

Lower Extremity Amputation in Diabetic Patients

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SUMMARY

One hundred and seventy-eight lower extremity amputations performed on 103 diabetic patients were reviewed. Although the healing rate for the above-the-knee amputation was higher, the probability of prosthetic use and ambulation was greater with the mid-leg amputation, particularly if the patient required bilateral amputation. Late breakdown of the mid-leg stump, once healing had occurred, was not a significant problem. We feel that the proper amputation level is best determined by the skin temperature and appearance at the proposed amputation site rather than rigid reliance on the presence of pulses, oscillometry, or arteriography and that every effort should be directed to retaining a functioning knee. *DIABETES* 19:189-95, March, 1970.

The principal reason for lower extremity amputation is undoubtedly ischemia, frequently associated with diabetes. Diabetic amputees pose particular problems with respect to wound healing, associated disability, survival, and potential functional attainment. As a result, for many years the popular philosophy has been that the first amputation in a diabetic should be the last. The present study was undertaken in part to evaluate the validity of this philosophy. Federal regulations requiring maximum rehabilitation of hospitalized patients, uninhibited by monetary considerations, provide an excellent opportunity to study healing, durability, and functional results in a series of patients.

MATERIAL

The series totaled 103 diabetic patients on whom 178 amputations were performed from 1952 to 1965. The surgery was performed by the resident staff under the supervision of many different attending surgeons. All of the patients were male, reflecting the characteristic

composition of a VA hospital; eighty-four were Caucasian and nineteen were Negro. The majority of patients were in the sixth or seventh decade of life at the time of their first amputation. The age span in this series was from thirty-seven to eighty-five years. The diagnosis of diabetes was made after the fifth decade in 87 per cent of patients. It is interesting to note that none of our patients had suffered from diabetes in early life (only one patient had developed diabetes in the first three decades of life). The interval between the diagnosis of diabetes and first amputation for eighty-three patients was quite variable, ranging from several months to fifteen years. The diabetic status of the remaining twenty patients was not established until the time of first amputation.

At the time of their first amputation, thirty patients were receiving no treatment for diabetes, seventeen were being managed by diet control alone, forty-two were receiving insulin, and fourteen were receiving oral hypoglycemic agents. Adequacy of diabetic control prior to hospitalization could not be evaluated but management in the hospital was not a significant problem in any patient.

Morbidity and mortality

Since diabetic gangrene is but one manifestation of a serious systemic disorder, our patients, as expected, manifested multiple associated disabilities. In preoperative evaluation, seventy patients had abnormal electrocardiograms and thirty-three had a history of heart disease. Blindness, arteriosclerotic senility, and kidney disease were present in varying combinations and degrees and at times served to complicate the postoperative period, particularly in planning and achieving the rehabilitation potential of each patient.

Of the 103 patients, sixty are known to be deceased. Thirty-nine patients (39 per cent) died within three years of their first amputation; twenty-four of them died while hospitalized following an amputation for an overall in-hospital mortality of 23 per cent. The causes of death are listed in table 1. It is interesting to note the low incidence of death from sepsis as compared to the

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LOWER EXTREMITY AMPUTATION IN DIABETIC PATIENTS

TABLE 1
Causes of death

Heart disease	22
Cerebrovascular accident	5
Kidney disease	5
Pneumonia	4
Sepsis	3
Miscellaneous	4
Unknown	17
Total	60

experience in the preantibiotic era when, according to Mandelberg and Sheinfeld (1944), the principal cause of hospital mortality of patients with diabetic gangrene was chronic toxemia.¹

RESULTS

Sites of amputation

Table 2 lists the final levels of amputation at the time of this review. Of the forty-three bilateral amputees, twenty-six underwent contralateral amputation within two years of the first amputation. The frequency of contralateral amputation as reported in the literature ranges from 26 to 39 per cent.²⁻⁴ Goldner, in following seventy-one unilateral amputees, found that 50 per cent had involvement of the contralateral limb within two years of the first amputation and that forty-seven eventually had some involvement of the other leg. Thirty-two of the seventy-one needed contralateral amputation.⁵ Whitehouse et al. feel that the risk of death is much more than the risk of contralateral amputation in that forty-seven of their sixty-seven patients were dead at follow-up while only nine had contralateral amputation.⁶

TABLE 2
Final levels of amputation

Unilateral AK	23
Unilateral BK	17
Unilateral ray	20
Bilateral	43
AK-AK	9
BK-BK	13
AK-BK	14
Ray-(AK, BK, or ray)	7

ABOVE-THE-KNEE (AK) AMPUTATIONS

Forty-nine AK amputations were performed upon patients whose average age was 62.7 years. The indications for amputation are listed in table 3. The average postoperative hospitalization of patients not requiring reamputation was 5.9 months, ranging from one to twelve months. It should again be emphasized that this

TABLE 3
Principal indications for amputation

	AK	BK	Ray
Gangrene	26	43	31
Uncontrolled infection	6	2	9
Neuropathic changes or ulceration	4	10	12
Failure of lower amputation to heal	13	13	2
Painful stump	0	1	0

was the period until the maximum obtainable rehabilitation was achieved.

