

CHAPTER 41

AMPUTATIONS

FORTUNATELY the number of servicemen requiring amputation of a limb has not been as great in the 1939-1945 as in the 1914-1918 war. The total of 682 among 39,803 Australians wounded in the 1939-1945 falls far below that of 3,241 in the previous war. Surgically this problem becomes significant from the moment of first aid, and continues so during the life of the limbless man. It will be understood that the word "limbless" is used in the sense of "having suffered an injury resulting in the loss of at least part of one limb".

An early technical instruction (No. 22 Middle East) dealt with the handling of men whose injury required amputation. The argument about "guillotine" amputations raised during the 1914-1918 war was renewed among surgeons, but the instruction pointed out that the term guillotine was sometimes interpreted too literally. Amputation performed as to make a straight cross section of a limb was of course usually indefensible. However, in operations done under conditions of war flaps should never contain muscle, on account of the risk of gas gangrene or spreading sepsis, and sometimes it is also necessary to cut straight across the muscular planes at the site of section of the bone. Flaps were left unsutured, but loose coaptation by a few sutures was permitted. Sometimes a few stitches were used to hold flaps back from the stump. The importance of drainage of this primary operation was enhanced by an understanding of the serious sequels possible from an undrained haematoma. The instruction further pointed out that while sites of amputations were in accordance with the usually accepted principles, sentiment should never obscure judgment. Of course conditions made a difference in the choice of the site. It is quite a different matter to amputate a limb obviously too shattered to warrant any attempt at salvage, and to be forced to undertake amputation after unsuccessful treatment of a compound fracture or a suppurative arthritis. In some instances of the latter in the thigh the site would perforce be at a high level, but this operation was often not formidable, as the existence of muscle wasting simplified procedures and blood transfusion before and after largely prevented shock. Such decisions were often difficult to make, even in base hospitals where the whole procedure was deliberate; in forward areas surgeons were particularly warned of their responsibility to patients on whom immediate amputation was necessary, and instructions stressed the importance of drainage and other measures designed to lessen the risk of infection. Conservatism was also important, in regard to the man's future. In war surgery the indications for amputation are severe damage to a limb, in particular where important blood vessels and nerves are seriously injured, and where complications of further vascular accidents and infection may endanger life. The operation is then designed to leave as much useful tissue as is wisely possible. As will be seen later,

the changes wrought by chemotherapy have introduced another factor for consideration. It is not necessary here to give details of methods appropriate to each site. In general it may be noted that the problems raised by injuries of the upper limbs are less serious than those of the lower limbs. In the upper limb infection does not tend to spread upwards so readily, and can be more easily controlled, but drastic measures were sometimes necessary to avert blood infections. The fate of a hand was not always easy to decide, owing to its functional importance, but once its loss was inevitable the site of amputation was not so difficult or significant. The peculiar problems of the wounded hand are discussed in detail in a special section.

Once safety from bleeding or infection has been assured the problem of the limbless man's future must be foremost in consideration. The performance of amputation of a limb must of course be done with the goal of the maximum functional activity of the limb before the surgeon's eyes. In the past re-amputation or at least some surgical re-adaptation of the stump for functional purposes was common. In fact in the 1914-1918 war a long stump was usually left to ensure that enough tissue was available to enable an ideal stump to be prepared later for a prosthesis, but sulphonamides and penicillin have made many primary operations definitive. Thus the limb-fitting surgeon can no longer centre the prosthesis round the ideal stump, he now often has to devise and fit prostheses for stumps which, though functionally practical, he would once have classed as not ideal.

Of course this only sharpened the interest and technical skill of those who since the war of 1914-1918 had been concerned with caring for limbless men, and the introduction of new alloys and methods of design and construction helped further advances. A lecture by Dr R. D. Langdale Kelham, Chief Limb Fitting Surgeon to the Ministry of Pensions, England, was circulated *in extenso* to all medical officers in the army medical services as a technical instruction. This was informative and stated the current views in England. Technical Instruction No. 88 was later issued which may be taken as expressing the general views of the Australian Army Medical Services (see appendix).

