Value of Preoperative Physiologic Amputation *

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The major part of the still high mortality associated with major amputations of the lower extremities is related to the advanced state of associated disease. Most patients with gangrene in the lower extremity requiring a major amputation have widespread atherosclerosis and many are diabetic. Often, when admitted to the hospital they have, in addition, severe dehydration, diabetic acidosis, infection of greater or lesser extent in and about the necrotic tissue, toxemia from severe infection, cardiac decompensation, or a combination of several of these. In such instances, a delay of the inevitable operative amputation until the reversible superimposed pathologic change has been corrected will decrease the operative risk of a major amputation, particularly when in the interval of delay, the patient can be spared the continued insult of the harmful effects of the necrotic or infected tissue in the affected extremity. Physiologic amputation, afforded by local hypothermia and tourniquet application above the affected tissue, grants this interval, free of the harmful effects of the involved part, in which to prepare the patient for operative amputation.

Local hypothermia, with or without a tourniquet, for this purpose is not new, but has been grossly neglected. This has probably been due to the common association of local hypothermia as a means of producing anesthesia. For anesthesia, local hypothermia has the disadvantage of interfering with wound healing, a severe limitation on its usefulness. No such limitation exists, however, when hypothermia is used solely for physiologic amputation and is confined to the area distal to the site of anticipated amputation. Nevertheless, the wound complications which followed its use for anesthesia have probably been influential in delaying its general acceptance and widespread use as a means of accomplishing a nonoperative physiologic amputation.

Beginning in 1937, Allen and his coworkers [2, 3, 6] reported on the effects of local hypothermia, both experimental and clinical. These included observations upon tissue survival and nerve degeneration and the beneficial effect of lower temperatures upon shock and survival time after ligation of limbs in animals. They reported a series of 45 patients in whom the involved extremity has been treated by application of tourniquet and ice for two to four hours prior to amputation and stressed the value of this procedure in reducing surgical shock and eliminating the need for additional anesthesia. They also noted that toxicity was decreased and the general condition of the patients was improved prior to operative amputation.

Adolph [1] recognized the benefits of a tourniquet in improving the preoperative status of patients and for use while getting patients to a hospital during the Sino-Japanese war. Following Allen's principles, McElvenny [11] reported a case in which marked improvement in a patient's general

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condition before amputation resulted from the use of ice about an infected extremity, and later [12] presented a variety of cases illustrating benefits of local cooling and tourniquet prior to amputation in patients with infected gangrene, crush injury and gross, overwhelming infection of the extremity. In 1943, Haley [9] outlined a method of icing an extremity utilizing two tourniquets, the initial tourniquet producing physiologic amputation and the later and higher tourniquet producing anesthesia. He reported good general improvement in 20 patients. In 1944, Large and Heinbecker [10] presented a modification of the technic used with good results in six patients.

In the patients reported, the benefits of local hypothermia were quite obvious. In most, part of this benefit was ascribed to its effectiveness in producing anesthesia obviating the need for additional anesthesia.

Since there is widespread question as to the advisability of using local hypothermia for anesthesia in any but the most profoundly ill patient because of its deleterious effect on wound healing, we have confined our attention to its use as a means of accomplishing preoperatively a physiologic amputation. As such, and completely divorced from its role in anesthesia, we have found local hypothermia to be of great value in patients for whom amputation is indicated and in whom there is a need to delay operation. Patients who have some general condition such as uncontrolled diabetes, congestive heart failure or electrolyte imbalance can be improved by a short concentrated interval of therapy. It is also very beneficial for those with a local condition of the extremity which is producing toxicity or which might be expected to interfere with wound healing, such as a grossly infected foot, grossly infected gangrene, or cellulitis and lymphangitis. When the local condition of the extremity is contributing significantly to the poor general status of the patient, physiologic amputation is doubly rewarding.

Method of Achieving Physiologic Amputation

Several means of applying cold to the extremity have been reported. Allen and several others have advocated and used cracked ice applied about the effected extremity to above the level of later tourniquet application. The foot and leg was inserted into a bucket of cracked ice in water or the ice may have been held in place by wrapping the ice and extremity in a rubber sheet. Gibbel *et al.*[8] froze the extremity by placing small blocks of dry ice about the wrapped part, holding the dry ice in place by wrapping with a blanket. Radigan and Shumacker [13] utilized a refrigerating unit into which the affected part was placed. A most convenient hypothermic blanket (Thermorite) has also been used very effectively.

Any of these methods are satisfactory but some may not be available in many hospitals. However, the materials required for obtaining a physiologic amputation by applying crushed ice to an extremity are readily available in any hospital. A simple method of using crushed ice for this purpose, which we have used and found to be satisfactory and practical is described here.