Preoperative evaluation

Gangrene extended above the ankle in six limbs, was limited to the foot in thirteen limbs, and was entirely distal to the metatarso-phalangeal joints in twelve. Twenty-two extremities had infection as manifested by cellulitis, lymphangitis, fever, or drainage. Skin ulcerations were present in seventeen extremities. Neurologic examination demonstrated a sensory deficit in eleven limbs and absent ankle and/or knee reflexes in twenty-four limbs.

Circulatory status

The lowest levels of palpable pulses are listed in table 4. Oscillometric studies were recorded in nineteen limbs. Twelve limbs showed insignificant or no oscillations in the involved extremity, five had oscillations confined to the thigh, and only two demonstrated oscillations as far distal as the calf. Arteriography, performed in nine limbs, demonstrated a block in all, located in the femoral artery in seven instances and the popliteal artery in two. Marked paucity of bleeding at the amputation site was observed in two instances.

Operative technic

With minor variations in the technic most amputations were performed approximately four inches above the knee, either with the construction of flaps or with a circumferential incision and closed by approximating the fascia and skin. No attempt was made to suture the muscle to bone nor was the immediate prosthetic technic employed. Some type of drain was used in forty-two of the forty-six closed amputations. Spinal anesthesia

TABLE 4
Lowest palpable pulse in the involved extremity

	AK	BK	Ray
Not recorded	2	5	3
None palpated	5	6	4
Femoral	28	29	13
Popliteal	14	27	13
Pedal	0	2	21

was employed for thirty-eight operations and general anesthesia for eleven. Thirty-two patients were given antibiotic therapy, twenty-three pre- and postoperatively, seven preoperatively alone, and two only postoperatively.

Postoperative course

Table 5 summarizes the immediate postoperative mortality and wound healing. Using thirty days as the criteria for an early death, the early mortality was 12.4 per cent. In addition, eight patients died in the hospital more than thirty days postoperatively. Of those patients surviving thirty days or more, primary wound healing occurred in all but two of their amputations. The two patients concerned died in the hospital before further surgical attempts could be made to achieve wound closure.

MID-LEG (BK) AMPUTATIONS

Sixty-nine BK amputations were performed, the average age at amputation being 62.5, virtually the same as the AK group. The principal indications for amputation are listed in table 3. The average postamputation hospitalization in the patients who had no further amputation was 6.7 months, or slightly longer than the AK group.

Preoperative evaluation

Gangrene was present in forty-four limbs, limited in all cases to the foot, and in nineteen instances confined distal to the metatarso-phalangeal joints. Twenty-seven extremities had some manifestation of infection and twenty-six had an ulceration of the skin. Neurologic exam demonstrated a sensory deficit in twenty-one limbs and diminished ankle and/or knee reflexes in six limbs.

Circulatory status

A total of forty-two limbs manifested evidence of significant circulatory embarrassment. Eleven patients gave a history of intermittent claudication. In thirty-five limbs there was no palpable pulse distal to the femoral (table 4). Oscillometry performed on thirty-three limbs demonstrated insignificant or no oscillations in twelve limbs. Eight limbs had oscillations limited to the thigh, nine

limbs to the midcalf, and four limbs to the supra-malleolar area. Arteriography, performed in twelve limbs, demonstrated a block in all, located in the femoral artery in four instances, the popliteal artery in two, and infra-popliteal in six. Paucity of bleeding at the amputation site was noted in ten instances.

Operative technic

A standard mid-leg amputation was performed in all cases, under spinal anesthesia in sixty-one instances and general anesthesia in eight. Primary closure was effected in sixty-six limbs while three were left open. Drains were used in fifty-six of the closed amputations. Of the three open amputations, one was performed as a planned first stage in the presence of uncontrollable infection, while the other two were brought about because of poor bleeding at the operative site. The two amputations left open because of inadequate bleeding healed following secondary closure. The third open amputation was followed by the planned AK revision. Forty-one patients had pre and postoperative antibiotics. Fourteen had preoperative antibiotics alone and three only had postoperative antibiotics.

