma, especially when the tumour is large and in the pelvis. Where X-ray examination, bone scans and the like have been performed, it is often possible to make a categorical diagnosis of chondrosarcoma and proceed to amputation as survival rates are higher than in osteosarcoma.

The pelvic tumours usually require a hind-quarter amputation. Any argument for amputation in other cases will depend on a full histological examination of the tumour removed.

Other tumours for a variety of reasons may bring about the need for amputation but then usually because of failed local excision or progression of the tumour to the point where there is gross bone destruction not amenable to other forms of treatment.

Infection

Occasionally emergency amputation is required in the case of gas gangrene. Otherwise the question of amputation in infection is usually confined to cases of longstanding infection associated often with ununited fractures and partial ischaemia of the tissues. In these cases the infection is walled off and amputation can be carried out through the affected bone.

Congenital limb deficiency

Congenital limb deficiency is comparatively rare in the experience of any one surgeon and, in my view, the management of these cases is perhaps best undertaken by special Centres which by reason of their competence have accumulated a large experience. Even in these circumstances concern about a basic understanding of the nature of the defects and the difficulties in comparing methods of management has been expressed by a number of authors attempting to name and classify the defects. The International Society for Prosthetics and Orthotics took a lead in this regard, following the interest displayed by the Committee on Prosthetic Research and Development at the National Academy of Sciences in the United States, and created a Sub-committee to look at this problem. This group, through a series of workshops, has reached a measure of agreement and the results of their work has been published and tested under field conditions (Kay, 1974). It is intended that further work and trials will be conducted to revise the system as referred to in Part I. There is fairly general agreement that congenital absence of the fibula is best treated by ablation of the foot. On the other hand, in for example, proximal focal femoral deficiency, controversy continues and the debate on surgical management must include procedures such as arthrodesis of the

knee, Syme's amputation, osteotomies and the more exotic procedures such as the Van Ness operation. Other deformities provoke similar controversy. In my view the clinic team, before proceeding to any operation, should have a clear picture of the likely natural history of the deficiency itself and of the patient in different situations. Parents should be fully informed and any decisions taken should be on the basis of a full understanding of the situation.

Limb discrepancy, deformity and paralysis

There remains a broad group of disease and disability categories which result in various combinations of deformity, paralysis and limb discrepancy. This group can provide the most difficult problems as amputation, if employed, is not a life saving procedure, nor indeed is it necessary to promote locomotion. A careful analysis of each of the elements of the problem must be undertaken and the team must have an intimate knowledge of the patient, her family and her aspirations if a correct decision is to be made.

Typical pathologies involved include septic arthritis of infancy, poliomyelitis, tuberculosis with premature closure of the epiphysis, the late effects of trauma and spina bifida. The result may include gross shortening, joint instability, arthritis, degrees of paralysis, deformity, neuropathy and ischaemia.

Westin (1967) in outlining the criteria for leg lengthening points out that the integrity of both hip and knee joints must be carefully evaluated and that in cases of extreme shortening amputation may be the treatment of choice. In his series of twenty-six patients, lengthening from 15 to 60 mm was achieved with residual discrepancies ranging from 15 to 110 mm. Over half the patients had major complications for example dislocation of the hip, fractures, osteomyelitis. This experience suggests that in discrepancies over 130 or 140 mm amputation should be considered.

Each case must be considered on its merits but knee disarticulation and Syme's amputation can be deployed with benefit as the usual cosmetic disadvantages do not apply as, by virtue of the shortening, the bulbous end can be contained within the prosthetic thigh or shank.

Joint instability may result from a variety of causes, for example paresis, architectural deficiencies or the development of arthritis. Each joint must be assessed prior to amputation

as to how it will be affected by amputation and prosthetic fitting. It may be improved by some other surgical procedure, be eliminated by the amputation itself, or be so gross that after amputation it will still require external support with perhaps only marginal benefits. This applies especially to proposed amputations below an unstable knee.

If a joint is arthritic it is amenable to standard treatments such as joint replacement, it may be removed by the amputation or the operation can be carried out through the affected joint.

Deformity of the short limb may be compounded of many factors such as reduction or enlargement of the part, gross wasting and angulation of the major bones or at major joints. The deformity may be eliminated by the amputation or by a separate procedure, for example osteotomy above the level of amputation.