Technic

A tourniquet is placed very tightly about the extremity requiring amputation and the extremity is surrounded by crushed ice. The preferred tourniquet is a rubber tube placed so tightly that arterial flow is stopped. A mild analgesic is often given prior to applying the tourniquet. Occasionally, the site for tourniquet application has been injected with 1.0 per cent procaine hydrochloride or xylocaine, but this has not often been necessary. The site for applying the tourniquet should be well below that of anticipated amputation, but above the gangrene or gross infection. It may cross an area of cellulitis or lymphangitis, although we have usually placed the tourniquet above the area of gross involvement. The crushed ice is applied to just above the tourniquet and is held in place by a rubber sheet wrapped around the extremity. Both the rubber sheet and the tight tourniquet are fastened securely by Kocher clamps. For convenience a rubber tube leads from the dependent portion of the ice pack to a bedside basin, allowing drainage of the excess water. A refinement of this technic consists of a metal bucket into which the limb is placed which obviates the need for the lower portion of the rubber sheet. Such a metal container should have a spout at its bottom for drainage of excess water and can be constructed very simply in the hospital workshop.

The extremity must be inspected about 30 minutes after beginning the icing to make certain that the tourniquet is tight enough to completely occlude the arterial inflow. If too loose, the foot and distal part of the extremity will show cyanosis and venous engorgement.

Crushed ice is replenished every four to six hours. When ready for operative amputation, the extremity is removed from the ice and wrapped in a sheet or large towel up to the tourniquet, the tourniquet being left in place on the part being amputated.

The chief advantage of the crushed ice method is the simplicity which makes it practical in any hospital. The nursing care required is more with this method than with the use of dry ice or the cooling blanket. It is also more messy, and it may prevent the patient from moving about in bed as much as he should. For these reasons we are now using a dry ice technic and are working on an inexpensive device which will circulate cold water through a plastic blanket which can be wrapped about the extremity.

This report is an evaluation of our experience wth local hypothermia used as a preoperative, physiologic amputation. The results obtained in patients requiring major amputation are reported and a comparison is made between those receiving, and those not receiving, physiologic amputation preoperatively.

TABLE 1. *Lower Extremity Amputations (Major), Talmadge Memorial Hospital*

(June 1956–April 1960)	Total	Iced	Noniced
Patients	132	75 (57%)	57
Men	97	54 (56%)	43
Women	35	21 (60%)	14
Average age		69.9 yrs.	64.5
Extremities	161	91 (57%)	70
Diabetic	41	31 (76%)	10

Case Material

This series includes all major amputations of the lower extremity performed in the Eugene Talmadge Memorial Hospital since its opening in June, 1956 through March, 1960, and consists of 161 amputations in 132 patients (Table 1, 2). The two groups (iced and noniced) are compared as to age, sex, and the coexistence of diabetes. The group having physiologic amputation was slightly older (41% were over 70 as compared with 33% of the noniced group being over 70) and contained the vast majority of the diabetic patients. Using the classification established by the committee on records and statistics of the American Society of Anesthesiologists,[4] nine of 11 patients placed by the Anesthesiology Department in the poorest physi-

TABLE 2. *Age Distribution*

132 Amputees		Iced (75)		Noniced (57)	
Average		66.9 yrs.		64.5 yrs.	
Range		44–92		35–86	
Decade	31–40	0		1	
	41–50	7		7	
	51–60	17		14	
	61–70	20		16	
	71–80	22	41%	16	33%
	81–90	8		3	
	91–100	1		0	

TABLE 3. *Indications for Amputation (by Number of Extremities)*

	Iced	Noniced
Gangrene, dry	20	34
Ischemic pain	0	7
Gangrene with infection	69	22
Infection	2	2
Ruptured aneurysm (femoral)	0	2
Paraplegia, foot deformity	0	3
Totals	91	70

TABLE 4. *Indications for Physiologic Amputation (This Series—91 Extremities)*

	Extremities
Infection	
Mild	30
Severe	41
Poor general condition	
(Diab. acidosis, dehydration, toxicity, digitalis intoxication, decompensation, etc.)	20

TABLE 5. *Duration of Physiologic Amputation*

Shortest	14 hours
Longest	24 days
Average	80 hours

TABLE 6. *Types of Amputations*

	Iced	Noniced
Primary amputations		
Above knee	70	49
Below knee	14	17
Secondary amputations		
Above knee	4	4
Primary closure	87	62
Without drains	77	55
With drains	10	7
Not closed	4	8

cal status category (Class 7) were in the iced group. Of 17 patients regarded as "poor" (systemic disorders which are an imminent threat to life), nine were in the iced group. Thus, by their independent evaluations 18 of the 28 patients regarded as "poor" or worse were in the iced group.

