Lower Extremity Amputation: *
Results in Nashville, 1956–1960

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Although extremity amputation is a common operation it evokes little consideration and few discussions. Whether distaste toward its destructive nature, lack of challenge of its rather simple technic or failure to recognize its still high morbidity and mortality causes this general lack of interest, it is remarkable that no general survey of amputations has ever appeared in the Transactions of the Southern Surgical Association, although several reports of specific amputation problems have been presented.

Concern with the current over-all risk of amputation in terms of morbidity as well as death prompted this survey of current practice to ascertain the problem and its scope and in order to look for corrective measures if needed.

Statistics of Clinical Series

Each case record of amputation of all or any part of the lower extremity was individually studied at each of the four major Nashville hospitals for the five years 1956 through 1960 inclusive. These included 140 patients at Vanderbilt University Hospital, 75 from Nashville General Hospital,** and 90 and 80 patients, respectively, from two private institutions, Midstate Baptist and St. Thomas Hospitals. Multiple procedures led to a total of 479 operations upon 385 patients.

The statistical composition of the series is shown in Table 1 and is not unusual. Most amputations occurred in older people, but the number in younger patients due to trauma was not completely expected. Power lawn mowers in particular caused many toe and foot amputations.

The greater attrition of males is known, as is the diabetic predisposition. No distinction was attempted between atherosclerotic thrombotic occlusion and Buerger's thrombo-angitis obliterans, and both are included as arteriosclerosis. Although still somewhat controversial, it appears that Buerger's disease is a particularly inflammatory type of arteriosclerosis often occurring at an early age and is not a completely separate pathologic entity. The remaining statistical summary may be helpful to indicate the over-all pattern of the series.

Two hundred eighty-nine of the amputations were performed by private surgeons (on 252 patients) while 190 operations were performed by various members of the resident staffs (on 133 patients). Figure 1 shows the large number of individual surgeons involved. However, only eight of the 55 operators performed 10 or more amputations within the five-year period, and 33 did less than 10 (which averages less than 2 yearly). This widespread performance of

* Presented before the Southern Surgical Association, Hot Springs, Virginia, December 5–7, 1961.

** Most of the amputations from Nashville General Hospital in the years 1957 and 1958 could not be surveyed due to difficulty with the microfilm system and are omitted.

TABLE 1. *Statistical Summary of 385 Amputation Patients, 1956–1960, Nashville, Tennessee*

Age:	
0–9	11
10–19	21
20–29	30
30–39	21
40–49	27
50–59	73
60–69	80
70–79	72
80–89	47
90–	3
Total:	385 patients (479 operations)
Sex:	
Male 251—65%	
Female 134—35%	
385	
Status:	
Staff	133
Private	252
	385
Hospitals:	
Nashville General	75
St. Thomas	80
Midstate Baptist	90
Vanderbilt University	140
	385
Etiology:	
Arteriosclerosis	220
Arterial embolism	19
Trauma	63
Tumor	22
Osteomyelitis and arthritis	28
Congenital anomaly	18
Miscellaneous	15
	385
Diabetes:	
106—27%	
Site:	
Above knee	260
Below knee	77
Foot	24
Toe	118
Total operations:	479
Anesthesia:	
General	137
Spinal	311
Local	29
Ice	2
	479

amputations leads to the conclusion that it is a quite occasional operation for the majority of operators.

The deaths of 36 patients constitutes a 9.0 per cent gross patient mortality rate (or 8.0% operative mortality rate). If the foot and toe amputations are disregarded the rate of deaths for major (thigh and leg) amputations is 11 per cent (36 of 337). Twenty-nine of the 36 deaths were in patients over 60 years of age.

The summary of causes of death in Table 2 indicates that 30 of the 36 were due to cardiovascular complications or to pulmo-

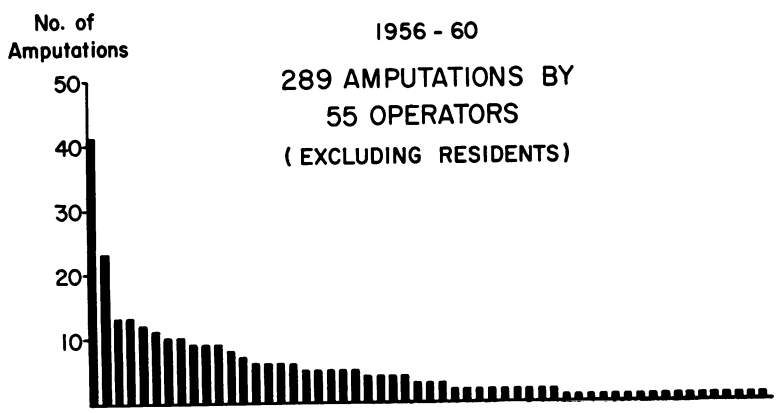

FIG. 1. Number of amputations performed by each of 55 private surgeons. Staff cases are omitted.