The decision cannot rest solely on functional considerations even in the male. The trap for the operating surgeon is to replace observed ugliness in static terms with an equally unpleasant and irremediable dynamic ugliness. Amputation in these cases may be a valid procedure but often it is only one of a programme of operations designed to ensure an improvement in both appearance and locomotor capacity. Surgeons not faced with prosthetic problems in their normal working lives are strongly recommended to consult surgeons in this field before undertaking the irrevocable step of amputation.

Special situations

Growth period

The surgeon must be especially cautious in undertaking amputation during the growth period. This caution has already been underlined with regard to congenital limb deficiencies but for the most part we are considering the question of trauma in children. Every effort should be made to retain joints and if a joint cannot be retained, the epiphysis may be saved. This should be attempted even when there is major skin loss. Quite extensive areas can be covered by split skin grafts and later, if need be, by full thickness skin. Split skin grafts are able to survive direct and shear forces during the growth period better than they do in the fully mature adult (Figure 2). Even when the epiphysis cannot be retained stumps should be as long



Fig. 2. Below-knee amputation in a boy of 12. Extensive skin loss. Survival of split skin grafts with prosthetic sore some years later. Refitting of PTB socket permitted sound healing.

as possible. If overgrowth of the bone occurs in relation to the soft tissues then trimming of the bone can be performed at later procedures. More proximal amputations should not be performed to avoid these further trimming procedures nor should operations such as epiphyseal arrest be considered. The procedures, therefore, which give the best long term results are clearly through-knee amputations and the Syme's procedure if they are justified on other grounds. In amputations through the shaft of a bone the general principles of tissue management should be maintained. At below-knee level it is my view that an osteomyoplasty should be performed if possible. Later developments such as a valgus deformity can be corrected by an additional surgical procedure as required.

Stump revisions

Revisions of initial amputation surgery are indicated from time to time. They should only

be performed with clear objectives in mind and any procedure should be discussed with the prosthetist as he may be able to offer solutions which avoid surgery. The revision proposed may be required to eliminate adherent scars, bony spikes, neuromata etc. The surgeon in performing these procedures should be sensitive to the requirements of the "ideal" stump. For example, in my view it is rarely sufficient to excise a neuroma which is seen to be the cause of disabling symptoms. It is usually also necessary to reconstruct the end of the stump ensuring secure muscle fixation, a well sculptured bone end, and a newly cut end of the nerve so placed in healthy muscle that it will not be involved again in the development of terminal scar tissue. In longstanding stumps the surgeon should look carefully for evidence of local terminal ischaemia. This can be demonstrated by a significant drop in temperature and sensory changes. Before proceeding to stump surgery it is often worthwhile to consult the vascular

surgeon with a view to possible lumbar sympathectomy. Close co-operation with the prosthetist is essential if the resultant scars are to be properly placed in relation to the load bearing areas.

In vascular cases it is all too common an experience for surgery to fail at below-knee level as the precise level of tissue viability is often difficult to determine. Before proceeding to a knee disarticulation or above-knee amputation the surgeon should carefully consider whether local excision of ischaemic and infected tissues can be done with a reasonable hope of primary wound healing and the retention of a useful below-knee stump. The author recommends a wedge resection certainly in those cases who have had a posterior flap amputation performed (Figure 3). In this procedure an undissected wedge of tissue is excised. After outlining the incisions to encompass the tissue, sharp dissection proceeds through the retained gastrocnemius muscle posteriorly to above the level of the affected tissue and the wedge is then removed en bloc by taking a Gigli saw upwards through soft tissue and bone alike. After minor bone sculpture at the anterior distal end of the

tibia wound closure can be affected in a neat and precise way.

Amputation in the anaesthetic limb

Amputation in this situation is usually considered in cases of high sciatic nerve damage, leprosy, spina bifida etc., and becomes necessary because of intractable infected trophic ulcers which have usually invaded bone or joint. The trap for the amputating surgeon here is that he may proceed to amputation at too high a level in an effort to remove anaesthetic skin. He should remember that the skilled prosthetist is able to transfer force actions via the socket in a much better way than is normally effected by footwear for example. The surgeon should consult the prosthetist in selecting the level of amputation in the confidence that the prosthetist will be able to design a socket to transfer the forces of weight bearing without irremediable skin damage. Even in anaesthetic end bearing stumps successful prosthetic fittings have been achieved (Scrivivan, 1973).

