frequently. These measures did not eliminate the bites but they reduced the number.

The treatment of bites was aimed to relieve the itching and to reduce scratching. Antipruritic lotions and pastes were helpful though messy, and their effects passed off in about an hour. Nevertheless, they were well worth trying when an individual was suffering. The following lotion[1] proved very useful:

	Gm. or cc.		Gm. or cc.
Zinc oxide	25.0	Camphor	5.0
Talc	25.0	Menthol	0.5
Bentonite or kaolin	5.0	Water	30.0
		Alcohol, 95%	30.0

With some persons who could not control scratching, it was necessary to cover the bites with a protective bandage.

Scratch infections were common and extremely resistant to treatment. They varied from small pustules to furuncles and ulcers. If the lesions did not heal after a week of dispensary care, the patient was hospitalized. They required the same care described for other secondary infections. The patient was put to bed, and the lesions and surrounding skin were cleansed well with green soap, sterile water, and alcohol. If the infection was severe, with surrounding cellulitis, continuous hot saline compresses were applied for about twenty-four hours, after which the lesions were covered with a sterile ointment or gauze impregnated with an ointment. Sulfadiazine in a water-soluble base, boric acid ointment, or plain petrolatum were all satisfactory. The use of adhesive tape on the skin was avoided as it favored the development of satellite lesions. If no improvement occurred in a week with this treatment, a full course of sulfadiazine or sulfathiazole was given by mouth. Experience showed that these infections once established tended to persist indefinitely even in the milder forms until the patient was put to bed and the lesions protected from dirt and trauma.

X-RAY

Facilities for x-ray therapy were limited. It was used most often in chronic forms of epidermophytosis. The results were disappointing, although it was effective against the secondary infections that complicated this condition. As secondary infections could be managed by less risky methods, the x-ray was not considered for routine treatment.

CONCLUSION

The skin diseases most commonly found in soldiers on duty in the tropics were epidermophytosis, dermatitis venenata, and the bites of insects and mites. Secondary infections sometimes complicated these conditions and caused prolonged hospitalization. Strong and irritating medications often aggravated the acute process. Good general care, strict adherence to aseptic surgical techniques, and the judicious use of local therapy were the important factors in treatment.

Tourniquet Problems in War Injuries

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The intelligent handling of tourniquets in war injuries of the extremities is a phase of war surgery that has been considerably neglected. The whole tourniquet question too often has been lightheartedly dismissed with the dictum, "Release tourniquets every twenty minutes to one-half hour," whereas, the problem requires thought and sound judgment. Tourniquets are frequently applied unnecessarily, but the rule of releasing tourniquets every one-half hour to "prevent gangrene" is extremely dangerous in many instances.

Each case requiring a tourniquet is an individual problem, not only if one is confronted with the patient initially, but also if the patient is seen with a tourniquet already applied. Only by careful, but often necessarily speedy, evaluation of the patient's blood loss, the state of shock, the facilities available for blood volume replacement therapy, the time interval likely to elapse before primary surgery can be done, and the extent of the damage to the extremity, can one arrive at a proper decision about the application or removal of tourniquets. It is of some concern that so little stress has been placed on this fundamental life- and limb-saving device.

During the past year on the Italian front, we have been actively engaged as a general surgical team of an auxiliary surgical group, functioning in "first priority" surgical hospitals. This type of hospital (a field hospital unit) is in physical conjunction with the division clearing station and accepts all extremity wounds in which shock is present and all cases which have tourniquets applied. We have seen a large number of this type of case, not only those admitted to our service, but those admitted to the service of the other teams with whom we worked.

Early in the Italian Campaign, the following questions caused the most concern:

1. What is an adequate tourniquet, and how is it best applied?

2. Should a tourniquet be applied early in a severe extremity wound, or should one wait for the spontaneous cessation of hemorrhage?

3. How long is it safe to leave a tourniquet applied, and how often is damage caused by tourniquets?

4. How are tourniquets best handled in patients who are in shock from blood loss?

5. Should tourniquets be applied to extremities in which external bleeding is minimal but in which there is progressive and pronounced hematoma formation?