TABLE 2. *36 Deaths Following Amputation*

Cardiac infarction and/or failure	10
Pulmonary embolism	9
Aortic graft thrombosis, bleeding, uremia	6
Cerebral vascular accidents	5
Sepsis	2
Uremia	1
Atelectasis—pneumonia	1
Metastatic carcinoma	1
Bleeding ulcer	1

nary embolism. This 83 per cent is comparable to the 77 per cent of deaths due to the same causes in an amputation series studied earlier.[3]

Complications are summarized in Table 3. The large number undoubtedly reflects the precarious situation of many of these patients, particularly the elderly arteriosclerotics. Wound complications were the single most common difficulty, occurring 92 times (with three deaths due to this) in patients with arteriosclerosis and 25 times (without death) in the non-arteriosclerotic group. In other words, 24 per cent of the amputation wounds failed to heal *per primam*. Further examination of these statistics resulted in Figure 2 indicating wound failure rates at different sites of amputation.

TABLE 3. *Complications in 479 Amputations (with Deaths in Parentheses)*

Complication	Cause for Amputation: Atherosclerotic	Cause for Amputation: Other
Wound failure or infection	92 (3)	25
Pulmonary embolism	8 (7)	6
Cerebral vascular accident	10 (6)	6
Heart failure or infarction	16 (13)	2
Renal failure or infection	7 (3)	0
Atelectasis—pneumonia	1 (1)	1
Phlebitis	2	0
Aortic graft thrombosis or bleeding	5 (5)	0
Sepsis	1 (1)	0
Acute thyrotoxicosis	1	1
Stump bleeding	2	1
Acute cholecystitis	1	0
Decubitus	2	0
Bleeding ulcer	1	0
Febrile convulsion	0	1
Major electrolyte problem	1	0
URI	0	1

Other complications listed in Table 3 indicate that pulmonary embolism and complications of widespread arteriosclerosis were particularly likely and were es-

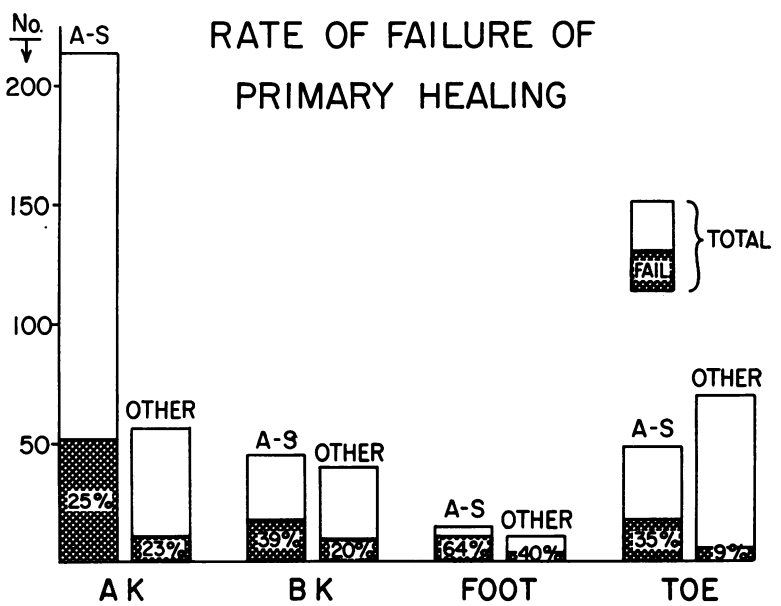

FIG. 2. Rate of wound healing in arteriosclerotic and non-arteriosclerotic cases at various sites of amputation.