Postoperative course

The immediate postoperative course is summarized in table 5. The early mortality was 8.7 per cent. In addition, five patients on whom six BK amputations had been performed died in the hospital more than thirty days postoperative: four of these amputations had healed prior to death. One limb was reamputated prior to death and one was unhealed at the time of death. Both of these latter two amputations were closed primarily.

Primary healing occurred after fifty-three amputations. These included seventeen limbs with only femoral pulses and six with no palpable pulses in the extremity. Arteriography had demonstrated femoral artery blockage in three of these healed amputations, popliteal block in two, and infra-popliteal block in three. Intermittent claudication had been present in seven limbs which went on to heal. Healing occurred in all of the ten limbs associated with poor bleeding at the amputation site.

TABLE 5
Immediate postoperative course

	AK		BK		Ray	
	Closed	Open	Closed	Open	Closed	Open
Total amputations	46	3	66	3	18	36
Died in less than thirty days	5	1	6	0	0	0
Healed in						
less than thirty days	19	0	19	0	9	0
thirty to sixty days	11	0	12	0	3	8
more than sixty days	10	1	20	2	4	11
Did not heal	1	1	9	1	2	16

Primary healing failed to occur after ten amputations. These included five limbs with only femoral pulses and one without any palpable pulses. Arteriography had demonstrated femoral artery blockage in one limb and infra-popliteal blockage in three limbs. Intermittent claudication had been present in four of the limbs which failed to heal.

Following discharge from the hospital, further information is available on thirty-two limbs. Only one required subsequent ipsilateral AK amputation, and this occurred three years and nine months following the BK amputation. Two other patients had area of breakdown in their stumps, but both healed and the patients were again able to use their prostheses.

RAY AMPUTATIONS

Fifty-four ray amputations were performed at an average age of 61.2. We define a ray amputation as one performed at varying levels in the digit itself but distal to the metatarsal neck. Several patients had separate ray amputations performed on the same foot at different times and for the purpose of evaluating healing these have been considered as individual amputations. The indications for amputation are listed in table 3. As might be expected, the postamputation hospitalization in these patients without the need for prosthetic fitting and training was much shorter than the other groups and averaged 2.3 months.

Preoperative evaluation

Gangrene was present in thirty-one extremities, extending proximal to the metatarso-phalangeal joint in four. In the remaining twenty-seven limbs, gangrene was limited to the digit alone. Infection was present in thirty extremities and skin ulceration in twenty-five. Neurologic exam demonstrated a sensory deficit in eighteen limbs and diminished ankle and/or knee reflexes in twenty.

Circulatory status

Table 4 lists the pulses found in the involved limb. Oscillometry performed on twenty-eight limbs demonstrated insignificant or no oscillations in three extremities. Two limbs had oscillations limited to the thigh, eight to the mid-calf, and fifteen to the supra-malleolar area. Arteriography performed in five limbs demonstrated an infra-popliteal block in all. Three patients had a history of intermittent claudication. Bleeding at the time of surgery was thought to be inadequate in ten patients.

Operative technic

Thirty-six wounds were left open and eighteen were closed. Forty-two amputations were performed under

spinal anesthesia and twelve with general anesthesia. Thirty-four patients had antibiotics pre- and postoperatively, five preoperatively alone, and five only postoperatively.

Postoperative course

The postoperative course is summarized in table 5. There were no hospital deaths in this group. Combining open and closed amputations, eighteen (33 per cent) failed to heal. The failure rate for closed amputations was 11 per cent as compared to 44 per cent failure for open amputations. In the healed group, pedal pulses were present in nineteen; popliteal but no pedal pulses were present in four; femoral pulses alone were present in eight; and the pulses were not recorded in two. The three patients with a history of claudication did not heal.

Eight of the twenty-four healed ray amputations which were followed for an average of forty-two months after discharge later required higher amputation, although not necessarily because of breakdown at the amputation site. Thus only eighteen of the fifty-four limbs with ray amputations have not required higher amputation.

MISCELLANEOUS GROUP

One foot disarticulation was performed in a patient with uncontrolled infection. The wound did not heal and the patient died within thirty days of surgery.

The two supramalleolar amputations which were done did not heal, and both required higher amputations although one was done as a planned first stage for uncontrolled infection.