In the later years of the war a difficulty presented itself in regard to limb fitting. This was that in Australia there was a dearth of young surgeons who had special experience in this branch of orthopaedic surgery. Need was felt for a rejuvenation of limb manufacture in Australia. Difficulties were considerable in making cineplastic prostheses, which had not kept pace with the surgical developments. At this time Air Vice-Marshal Hurley arranged for a mechanic from the R.A.A.F. to work in the laboratory dealing with prostheses. The step was taken of sending a special delegation in orthopaedics who could report to the medical heads of the armed Services and the Repatriation Commission on the work being done abroad and the requirements in Australia. This delegation consisted of F. H. McC. Callow, B. T. Keon Cohen and J. M. Jens, who presented a report and later published an account which summarised the indications for various types of amputations.

Investigation overseas showed that agreement was by no means universal about the value of certain types of amputation and of the stumps they produced. The wider outlook of recent work, as remarked above, has extended the field in various ways, and future experience alone can solve some of the problems.

Here it is sufficient to state some general and non-controversial principles. In carrying out an amputation the total length of the flaps was taken as at least the diameter of the limb, the muscles were divided at the point of bone section sufficient fascia being preserved to cover the bone. No special treatment was given to nerves other than cutting them after gentle traction. Drainage of the stump was advised for a day or two to obviate haematoma. A technical instruction (No. 44) on the care of amputation stumps directed that a full range of movements in all directions should be maintained in the joint or joints above the site of amputation, and that such pressure should be applied to the stump as could be obtained by the firm application of a crepe bandage. The need for special precautions during the patient's transit to a base hospital was recognised. Therefore, while the preservation of joint mobility was necessary, it was also advisable to ensure that retraction of the tissues on the stump did not occur. To this end traction in a Thomas splint with stockinette and skin glue was advisable.

After penicillin had been made freely available, secondary closure was often safely possible at an early stage after the wounding of the patient. If this could not be done and if re-amputation was necessary, this was carried out at a stage when in the judgment of the surgeon the wound was healthy enough to justify action. Here again penicillin afforded a great measure of security in the control of sepsis.

The fitting of a prosthesis was made simpler and good function was more likely if adequate preparation had been carried out. Physiotherapy and exercise were essential at this stage. In some instances a temporary pylon was fitted to bring about correct shaping of the stump.

If re-amputation was necessary this could be done without waiting for complete healing, and the general feeling was that a general assessment of the patient's general and local conditions was more valuable than the findings from bacteriological culture. Callow, Keon Cohen and Jens stated the local criteria as follows: firm granulation of the surface of the wound, including the sectioned bone; absence of sloughs; minimal discharge; absence of oedema; no radiological evidence of sequestra or bone infection; and a healthy ingrowing skin margin. Skin grafting as a temporary measure was sometimes necessary; if permanent augmentation of skin in the weight-bearing area was required it was necessary to use pedicle grafts of full skin thickness. In these final readjustments penicillin lessened the risk of sepsis and accelerated the whole procedure. Ideally the stump when ready for a prosthesis should then be firm and free from oedema, with the remaining musculature of good function, and there should be no deformity or stiffness of joints. Complications of amputation stumps are important, as even minor disturbances may make the wearing of a

limb impossible. Very little trouble was encountered with the earlier complications, such as spasmodic muscle twitching or pain in a phantom limb. The later complications such as tenderness of the scar, boils or sebaceous cysts belong to the period of after care, but one of these is important from the preventive aspect. This is the formation of an annular roll of tissue over the origin of the adductor muscles of the thigh after amputations above the knee. The full solution of this and other problems relating to the fitting of prostheses to some of the more troublesome types of stump is still receiving close attention from all official organisations dealing with "veterans" of all countries. The British Official Medical History of the war should be consulted for recent work on the subject.

The extension of the principles of plastic surgery to the preparation of amputation stumps for prostheses has introduced a somewhat new aspect of the subject. By the use of the familiar plastic procedures it is possible not only to save time eventually, but also to provide a better weight-bearing area. Therefore the collaboration of the plastic surgeon in this branch of orthopaedic surgery, or at least the adoption of the principles of his work, has conferred definite benefits. These principles were chiefly applied as follows.

Unsatisfactory scars or chronic wounds in relation to weight bearing areas were replaced by flaps of skin and fat, either as cross leg flaps or as migration pedicles from the trunk. Useful joints such as the knee could thus be sometimes retained.