TABLE 4. *Statistics Calculated by Total Operations*

	No. Cases	1° Healing Rate %	Complication Rate %	Mortality Rate %
Status: Staff	174	62	50	10
Private	305	79	32	6
Etiology: Atherosclerotic	314	70	47	11
Other	165	88	29	2
Sympathectomy*: Yes	96	65	—	—
No	195	70	—	—
Site: Above knee	260	72	23	14
Below knee	77	62	32	1
Foot	24	50	54	0
Toe	118	79	19	0
Over-all	479	76	38	8

* Only arteriosclerotics considered.

pecially lethal in the postoperative period. It should also be pointed out that since many of the records examined were very sketchy in terms of postoperative notes that this complication rate is a minimal one and it is beyond doubt that many less serious similar complications were not recorded in the charts. Table 4 shows further statistical analysis.

Clinical Management

The current principles of amputation management outlined below do not necessarily reflect the average or even any particular percentage of the analyzed series. They have been determined by an original base of training altered greatly by experience and consideration of personal and other results.

Preoperative Care. Attention to uncontrolled disease and decompensated functional systems is particularly directed toward diabetes and cardiac lesions because of their high incidence in patients requiring amputation. Further, the recognized incidence of failure of wound healing and wound infection demands every possible preoperative attention. *pHisoHex scrubs* for the skin, special attention to sutures and healing wounds near the amputation site, and preoperative *antibiotics* as well as judicious *incision and drainage* of pocketed pus about the toes or foot are important.

Control of absorption of toxins by *icing* and a tight *tourniquet* at the proximal hypothermic region will allow time for compensation of uncontrolled problems of diabetes and heart disease. Delayed proximal amputation will then be better tolerated.[8]

It has been observed often that patients may be toxic and febrile due to a partially gangrenous extremity and that waiting for the fever to subside or the general condition to improve beyond a certain point is not only without benefit but actually harmful as the general situation will continue to deteriorate. Under these circumstances, early rather than delayed amputation is indicated.

Principles of Surgical Technic. Although a discussion of technic may seem unnecessary because of general familiarity with amputations, the following principles are important and the briefly described technic appears to be an efficient and simple one which follows these principles. It

has been arrived at after considerable thought and trials of variations in technic with accumulating experience. Important principles of operative management may be summarized as follows: 1) sufficient skin and soft tissue length in relation to bone length to allow closure without undue suture line tension; 2) amputation level through vascularized tissue, with immediate change to a higher level if nonviable deep tissues are found; 3) avoidance of undue tissue damage; 4) brief stump drainage to allow escape of the sero-sanguinous fluid which inevitably occurs despite meticulous hemostasis; 5) selection of certain cases for open stump management rather than immediate closure; and 6) careful postoperative dressing.

A sharp dissection technic followed stepwise from the anterior aspect of the extremity directly through to the posterior aspect has gradually been evolved as the simplest and most efficient way of performing the amputation.

Rough sponging, inclusion of large bits of muscle or fat in ligatures, excessively tight sutures, and excess foreign body (which includes hematoma and serum collections) are known criteria of poor technic. To be similarly frowned upon are scraping periosteum from the bone end, chemical injections into the nerve, use of large plugs of *bone wax*, and multiple small scapel cuts rather than tissue severance with a long amputation knife.

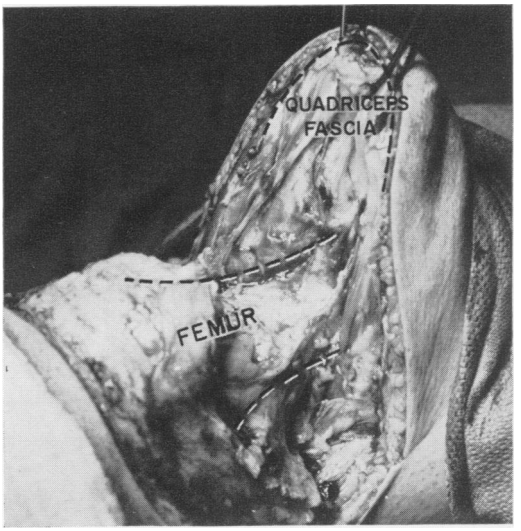

FIG. 4. Anterior skin flap-fascia-muscle flap elevated by Allis clamps and dissection carried to femoral periosteum medially, anteriorly and laterally.

FIG. 3. Relatively long anterior and shorter posterior skin-flaps dissected through deep fascia, and hemostasis obtained with 3-0 chromic gut ties.