6. What is the role of temperature with regard to the handling of tourniquets?

After a year of service in the most forward surgical hospitals, we have seen enough cases presenting these problems to form opinions and gain impressions, some of which are at variance with accepted practices. These views are in general agreement with those of other general surgical teams having had similar experiences.

AN ADEQUATE TOURNIQUET

The term "adequate tourinquet" requires clarification. Complete control of bleeding is the primary aim of tourniquet application, and any procedure short of this is considered inadequate. We believe that the strap-and-buckle type tourniquet in common use is ineffective in most instances under field conditions, and recommend that it be discarded, substituting a soft-rubber-tubing tourniquet. The strap-and-buckle tourniquet is too narrow and cuts into the tissues, and it rarely completely controls bleeding, no matter how tightly applied. This circumstance, which has been observed repeatedly, possibly can be accounted for on the basis of the customary practice of placing a gauze roll or other firm object over the course of the vessels and securing the tourniquet over it. The vessels tend to slip out from under this firm object, or, if the principal vessels are occluded, the firm object elevates the tourniquet on either side so that no pressure whatsoever is exerted on the collaterals running parallel to the main vessels. Where the strap-and-buckle must be used, the substitution of mechanic's waste or a Carlisle dressing for a pad or using no pad whatsoever seems more logical. The ideal tourniquet is one of a pneumatic type, in which the pressure can be accurately adjusted and maintained. This type has the inherent danger of pressure leakage and is not feasible for combat zones because it is relatively cumbersome and complicated.

The simplest and most effective device for a tourniquet, in our experience, is one of soft-rubber tubing properly applied, the ½-inch soft-rubber tubing, Medical Supply Catalog Item No. 3879000. This tubing should be at least 6 feet long. Our procedure is to pad the extremity with a towel, a shirt sleeve, trouser leg, or any other material available, at the level at which the tourniquet is to be applied. Four parallel turns of the rubber tubing are wound around the leg under moderate tension only, the end first applied being overlapped and anchored by the second turn, and the last turn being anchored by the next to the last turn. Most rubber-tubing tourniquets are applied too tightly; actually, if several turns are used, only moderate tension is required completely to occlude all vessels. If ½-inch tubing is not available, the ¼-inch soft-rubber tubing (Med. Dept. Item No. 3878000) is a satisfactory substitute. More turns are necessary, however; eight or ten turns on the thigh are desirable, and four or five on the arm.

A tourniquet should be placed as close to the site of injury in the thigh or arm as is feasible. If large defects are present in the extremity, care must be taken that the tourniquet is placed sufficiently above the injury to prevent the tourniquet from slipping down into the defect. Tourniquets about the forearm or leg are of dubious effectiveness, since bleeding from the incompressible interosseous vessels may continue to lead to a considerable loss of blood.

WHEN TO APPLY A TOURNIQUET

Many severe wounds of extremities, especially badly contused or avulsed wounds not involving major blood vessels, require no tourniquet. An inadequate tourniquet may actually increase bleeding from this type of wound. Yet the impression we have gained on the Italian front is that tourniquets have not been used sufficiently nor early enough in serious extremity wounds, particularly in wounds involving large blood vessels or in patients with traumatic amputations. There may be some bias attached to this observation, since the only patients admitted to field hospitals were those in shock or those having tourniquets. Yet certainly in this particular group, many were seen who undoubtedly could have been benefited by the early application of a tourniquet. Statistics are not available to show what percent of wounded bleed to death on the battlefield from extremity wounds, nor is it known how many succumb from hemorrhage after receiving first-aid treatment. It seems probable that some do, although the proportion may be small. We do know that many patients with extremity wounds are seen in field hospitals with no tourniquets applied. These patients have lost more blood than conditions would seem to warrant. Blood volume and blood count studies preoperatively and postoperatively indicate that, on the whole, these patients had often lost from 33 to 50 percent of circulating blood volume.