Palliative grafts have been used freely on wounds near amputation stumps so as to promote healing and hasten future reconstruction. Such efforts were of particular value in assuring healing before section of bone in re-amputation was attempted. In the pre-penicillin era breakdowns in these cases were a frequent source of disappointment.

Cineplastic re-amputations were carried out in 2nd Plastic Unit at Heidelberg on a small series, advantage being taken of the collaboration and facilities there. The results were very gratifying particularly in relation to hand prostheses of this type, and were reported by B. K. Rank and G. D. Henderson.

The commission investigating the methods of treating limbless men found some divergence of opinion in England and the North American Continent about the value of various sites for final amputation. In general the mid-tarsal amputation of the fore-foot was not approved as it created an *equino-varus* deformity. Other modifications of this were under trial. The Syme amputation was one of the most controversial. In England more than half the men with this amputation resulting from war wounds in 1914 have had re-amputations, and only 20 per cent of the remainder were able to tolerate full weight-bearing on the end of the stump. In Canada experience was different, and re-amputation was unusual. In the United States also there was confidence in this operation which was still being performed. Examination of men with a long history of Syme's amputation showed, however, that deterioration was not unlikely. Various reasons are given for this, some due to faults in the technique of fashioning

the flaps, or to later defects in blood supply, others due to faults in the prosthesis. There seems no doubt that this operation calls for great precision, following the original description of Syme, for close post-operative care and the provision of a light prosthesis whose attachments do not constrict the blood supply.

In the leg, stumps not longer than 5 or 6 inches were preferred, and in the thigh, stumps not longer than 10 inches. Here too, and also in the fitting of a limb after disarticulation of the knee joint it seemed as if the last word had not been spoken. Though the longer stumps have given trouble, they are not alone in this, and recent work in Canada and U.S.A. indicates that satisfactory results may be attained in circumstances once thought unfavourable. As pointed out before, the long stump may be more frequently seen owing to the possibility of securing earlier healing without much risk of sepsis. The ideal length of the stump in mid-thigh amputation is stated at ten to twelve inches of femur from the tip of the great trochanter.

In the upper limb functional considerations are different. Consideration of the hand is paramount. This is dealt with elsewhere. Vascular deterioration may occur in upper limb stumps also. Disarticulation at the wrist joint has been associated with vascular and mechanical troubles, but improvement and lightening of the appliances may yet preserve its value. In forearm stumps the same may occur, but here too it is possible that the objections to stumps longer than the "ideal" 7 inches from the tip of the olecranon may be overcome by lighter and better prostheses. The value of the unaided arm stump must always be remembered with the great advantage of direct skin sensation. Amputation through the upper arm usually needs 4 to 8 inches of humerus from the acromion. The Krukenberg claw forearm, with certain advantages of application of direct muscular force and of useful sensation has not been used in the Australian forces. Cineplastic operations have been mentioned, but cannot be dealt with here. They require a cooperative intelligent patient, capable of a high degree of muscular training, a close alliance of orthopaedic and plastic surgeons, and a great expenditure of specialised knowledge and technical skill in constructing a practical prosthesis. The future will surely see many improvements in prosthetic appliances. Material and mechanical devices are now more varied and applicable to a wider range of disability. Moreover the peculiar problems will receive fresh consideration, and cortical cerebral function should be able to be expressed better through mechanical means.

This history does not follow through into the post-war period, and hence is not concerned with the activities of the Australian Repatriation Commission. Though the after care of men who have suffered amputation of a limb naturally concerns the Repatriation medical service, the fitting of prostheses and rehabilitation of these men concerned also the medical services of the army, navy and air force as an important part of their responsibility while they had full charge of the large base hospitals. The necessary training to prepare men to face the world after amputation began

in the base hospitals once the stump was firmly healed with a painless scar and could be handled without discomfort, and when the most rapid degree of shrinkage was over.

LEG TRAINING

The first important point in training was to ensure that the prosthesis was worn for only short periods during the first few days, to avoid possible damage to the stump. The art of balance and of walking then were taught, two sticks being allowed first and later dispensed with. Walking along lines and in front of mirrors as practised in oversea centres has been found of great value. Later patients were trained to walk over obstacles, to negotiate stairs and to mount vehicles with confidence.