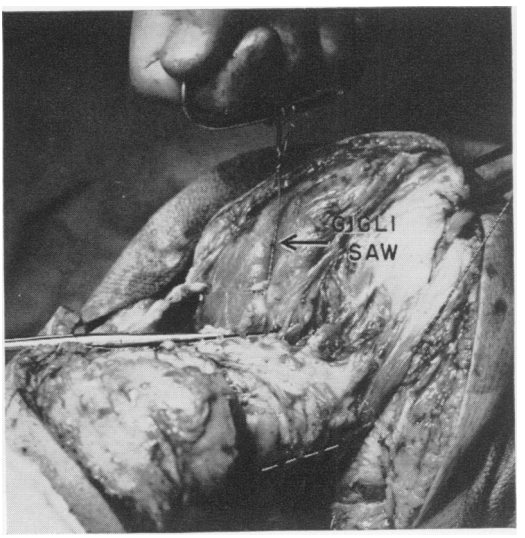

FIG. 5. Gigli saw passed about femur and used to sever this.

FIG. 6. Femoral vessels seized with clamps in their position posterior and medial to the severed femur and cut across.

The desired skin flaps are laid out and dissection carried through to the level of the deep fascia both anteriorly and posteriorly (Fig. 3). After severing the anterior, medial and lateral fascia and underlying muscles or tendons the anterior flap is elevated by means of an Allis clamp (Fig. 4). A curved clamp is passed posterior to the bone and used to pull through a Gigli saw, by which the bone is cut (Fig. 5). A bone holding forceps is placed upon the distal end of the severed bone and with this elevated the main vessels are clamped and cut (Fig. 6).

The long amputation knife is used to sever the posterior soft tissues which remain (Fig. 7). The amputated extremity is removed and 3-0 chromic ties used to control bleeding. The previously severed vascular bundle is dissected so that artery and veins may be individually doubly ligated with 2-0 silk. A single 3-0 chromic tie is placed about the nerve as high as possible to control bleeding and the distal portion cut away. If bleeding continues to occur from the bone end, it is controlled with Gelfoam and pressure. The wound is irrigated with saline. Interrupted 2-0 chromic gut sutures are used to close the fascia, leading a quarter inch Penrose drain completely across the depths of the wound and out each angle (Fig. 8). Additional 3-0 chromic gut sutures approximate the fat of the subcutaneous tissue at strategic places so that the skin flaps lie together without tension. Interrupted 4-0 silk sutures are placed in mattress fashion to additionally support the flaps and a meticulous continuous closure of the edges of the skin* is done with 5-0 Nylon (Fig. 9).

Dressing is accomplished by placing a generous amount of gauze about the ends of the wound to absorb drainage. The Penrose drain is led out from each angle through the dressing and buried very

* Many operative descriptions include "loose closure of the skin," which allows fat to protrude and encrustations to form. Careful edge-to-edge closure is better, with drainage as necessary.

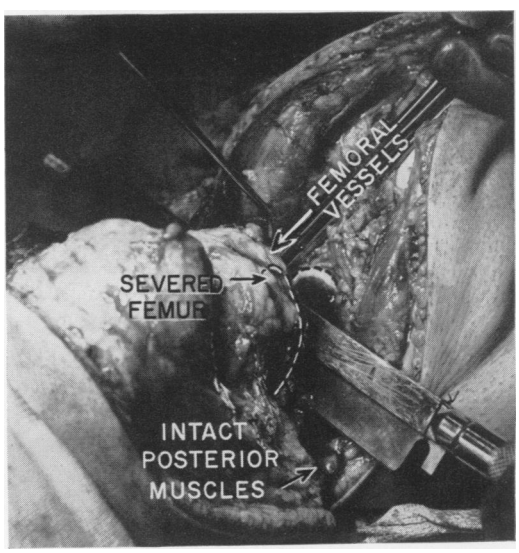

FIG. 7. Amputation knife passed between severed femur and several femoral vessels and used to cut across posterior muscles in line of previously laid out skin flap.

superficially in the dressing (Fig. 9, insert) which is held in place with carefully wrapped elastic bandage.

The photographs indicate an above knee amputation. The same general technic is used below the knee, bevelling the tibia and removing more of the fibula.

While many variations in technic are possible and indeed have been used in this series, it is believed that this particular one requires less assistance, less moving about of the extremity, less soft tissue retraction, immediate control of bleeding with a minimum of clamp application and ligature placement with early removal of the distal amputation specimen. A layer closure of fascia, fat and skin places whatever tension occurs upon fascia and emphasizes prevention of dead space by the wound build-up through fat and skin.