Flexion deformities

Flexion deformities are the bane of the surgeon and prosthetist's life. The best treatment is prevention and the clinic team's efforts in this direction must be initiated where possible from before amputation and throughout the period of rehabilitation. It is tempting to give angles of flexion deformity which can be accommodated by the prosthetic design but individual cases are best discussed with the prosthetist. These deformities usually occur as a result of contracting scar tissue or because of sustained flexion prior to amputation. In the latter instance it is usually an elderly patient with vascular disease who has had a long period of enforced bed rest accompanied by severe pain. The trap for the surgeon here is that he may be tempted to operate at a higher level because of an apparent gross flexion deformity. He should leave his final decision until the patient is completely anaesthetized. In the post-operative period splintage of the proximal joint may avoid the development of a chronic flexion deformity. Needless to say the role of the physical therapist is of paramount importance. Harmful stump postures in the rehabilitation period are well known and instruction in their avoidance should be part of the clinic team's programme of management.



Fig. 3. Failed posterior flap amputation. Wedge resection with en bloc removal of infected and ischaemic tissues. Primary wound healing.

Where physiotherapy and prosthetic alignment measures have failed to correct the flexion deformity surgery may be considered. At the hip this would certainly include elevation of the origins of the strap muscles and tensor fascia lata from the anterior superior iliac spine and adjacent iliac crest and division of the ilio-psoas tendon. It may also require elevation or division of the origins of rectus femoris. At the knee it may require division or elongation of the hamstrings and perhaps even division of the posterior capsule of the knee joint.

Recent advances

Skeletal attachment

Work on skeletal attachment of the prosthesis continues. Acceptable clinical solutions have been achieved in individual cases and the main problem relates to the percutaneous interface with the search for biocompatible materials and shapes. Other considerations will assume greater importance when the philosophy is applied to the lower extremity.

Biofeedback training for amputees

This approach appears to have benefits in training the amputee to walk in an optimum manner with his prosthesis and are clearly of great value in the primary, elderly amputee. These techniques are usually based on making the patient aware of the prosthetic knee position, trunk attitude, step length and weight transference by audible or tactile signals.

Stump environment

Since the pioneering work of the Seattle group many Centres employ a rigid cast as the initial dressing following amputation with benefits in terms of tissue stabilization, non-interference with the wound, freedom to move and the ability to exercise the muscle (Burgess and Romano, 1968¹; Mooney *et al*, 1971). Reference has already been made to controlled environment treatment and its benefits. One important aspect of this innovation is that it provides a "laboratory" for the study of wound healing in a controlled environment.



Fig. 4. Gross chronic indurated lymphatic oedema of leg and foot. Result following cyclic pressure in controlled environment treatment device and plastic surgery. No amputation.

Conclusion

The experience of the last twenty years demonstrates that the amputating surgeons need no longer be regarded as they were by Guy Patin in the 17th century

“Mere booted lackeys—a race of extravagant coxcombs who wear moustaches and flourish razors.”

The surgery is now more considerate, more conservative and more in tune with the patient's needs. Indeed the surgeon involved in amputation surgery is perhaps more sensitive to solutions other than amputation because of his awareness of the life of the amputee. Figure 4 shows a grossly ugly leg due to chronic indurated lymphatic oedema of doubtful origin. The patient was presented for amputation. Employing Controlled Environment treatment the oedema was gradually dissipated permitting

plastic surgery and a very satisfactory result without amputation.

It has been demonstrated that this field of scientific endeavour covers the whole range of disciplines in medicine and the physical sciences. It is now clear that the rehabilitation of the amputee does not depend solely on the operating theatre and the prosthetist's shop but that a team approach is necessary if the amputee is to be returned to his home and work, integrated with his prosthesis and the community. There are clear implications for funding authorities in terms of the organization of systems to ensure that all the professional skills are brought together in a collaborative way for the benefit of the patient and underlying all the problems is the need for proper education of all professionals both at undergraduate and post-graduate level.

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