Three complete transmetatarsal amputations are included in this series. One was done as a first stage for uncontrolled infection and was followed later by the planned higher definitive amputation. The wound was left open in the transmetatarsal amputation performed for gangrene, and because the limb did not heal, a higher amputation was required. Our one successful transmetatarsal amputation was done in a patient with an infected foot in which the wound healed more than sixty days following surgery and remained healed at follow-up.

FUNCTIONAL ATTAINMENT

Functional attainment was evaluated in all patients with healed amputations at the time of discharge. Patients who required a contralateral amputation at a different hospitalization were re-evaluated after the second amputation.

AK amputations

Of twenty unilateral AK amputees, ambulation could not be attempted in seven because of associated medical disabilities. Ambulation was attempted without success in two. Successful ambulation with a prosthesis was achieved in eleven of the thirteen unilateral AK amputees deemed eligible, leaving nine of the twenty unilateral AK amputees nonambulating. Three used a prosthesis, with only one cane, while eight required two crutches in order to ambulate.

Ten of the eleven ambulatory unilateral AK amputees were followed after discharge for an average of twenty-six months. One is known to have abandoned ambulation and four required contralateral major amputation (three BK, one AK). Seven of the nine nonambulatory patients were followed after discharge for an average of fourteen months and one required contralateral AK amputation. Thus five of the twenty unilateral AK amputees are known to have required contralateral major amputation subsequent to discharge at an interval of twenty months.

BK amputations

Of twenty-seven patients with unilateral BK amputation at the time of discharge, twenty-six were successfully ambulated following prosthetic fitting. The single exception was found to be ineligible for further VA care following healing of his stump. He was referred elsewhere for rehabilitation and has been lost to follow-up. Of the twenty-six ambulatory patients fifteen required a cane, ten required two crutches, and one required a walker.

The posthospitalization course averaging fifty-three months is known in twenty-one of the twenty-seven unilateral BK amputees. There was no change in the ambulatory status of eleven patients who did not require further amputation. Nine required a major contralateral amputation (six BK, three AK) at an average time interval of forty-five months. One patient noted earlier required ipsilateral AK amputation following late breakdown.

Bilateral amputees

Ten patients with bilateral BK amputations had achieved prosthetic ambulation at the time of discharge from hospital, nine requiring the use of two crutches and one requiring a walker. In four instances the amputations had been performed in close succession during the same hospitalization. Posthospitalization follow-up averaging twenty-seven months, available in seven of the ten patients in this group, revealed that prosthetic ambulation had been abandoned in only one case.

None of the five patients with bilateral AK amputations was permitted to attempt prosthetic ambulation because of overriding associated debility or medical disability. In two instances the amputations had been performed in close succession during the same hospitalization. Of the remaining three patients, only one had achieved prosthetic ambulation prior to contralateral amputation.

Of twelve patients with bilateral AK-BK amputations, ten achieved prosthetic ambulation, eight with the aid of two crutches, one with a single cane, and one with a walker. Prosthetic ambulation was attempted unsuccessfully in two instances. In the posthospitalization follow-up, averaging forty-five months, three patients became nonambulatory.

DISCUSSION

Morbidity and mortality

The over-all experience with respect to associated medical disabilities and survival times in our series of patients is quite typical (table 5). The early and total in-hospital mortality, however, was somewhat lower than elsewhere reported in the literature. Pearse and Ziegler reported an operative mortality of 32 per cent in 1940;⁷ Mandelberg reported an in-hospital mortality of 32.8 per cent in 1944;¹ and Levin and Dealy reported a 50 per cent postoperative mortality.⁸ Subsequent to 1950, reports reveal a significant drop in postoperative mortality rates. Silbert and Haimovici reported 9.3 per cent postoperative mortality,⁹ Smith, a 12 per cent mortality,¹⁰ and Hoar and Torres 7 per cent.¹¹ This reduction is probably best attributed to antibiotic usage.

Choice of amputation level

Our results again confirm that the judgment as to the proper amputation level is best based upon skin temperature and appearance rather than pulses, oscillometry, or arteriography. Certainly the mid-leg amputation is capable of primary healing despite the absence of a popliteal pulse and poor oscillometric readings, or even poor bleeding at the site of intended amputation. Rest pain above the ankle or calf claudication are better indicators of poor prognosis for primary healing of BK amputations. Silbert and Haimovici have stated that a recent femoral artery thrombosis may be regarded as contraindicating BK amputation.¹² Our experiences with arteriography, while not extensive, do not show it to be a good prognosticator of ability to heal. The literature suggests controversy on this subject. Tolsted and Bell found arteriography of considerable value, noting poor chance of successful healing if the super-

ficial femoral artery is found to be blocked at the adductor hiatus, or if the supreme geniculate artery is not patent.¹³ Lim et al., however, found arteriography to be of no help in predicting success or failure.¹⁴