Amputation wounds have a relatively large surface area, and like burns and abrasions, this area exudes fluid despite the most meticulous hemostasis. While our earlier experience emphasized closure of amputations without drainage a later change to 48-hour drainage has allowed better healing with less induration of the wound. In the surveyed series it was not possible to ascertain exactly how many amputation wounds were not drained but it appeared that the great majority were.

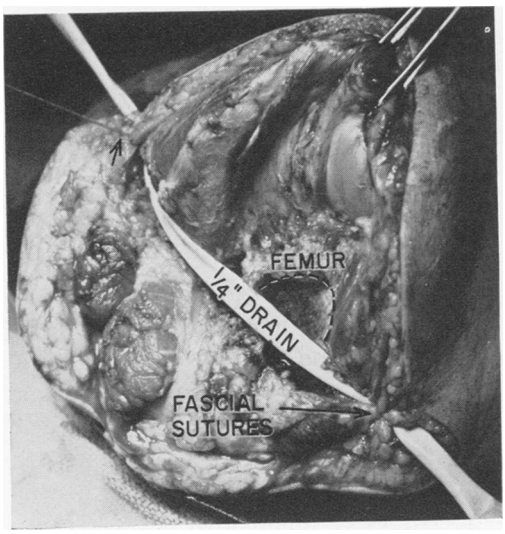

FIG. 8. Following hemostasis with 3-0 chromic gut ties and individual suture ligation of femoral vessels, fascial closure is begun with interrupted 00 chromic gut leading a through and through drain across the bone end deep to the fascia.

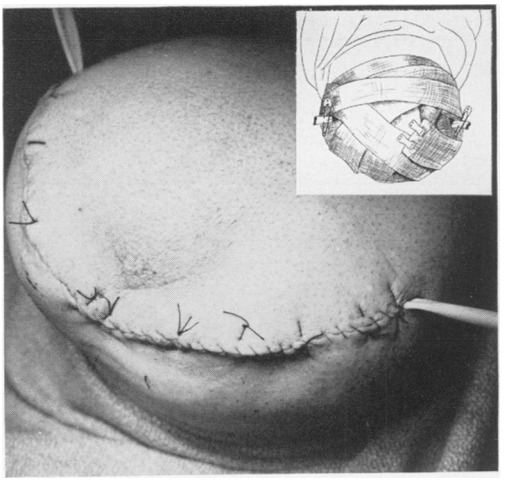

FIG. 9. Following fascia and fat closure with interrupted #00 chromic gut, the skin is closed with a few interrupted mattress sutures of 4-0 silk and the edges are carefully approximated with a loosely placed suture of 5-0 nylon. *Insert,* shows drain led through dressings to allow easy removal later. Ends will be covered.

In summary, it may be said that individual technical variations should all be directed toward an absolutely top notch performance because of the known difficulty with healing of amputation wounds.

Postoperative Management. *Antibiotics* are ordered only for specific indications of actual or suspected infection in the tissues and are not used routinely.

Drain and dressing management require individualization but follow certain principles. Removal of the drain is done at 48 hours by burrowing into the dressing with sterile scissors and cutting one end to allow its removal without changing the entire dressing. Thus the flaps are not at all disturbed until dressing on the fifth day, when any excessively tight sutures are removed,

TABLE 5. *Healing Rates without Revision in Amputations for Atherosclerosis*

	Diabetic		Nondiabetic		Total
	No.	% Healing Without Revision	No.	% Healing Without Revision	Healing Rate %
Sites:					
Above knee	78	95	122	82	87
Below knee	25	92	17	53	76
Foot	13	46	1	0	47
Toes	27	52	28	86	69

leaving most in place for 10 to 14 days. Throughout this period a firm pressure dressing is held in place with carefully wrapped elastic bandages held in place with longitudinal strips of tape so that it does not slip down around the very end of the stump.

After 48 to 72 hours the patient is asked to *lie on the abdomen* for five to 10 minutes three times a day to prevent flexion contracture of the hip and is also encouraged to begin to get about in a wheel chair. If below the knee, the stump is maintained in a posterior hamstring splint continuously throughout the early healing period to prevent knee flexion contracture. Although some patients may use *crutches* in the early postoperative period, particularly if they have learned this before operation, this is actively encouraged only when the patient has regained sufficient balance and strength to be fairly certain that a fall will not occur which might damage the healing stump. An overhead *trapeze* is useful during this period to enable the patient to move about in bed and to maintain muscle tone in the upper extremities and shoulder girdles.