In most of the patients we have seen with severe wounds of an extremity, bleeding had stopped by the time they reached the field hospital, usually from six to eight hours after wounding. This apparently does not occur so readily as some authors would lead us to believe, since the general condition of the patient is often critical from blood loss. It would seem that spontaneous arrest of hemorrhage frequently does not take place until the systemic pressure has fallen and sufficient spasm has

developed in the vessels to effect cessation of flow. This, in our opinion, is a somewhat dangerous method to rely on to control hemorrhage. The following case is illustrative.

A sergeant was seen immediately on admission to a field hospital. A shell fragment had perforated his left arm at about the middle third five hours prior to admission. No other wounds were present. He was extremely pale, restless, and apprehensive, although his initial blood pressure was 115/60. His pulse rate, taken by carotid artery, was 128. He had obviously lost a large quantity of blood. Generalized vasoconstriction was intense. Examination of the wound showed no bleeding whatsoever at the time. Cross-matching of his blood was started, but within ten minutes of admission his general condition began to deteriorate rapidly, the blood pressure dropping to 72/40. A transfusion of low titer "O" blood was immediately started, the blood being forced in rapidly under pressure. He received about 300 cc. of blood during the ensuing fifteen minutes, in spite of which death occurred twenty-five minutes after admission. A careful, complete autopsy was performed. The only finding of significance was a perforating wound of the left mid-arm which produced transection of the brachial artery (which showed no evidence of an intralumen clot), and a compound comminuted fracture of the left humerus. No symptoms suggestive of fat embolism were present before death, and no signs of this process were seen at autopsy. A diagnosis of death from hemorrhagic shock was made.

The circumstances preceding the admission of this case are not known, and there is a variety of possible reasons why this man had no tourniquet applied. No criticism is implied in making the statement that had it been feasible to apply a tourniquet before an excessive hemorrhage had developed, the regrettable sequela would, in all likelihood, not have occurred.

We are convinced that an adequate tourniquet should be placed, at the earliest possible moment, proximal to any extremity wound that is bleeding freely. Many of the fears of damage from tourniquets are probably unfounded to a large extent, and certainly the saving of each possible ounce of blood is desirable from the standpoint of the patient's general condition.

THE TIME FACTOR

Fear of possible damage to an extremity from a tourniquet seems based on no reasonable grounds. The greatest fear is exhibited regarding "gangrene" of an extremity. Unquestionably an extremity will become gangrenous if a tourniquet is left on an excessive length of time, but in our experience, a tourniquet may be left on from two to six hours, depending on the temperature of the atmosphere and of the extremity, without clinically detectable damage. We have seen tourniquets left on as long as eight hours, during the winter of 1943-44, without apparent deleterious effect. Tourniquets applied four to six hours without loosening have been observed on several occasions. The surgeons of an auxiliary surgical group have performed amputations on about 1,000 patients in forward hospitals. These surgeons have all seen extremities on which tourniquets have been left applied up to four hours; yet no case of gangrene solely from a tourniquet has been noted, as far as we have been able to determine. It is conceded that the tourniquets may have been a factor in the production of gangrene in some cases of extensive vascular injury, but the importance of this factor is a debatable point. Even in civilian surgery we have seen extensive hand cases operated on with a tourniquet applied up to three hours with no evidence of harm. In this temperate climate, we are definitely of the opinion that a tourniquet left in place for periods of two to four hours causes no particular harm from depriving the tissues of circulation. There have been no unusual edema, no slough of skin edges, no ischemic muscle complications that we could attribute solely to the tourniquet; therefore, the fear of producing tourniquet gangrene unless the tourniquet is loosened every one-half hour seems to have little basis in fact.

We are aware that tourniquets may produce nerve paralyses and even vascular thrombosis. The experience of our group indicates these complications are very rare; in fact, an analysis of 200 random cases in which tourniquets had been applied shows that these complications did not occur in a single instance, unless they showed up after the patients left our hands, usually five to ten days after surgery. Even if these complications did occur more frequently, the role of the tourniquet as a lifesaving measure would still make its use imperative.

It is possible that prolonged tourniquet applications may be a factor in the development of gas infections in extremities. We have seen gas infections develop in extremities both with and without the application of tourniquets and have not been able to form a definite opinion on this point. The impression gained, however, is that gas infections are more prone to occur in the bloodless extremity.