ARM TRAINING

This is of great importance, as a man lacking an upper limb is much more likely to use a prosthesis to full advantage if his training begins early, so that he may be helped over the most difficult stages. Effort was directed towards encouraging the man to use both arms. Where classes could be organised for special instruction in every day activities, especially those of domestic and industrial nature, progress was more rapid and satisfactory. Some effort was made at Heidelberg and Concord Military Hospitals to construct and use "panels" of all varieties of domestic fittings and public utilities.

Ideally close cooperation should be maintained between the designers and makers of prostheses, and the surgeons responsible for the preparation of a suitable stump. Thought has also to be given to the probable future activities of the patient, so that he may early acquire confidence and cooperate in learning new muscular adjustments necessary and the applications of his prosthesis if he can be fitted with one, to everyday life.

Economic training is of the first importance. It is beyond our present scope, but it is obvious that from the first surgical steps taken to repair the damage of war thought must be given to the fitting of each man in an altered state into a community of people who cannot fully understand his difficulties. That a wider range of occupation is opening out before men who have lost a limb is a challenge not only to the medical profession but the whole of society.

AMPUTATIONS IN JAPANESE PRISON CAMP HOSPITALS

Amputations were unfortunately necessary to relieve the inescapable sufferings of men with severe so-called "tropical" ulcers of the legs in the various Japanese-controlled working camps and associated hospitals. The subject of tropical ulcers is dealt with in the section on medicine and surgery in captivity, from the clinical aspect, and the fuller story of the Australian medical officers' work in these hospitals will be told more adequately in the operational volume dealing with the South-East Asian Area. Here only a brief reference can be made to the methods

adopted. Amputation was a risky procedure on these debilitated men, faced with daily hazards of cruelty, malnutrition and tropical disease. Spinal anaesthetics were usually employed.

Captain F. J. Cahill, A.A.M.C., in reporting a series of 420 men suffering from tropical ulcers in Tanbaya camp hospital, described the almost incredibly unfavourable circumstances under which amputation became necessary for the rapid spreading of these ulcers. The tibia was often exposed and wide-spread sepsis was very common. Amputation was done on 40 men, at first as low a site as seemed advisable being chosen, but the site of election too often ran through an ulcerated area, and sloughing of flaps was frequent, often with secondary haemorrhage. Cahill found the association of oedematous beriberi with acute ulcer was very often fatal, and in this condition amputation was abandoned. The level of amputation was at mid-thigh in twenty-five cases and the upper third of the thigh in fourteen. Though these men survived immediate operation, only four patients were still alive three months after the last operation. Under more favourable conditions the hazard of spreading sepsis and chronic osteomyelitis in the lower limb could be reduced by an earlier and bolder policy of amputation at a reasonably high level before ulceration spread in the limb. At the stationary hospital finally reached at Nakom Paton Lieut-Colonel A. E. Coates and his colleagues found that by mid-thigh amputation they could avoid the danger of sepsis invading the fascial planes, and could even coapt the flaps to aim at primary healing. It was remarkable that this could be attained in a high proportion of cases. Even so, of 173 men who recovered from amputation at Nakom Paton, half the number, despite satisfactory healing, died at variable periods afterwards from intercurrent disease of infective or nutritional origin. Experiences in several of the camp hospitals in Burma and Thailand showed that conservatism was often dangerous. The most favourable site for amputation was the mid-thigh: the upper third of the thigh was less suitable, owing to the risks of sepsis and secondary bleeding.

In a different category were German surgeons in some of the German prisoner-of-war camps, who were distinctly more radical in outlook than British or Australian surgeons. For various traumatic conditions they advised amputation of a limb in patients who later made a good recovery under conservative treatment by their own medical officers.

APPENDIX

Technical Instruction No. 88

Amputations

Where to amputate—

The teaching now is to leave the shortest stump that will efficiently control the artificial limb.

The passage of time has shown that circulatory disturbances and ulceration occur in the end of long stumps. Long stumps may furthermore prevent the patient being fitted with the most serviceable type of limb. This is noticeably so in long leg stumps in women. The prosthesis available for these is unsightly.