Traction to the skin is unnecessary if the soft tissues have been severed at a proper level in relation to the bone length (and probably will not prevent wound difficulties if this has been done improperly).

Prosthesis fitting is encouraged as soon as the stump is solidly healed (and without the use of a temporary pylon). Not many persons beyond the age of 60 are able to manage a prosthesis satisfactorily. If the patient has sufficient general strength, balance and mental determination to master a prosthesis beyond this age he is encouraged to do so, even though falls are somewhat more dangerous than in younger people.

Management of *stump complications* should be undertaken vigorously by early removal of sutures if infection occurs and by early stump revision if necessary.

Since essentially every patient has some sensation of *phantom* limb, but only a few have a serious problem, a casual explanation of the sensation is made without dwelling upon the possibility of its continuation. The patient is encouraged by the knowledge that it ordinarily disappears spontaneously with progression of time.

Discussion

Although the history of surgery is intimately bound up with the evolution of amputations,[7] the morbidity and mortality are still high and solution of the problem is not yet complete. Difficulties with wound healing and with other complications and frequent death following amputation become of increasing concern as the general longevity of the population increases.

Although amputation for gangrene was described as early as the fifth century B.C., this presently common indication is new in terms of total numbers. Just prior to the

advent of anesthesia, Buel's summary of experience at the New York Hospital from 1839 to 1848 indicated an over-all amputation mortality rate of 29 per cent in a group of 91 patients where the oldest was 54 years and where none of the amputations were done for gangrene.[1] Similar mortalities were reported at the same time in other American cities[6] as well as in France, Germany and Great Britain.[4] The overwhelmingly common cause for amputation was trauma and the chief causes of complications and death were shock and infection. The highly developed rapidity of operation is well known and details were carefully practiced. Baron Larrey of France performed 200 amputations in a 24-hour period following Napoleon's capture of Smolensk in the Russian campaign and is credited with a perfected technic permitting him to disarticulate the hip within 14 to 15 seconds after the primary ligation of the femoral vessels!

Following the advent of Lister's antiseptic technic and the somewhat later aseptic technic the operation of amputation upon which surgical reputations had rested prior to the advent of asepsis became too simple a yardstick for further effective measurement.[4] Although infection has in general been controlled, a shift in the most common etiology to arteriosclerosis has led to continuation of relatively high morbidity and mortality rates due to noninfectious complications.

This analysis of five year's experience of all Nashville surgeons emphasizes two chief problems, namely that of wound healing and that of thrombotic complications of the vascular system, many of which are incident to widespread arteriosclerosis. The same problems are apparent in the reports of others.[2, 8-10] The over-all 24 per cent failure of primary wound healing (Table 4) was evaluated further in terms of final healing at different sites and this is shown in Table 5, which considers only amputation for arteriosclerotic disease and shows rate of healing wihout operative revision at different sites. The secondary operation rate was progressively higher from thigh to calf to foot. The diabetic group healed both thigh and calf operations much better than the nondiabetic atherosclerotics. The toe healing of diabetics was poorer than nondiabetics, seeming to support the general concept of atherosclerotic occlusion in diabetics as a more distally located disease. This analysis points toward more caution in distal amputations, particularly at the toe and foot levels in diabetics. Calf amputations however, healed much better in diabetics than in nondiabetic arteriosclerotic people.

The transmetatarsal amputation re-emphasized recently by Wheelock's report[12] of 428 such between 1944 and 1958 has not become widely used. He reported salvage of 63 per cent of diabetic extremities for two years or more. From the description it seems likely that many of those patients would have been subjected by us to open toe and metatarsal head amputation without the necessity for loss of all the toes and metatarsal heads. In other words, it is believed that lesser operations will allow maintenance of a walking foot until a time when the extent of tissue loss necessitates an amputation above the level of the foot. This point has been somewhat controversial for the past 12 years but figures in the present series indicate less rather than more use of foot amputations. Personal experience as well as this analysis shows that if a toe amputation cannot be successfully accomplished there is a great risk of failure at the foot level.