The indications for amputation in the two groups are given in Table 3. There were 69 patients with infected gangrene in the "iced" group as compared with 22 patients with infected gangrene in the "noniced" group. The reasons for using physiologic amputation in the 91 extremities are given in Table 4. Mild or severe infection was present in 71 extremities, while "icing" was indicated by the poor general condition of the patient in 20. The duration of physiologic amputation prior to operative amputation is given for this series in Table 5.

The types of amputation performed in the two groups are compared in Table 6. All amputations were of a modified Guillotine type without long flaps, the type of amputation we believe is safest for those with arterial insufficiency. It is to be noted that primary closure was elected in 87 of the iced group as compared with 62 of the noniced group, despite the fact that many more of the iced group had infected gangrene. Secondary amputations were required in four of each group because of poor healing or gross infection. Only four of the "iced" group were left open primarily, whereas eight of the "noniced" group were left open.

Results

The most striking result of physiologic amputation was complete cessation of pain within a very few minutes and improvement in general condition, related both to loss of pain and to cessation of absorption of "toxins" from the affected part. There was usually an increase in appetite and a sense of well-being and, if fever had been present, a decrease in temperature. Several instances were observed in which fevers of 39° C. returned to normal within 12 hours of "icing" and remained normal, and in which leukocyte counts of 18,000 to 21,000 fell to normal range within 24 to 48 hours of refrigeration. The average leukocyte count prior to icing was 16,700 and this fell to an average of 12,800 within 48 hours after refrigeration.

A mortality rate of 10 per cent (by number of extremities) and 12 per cent (by number of patients) applied to both the "iced" and "noniced" groups. This is shown in relation to patient age in Table 7. Six of the nine deaths in the "iced" group and only three of the seven deaths in the "noniced" group occurred in patients over 70 years of age. The causes of death are given in Table 8. One point of interest in this respect is that the only death attributed to septicemia occurred in the group of physiologic amputations. However, this patient was a severe diabetic whose stump had been left open because of an abscess in the muscle at the site of mid-thigh amputation. His diabetes was not well controlled and infection, though improved, was still present in the stump when he died 10 days after amputation, having developed acute cholecystitis with focal peritonitis, pneumonia and septicemia.

Table 9 gives the incidence of wound infections occurring in the two groups. We assumed that an infected area physiologically amputated for 48 to 72 hours would no longer contra-indicate primary closure of the amputation site. Eighty-seven of the 91 in the "iced" group and 62 of the 70 in the "noniced" group were closed primarily. Gross infection occurred in 12 (15%) of the 87 "iced" extremities and in eight (13%) of the 62 "noniced" extremities. Excluding three patients in each group whose prolonged hospital stay was for completely unrelated disease, the length of hospitalization was slightly less in the "iced" group (14.7 days) than in the "noniced" group (18.2 days).

TABLE 7. *Results—Mortality*

	Deaths	
	Iced*	Noniced
Decade		
50	0 (7)	1 (8)
51–60	3 (17)	2 (14)
61–70	0 (20)	1 (16)
71–80	3 (22)	2 (16)
81–100	3 (9)	1 (3)
Mortality rate		
No. extremities	9 (10%)	7 (10%)
No. patients	12%	12%

* Number in parenthesis is number of patients in that age group.

TABLE 8. *Cause of Death*

	Iced	Noniced
Vascular		
Cerebro-vasc. accident	4	2
Pulm. embolus	1	0
Cardiac decompensation	1	1
Renal		
Uremia	1	1
Other:		
Septicemia (not prim. closed)	1	0
Pneumonia	1	1
Leukemia (1), Brain tumor (1)	0	2
	9	7

TABLE 9. *Results—Wound Infections*

	Iced	Noniced
Primary closure	87	62
Wound infection—gross	12 (14%)	8 (13%)
minor	11 (12%)	8 (13%)
Re-amputation required	4 (4%)	4 (6%)

Discussion

Having noted repeatedly the marked and almost immediate general improvement in patients receiving physiologic amputation and believing it is not very generally used and appreciated, an appraisal of its effects, purely as a means of ridding the body of an infected area without the insult of an operation at that time and without consideration of its possible role in anesthesia, might be of value.