BK versus AK amputation

Although we achieved a higher primary healing rate with AK amputations in contrast to BK amputations, the failure rate of 15.1 per cent with BK amputations must be weighed against the associated advantages (table 6). Review of past reports reveals AK amputations to be more commonly employed than BK amputations in diabetic as well as in patients with peripheral vascular disease, largely because of the superior healing rate. The rate of primary healing in BK amputations in our series compares well with that reported by Burgess (82 per cent),¹⁵ as well as by Hoar and Torres (90 per cent).¹¹ Transcending, we believe, the lesser rate of primary healing, are the decreased mortality rate and greater potential for functional attainment associated with BK amputations. Significantly lower mortality rates after BK amputation contrasted to AK amputation have been reported by Lim,¹⁴ Silbert and Haimovici,⁹ and by Ensig-Karup.¹⁶

TABLE 6
Mortality, healing, and prosthetic use in AK and BK amputations

Type of amputation	Per cent	
	AK	BK
Early mortality	12.4	8.7
Failure of primary healing	4.7	15.1
Prosthetic users		
Unilateral	55	96
Bilateral	0	100
AK-BK		83

The prospect for successful prosthetic ambulation is generally considered to be much less for AK amputees than for BK amputees, in keeping with our own experience. Hansson found that the prospect of prosthetic ambulation in bilateral amputees was twice as good if one of the amputations is below-knee.⁴ Erlacher reported no prosthetic users in a series of seventy-six bilateral AK amputees.¹⁷ The better chance of primary healing after AK amputation unfortunately appears to contribute little to functional attainment. Improvements in prosthetic design permit fitting of the BK amputee with successful function even in the presence of defective knee function such as a flexion contracture (not exceeding 35 per cent). Of considerable importance in the elderly diabetic amputee with associated cardiovascular disability is the knowledge that a unilateral BK amputee

expends little more energy in ambulation than the same individual with intact limbs. On the other hand, the unilateral AK amputee has been estimated to require 20 per cent more oxygen consumption in order to ambulate. For the elderly diabetic patient, this added stress may make the difference between the opportunity for prosthetic ambulation and a wheelchair-bound life. Retention of knee function also provided better balance and maneuverability in transfer activities and, of no less importance, will decrease the demand upon the contralateral limb.

A recently published study comprising 411 amputations in fourteen VA hospitals for ischemia, approximately 50 per cent of which were in diabetics, reported findings similar to our own. The in-hospital mortality rate was 10 per cent for BK amputations and 28 per cent for AK amputations. The primary healing rate was 68 per cent for BK and 81.8 for AK amputations. Of those with unilateral amputations, 46 per cent of patients with AK amputations and 76 per cent of those with BK amputations walked again. Of interest were the conclusions that certain factors had no discernible effect upon the healing rates. These included the presence or absence of popliteal pulses, diabetes, preoperative sympathectomy, and preamputation major arterial reconstruction.¹⁸

Transmetatarsal amputation

Prior to the initiation of this review, we had limited use of the transmetatarsal amputation. The experience of others with this amputation, as well as our own more recent experience, has been encouraging. The major advantages at this level are that a minimum of soft tissue dissection is needed to achieve primary healing and that ambulation can be achieved without the need of a prosthesis. Wheelock has reported 428 transmetatarsal amputations performed for ischemic gangrene in diabetic patients. Of 336 patients who were alive after two years, 63 per cent still had a healed transmetatarsal stump.¹⁹

The transmetatarsal amputation is best indicated in the patient with gangrene or infection localized distal to the metatarso-phalangeal joints. The absence of extremity pulses will not preclude wound healing. According to Wheelock, amputation will fail at this level if performed for a failing toe amputation or if there is gangrene on the dorsum of the foot itself.¹⁹ Despite a not insignificant failure rate, transmetatarsal amputation is indicated if the criteria of Wheelock are met and meticulous attention is given to his technic, in view of the advantages noted above.

Ray amputation

Ray amputation is probably only indicated when the gangrene or infection is well localized to the distal phalanx and there is no rest pain in the foot. Primary closure of the wound should be obtained without tension. If the above criteria are not met, a transmetatarsal or higher amputation should be attempted. Ray amputations with little chance of success or which require the wound to be left open should not be attempted, since failure may preclude a subsequent transmetatarsal amputation.

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