Table 6 indicates that the experience of others shows similarly poor healing rates as well as high mortality rates, and while the list is not encyclopedic the trend is apparent. It seems likely that these *poor results of amputations are not generally recognized* by surgeons at present. Wide-

TABLE 6. *Wound Complications and Mortality Rates Reported for Series of Major Amputations*

Authors	Year	No.	% Wound Complications	Mortality Rate %
Reeves, Quattlebaum[9]	1956	114	25	18
Clauges, Graham, Hamilton[2]	1958	118	24	11
Dale, Capps[3]	1959	284	38	17
Schlitt, Serlin[10]	1960	98	56	12
Moretz, Vogles, Thomas[8]	1961	149	32	11
Present series	1962	337	30	11

spread recognition of the problem should focus attention and result in improvement. Failure of healing is often a tissue problem but also reflects incorrect judgment of the site of amputation.

The problem of thrombotic complications occurs on both the venous and arterial sides of the circulation. The incidence of pulmonary embolism, cerebral vascular accident, coronary arterial occlusions, and peripheral arterial embolism and occlusions is striking and the concentration of risk strongly suggests preventive measures.

Recognizing the risk of postamputation pulmonary embolism one of us earlier reported a series of 27 superficial femoral vein ligations at the time of amputation.[3] The 15 per cent pulmonary embolism in that small series was compared to 7.0 per cent in the larger series of 210 nonligated patients. This failure of vein ligation resulted in its abandonment. In this present series seven patients had vein ligation without subsequent embolism.

TABLE 7. *Direct Arterial Procedures Prior to 44 Amputations*

Aorto-iliac (or femoral) graft	13
Aorto-popliteal graft	4
Iliac or femoral popliteal graft	20
Spleno-femoral graft	1
Femoral thromboendarterectomy	4
Femoral embolectomy	2
	44
Earlier than 1 month post op.	25
Later than 1 month post. op.	19
	44

Since then systemic anticoagulation therapy has been used in a small personal series of amputations, by administering Coumadin to reduce prothrombin time to the 20 to 40 per cent level, starting 48 hours postoperatively and maintaining therapy during hospitilazation and in some patients for a total of eight weeks. Determination of results of such therapy will require a rather large group of amputation patients who can be carefully followed. Such a program appears rational and is in progress.

Evaluation for the possibility of direct arterial reconstruction has become increasingly important with the development of diagnostic and operative vascular technics which may permit extremity salvage. It is not yet known what absolute percentage of threatened amputations can be prevented or delayed by these technics, but if the individual patients falls into even a small percentage, there are benefits of undoubted value to the individual, his family and the community as a whole. Therefore, it is advocated that prior to amputation, angiography and/or direct operative exploration of the distal femoral or proximal popliteal artery be strongly considered.

In addition to the patients listed in Table 7 who required amputation despite or because of direct arterial reconstructive procedures, there were 23 others who were evaluated by arteriography and judged to be unsuitable for arterial operation. A few others had direct operative exploration of the distal artery with operation continued as amputation rather than direct arterial reconstruction.

The 44 patients listed in Table 7 required operation following a direct reconstructive arterial procedure. The time intervals between arterial operation and actual amputation varied between one day and three years and indicated that while some patients required amputation despite an attempt at reconstruction and others no doubt had amputation hastened to some degree by the attempt at salvage, there were some going on for many months prior to the necessity for the destructive procedure. It has not been possible to learn the number of extremities which have been salvaged by virtue of a direct reconstruction in this community to date and the topic lies outside the realm of this discussion.

The place of direct arterial reconstruction clearly requires further study to determine its proper indications. Current disillusion with small vessel repair appears the result of over-use of the available technics for too liberal indications. There is no doubt that some extremities can be salvaged when amputation is imminent, but the number of these is still unknown.

Summary

1. 479 amputations in 385 patients in four Nashville, Tennessee, hospitals during 1956–1960 inclusive, by 55 surgeons and numerous surgical residents have been analyzed to determine community-wide results.

2. Preferred principles of management before, during and after amputation are outlined.

3. The chief problems apparent in the series are failure of primary wound healing and thrombotic vascular complications leading to high morbidity and mortality rates. Their common occurrence warrants efforts toward improvement.

4. Possible use of anticoagulant therapy to prevent complications and death is suggested.

5. Recognition of greater wound risk of distal amputations is re-emphasized.

6. Evaluation for direct arterial reconstruction is suggested prior to actual amputation.

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