This is not a strictly controlled series. Management of these patients was by surgical residents under supervision of various attending surgeons. Physiologic amputation was encouraged for those patients who might benefit from its use. No strict regulations were set up controlling indications, duration of "icing" prior to operation, criteria for leaving stump open, the use of drains, etc. Consequently, there were a few patients in each group who might better have been in the other. Nevertheless, the information revealed in comparing the two groups is convincing.

The immediate improvement which takes place with "icing" is most apparent to those observing the change and includes a striking improvement in general condition, appetite, and sense of well-being. This general improvement is the result of pain being abolished and absorption from the area being stopped. Infection is held in a abeyance. As Haley[9] states: "to be convinced, it is necessary to see this change, since it is difficult to evaluate statistically."

A comparison of mortality rates of this series with others is not meaningful, because of differences in hospital population and methods of reporting. However, the 10-per cent operative mortality in this series compares very favorably with the 17.5 per cent reported by Reeves and Quattlebaum,[14] the 16.5 per cent reported by Dale and Capps,[7] the 12.1 per cent of Silbert *et al.*[15] and the 15.2 per cent (including all deaths) of Claugus *et al.*[5]

Of more significance is a comparison between the two groups in this series. As shown in Tables 1–4, the "physiologic amputation" group was older, contained more diabetics and most of those with infected gangrene, and included the vast majority of the poorest-risk patients. Despite these differences in the two groups of patients, an almost identical mortality rate was obtained in each, 10 per cent by number of extremities or 12 per cent by number of patients. This relatively low mortality in the "iced" group is related to several factors. Time is allowed in which to correct reversible or correctable states. These corrective measures can be carried out with the patient no longer in pain and no longer suffering from the absorption of toxic products of necrosis and infection and can, therefore, be more thorough and more effective. In this regard it was of interest to note the independent patient evaluation made by the anesthesiologists just before operation in those patients whom we had considered on admission to be very poor risks for operation. Of the 20 patients in the "iced" group whom on admission we considered very poor risks, nine had improved sufficiently during this period of physiologic amputation to be regarded by the anesthesiologist as being in good or fair condition.

In most instances, an infected extremity was considered to be safe for primary closure after two to three days of "icing." The comparable percentages of gross and minor wound infections in the two groups support this assumption, although no bacteriological studies of the amputation sites were carried out. The length of hospitalization in the "iced" group was shorter than in the "noniced" group, a factor of some importance since in this age group anything can happen at just about any time and the longer a patient stays in the hospital, the greater his chances of developing one of the complications of old age. Hospitalization would undoubtedly have been prolonged if primary closures had not been elected whenever feasible. The possible effect of drains in the amputation stump on subsequent infection could not be evaluated by this series. Eighteen of the 132 "nondrained" closures and three of the 17 closures with drains developed gross infection.

The ideal method of producing physiologic amputation would be an inexpensive, compact unit applicable to an extremity which does not restrict the patient's movements. Such an ideal method has not yet been developed, but any of the methods in present use is satisfactory for producing the desired effects, and the simplicity of the crushed ice technic makes it practical in almost any situation.

The marked general improvement commonly observed following physiologic amputation of an infected nonviable limb and the interval of time provided by it, during which corrective and restorative measures can be very effectively utilized making the patient a better operative risk, combined to make preoperative physiologic amputation a valuable adjunct in the treatment of those conditions requiring major operative amputation.

Summary and Conclusion

Preoperative physiologic amputation has been used in a series of 91 extremities requiring amputation and the results compared with those of a series of 70 extremities requiring amputation in which preoperative physiologic amputation was not utilized. As applied in this series, local hypothermia with proximal tourniquet was used exclusively as a means of producing physiologic amputation without regard to its possible role in producing anesthesia for amputation. The group having physiologic amputation included the poorest-risk patients and most of those with significant infection in the extremity. Despite this inequality of the two groups, the results in each were comparable as to mortality (10%) and morbidity, indicating that physiologic amputation was of value. This benefit is due not only to the relief of pain, but also to cessation of absorption from the nonviable and infected area and to the interval of time thus provided during which poor-risk patients can be better prepared to withstand the operative amputation. It is our impression that the application of ice and tourniquet above an infected area for a period of 48 to 72 hours permits primary closure of the amputation stump with more safety.

A simple means of producing physiologic amputation utilizing crushed ice is described which is applicable in any hospital.

Preoperative physiologic amputation is advocated in patients requiring major amputation in whom absorption from the local areas of infection or necrosis is contributing to the patient's poor general condition, and particularly in the poor-risk patient in whom a few days of concentrated medical therapy may be expected to improve his general condition significantly. It is also advocated in those patients with inflammatory reaction so close to the site of proposed amputation that primary closure of the stump would otherwise be feared or contraindicated.

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