Site of election are—

In the lower extremity:

1. One inch above the ankle joint; the Syme amputation. This is satisfactory only if it is performed using a short non-bulky flap.
2. Five and a half inches, not 4 inches, below the line of the knee joint. A stump shorter than $5\frac{1}{2}$ inches can be fitted with an artificial limb, stumps as short as 3 inches should be preserved.
3. Ten to 12 inches measured from the top of the great trochanter. There must be at least 6 inches of femur for the fitting of an artificial limb.
4. Four inches of femur, measured from the top of the great trochanter, is ideal when only a tilting table limb can be fitted.

In the upper extremity:

1. Seven inches below the tip of the olecranon.
2. Eight inches below the tip of the acromion process. An amputation immediately below the shoulder joint or hip joint is to be preferred to a disarticulation.

It must be insisted that as a primary operation in the forward area the maximum length of limb possible will be preserved. In these circumstances operation will not be carried out at the site of election. The consequences of failure of a sepsis resulting in a limb too short for the most suitable prosthesis are too serious for this risk to be undertaken.

Skin Flaps—The aim is a linear scar, free from folds, away from pressure and freely mobile.

A linear scar implies freedom from infection, this irrespective of whether the suturing is carried out as a primary delayed or secondary procedure. A scar without puckers implies that the skin edges must be of equal length. This is easy to achieve if the flaps are of equal length. It is, however, not so simple if they are of unequal length, the common procedure to effect a posterior scar, then the posterior flap should encroach on the anterior half of the circumference. The skin incisions should be tapered, not rectangular as in operative surgery demonstrations. A coronal wound heals better than a sagittal. The old fashioned operation of equal lateral flaps will not be carried out unless the skin loss prevents antero-posterior flaps.

A mobile scar is obtained by the avoidance of haematoma formation or infection. In the lower extremity a scar that is a little posterior is to be preferred. The flaps consist of skin and subcutaneous tissue only, the muscle is cut circular fashion at the point of section of the bone. The bone is divided at right angles to the shaft. The periosteum is not disturbed prior to or after section of the bone.

In the leg the sharp anterior edge of the tibia is removed and the fibula cut across one to one and a half inches higher than the tibia.

The nerves should be cut cleanly at a slightly higher level than the muscles but should not be roughly pulled down to do so. They should neither be crushed nor ligatured unless to control haemorrhage. The end of the bone is covered with *skin and subcutaneous tissue only*.

Formerly when stumps were end-bearing the aim was to prevent a conical stump, stumps are no longer end-bearing and a conical stump is to be desired.

Whether the flaps will be sutured immediately or as a delayed primary or secondary procedure will be determined by:

- (a) The condition for which the amputation was performed.
- (b) The time that had elapsed between the injury or onset of the pathological condition.
- (c) The condition of the tissues as revealed at operation.

If this technique is carried out in forward areas the risk of gas infection spreading in the muscle is to some degree obviated as the muscle has been excised to the level of the line of section of the bone. A few coapting sutures can be used at any period of from 36 hours to a few days.

In forward areas flaps will not be sutured at the time of the original operation.

Amputation through the knee joint, as a temporary expedient in cases of irreparable injury below the knee or intractable septic arthritis has a definite value. Because

of the few structures interfered with amputation through the knee joint is associated with less haemorrhage and shock and is more quickly carried out than any other amputation through the leg or thigh.

Injury about the wrist—If an amputation is inevitable nothing is gained by saving the inferior radio-ulnar joint. The attachment of a prosthesis to a stump in which the inferior radio-ulnar joint has been retained presents difficulties of such a nature that normal pronation and supination combined with a useful mechanical hand cannot be obtained.

Guillotine amputations—The modern amputation is in fact guillotine except for the skin and subcutaneous tissue flaps.

The protection to the large raw area provided by skin flaps, even when such are not sutured, is so beneficial that flaps should be cut wherever possible. There will be few cases where this procedure will not be possible either because of the extent of the injury or the operating time involved.

Guillotine amputation *will not* be a routine procedure and will *only* be carried out in cases of extreme urgency.

Whenever a guillotine amputation is performed or skin flaps are unavoidably short because of the injury to the soft parts skin traction will be applied to prevent retraction.

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