THE TOURNIQUET IN RELATION TO PATIENTS IN SHOCK

It cannot be denied that many extremity vascular injuries stop bleeding because of thrombosis of the injured vessels, vascular spasm, or a marked fall in systemic blood pressure. Nor can it be refuted that many large soft-tissue wounds of the extremities *not* involving major vessels develop a spontaneous arrest of hemorrhage within a very short time and are best treated by pressure bandage, or, if a tourniquet has been applied, by early removal of the tourniquet. However, there are cases in which the removal or loosening of a tourniquet is unwise and unnecessary; in fact, the results may be disastrous. Two cases illustrate this effect:

An officer, admitted to a field hospital in 1943, had been wounded three hours previously by a shell fragment, which traversed his right lower arm, producing a compound comminuted fracture of the right lower humerus. No other wounds were present. Pallor, vasoconstriction, and mild to moderate shock were noted. Blood pressure was 110/66, pulse 112. It was fairly obvious that this man had lost considerable blood but was still in fair condition. Examination of the wounded arm showed an impro-

vised splint, a strap-and-buckle tourniquet applied tightly at the level of the insertion of the deltoid, a fairly extensive perforating wound of the inner aspect of the lower arm. A slight but persistent ooze was present through the wound, which, it was thought, was probably venous in character and was produced by back-stasis from a nonocclusive tourniquet. Consequently, a blood pressure cuff was placed about the arm over the tourniquet as a safety measure and the tourniquet was loosened and slipped off. The severed brachial artery promptly let loose, and during the few seconds required to pump up the blood pressure cuff, the patient lost enough additional blood (certainly not more than 100 cc.) at this critical level of his circulatory volume to reduce his blood pressure from 110/66 to 80/40 and materially deepen his shock. It is obvious what would have occurred if measures for prompt control of this hemorrhage had not been available. After 2,000 cc. of infused blood the patient underwent operation, and recovery was uneventful.

A private, admitted to a field hospital in July 1944, had received a traumatic amputation of the left leg, just below the knee, from a German "Schu" mine six hours before admission. A marked degree of shock was noted, the blood pressure being 86/56 and pulse 116. Examination of the injury disclosed a persistent trickle of blood escaping from the badly contused stump in spite of two tightly placed strap-and-buckle tourniquets about the thigh. A large, soft-rubber-tube tourniquet was applied about the thigh which controlled the bleeding promptly. Vigorous antishock measures were undertaken in the form of transfusions of blood. At the end of three hours' treatment, having received 2,000 cc. of blood, the patient was still in such poor condition that operation was considered unwise. Ordinarily, this type of patient can be made ready for operation within one to one and one half hours, and failure to respond usually indicates a gas infection or continued bleeding. Consequently, a further search was made for one of these causes. We were astonished to find that the fresh dressings, applied to the stump after the initial examination, were saturated with blood, and a pool of blood had collected under the patient's buttocks. The tourniquet, however, seemed adequately applied. Questioning disclosed that the tourniquet . . . been loosened at one-half hour intervals, and the patient had probably lost as much blood as he had gained. An additional 1,000 cc. ' lood, leaving the tourniquet in place, produced the desired effect and the patient underwent a successful reamputation.

Similar cases have been seen with enough frequency to make us regard tourniquets with a healthy respect. The results of these experiences led us to conclude that *under no circumstances* should a tourniquet be loosened on a patient *in shock or in incipient shock* unless means are present and immediately available to control any hemorrhage that may occur and to replace rapidly the volume of circulating blood.

It is true that an individual who has lost a moderate amount of blood can tolerate additional, mild, rapid loss of blood without his recovery being jeopardized in the least. There are many patients, however, who have lost blood up to their critical level and are able to maintain only a semblance of circulatory equilibrium through intense vasoconstriction, rapid heart action, and other physiologic compensatory mechanisms. In these individuals the most urgent care must

be used to prevent additional loss of blood volume. The rapid loss of even 100 cc. of blood may completely break down the delicately balanced mechanism, so that the vasoconstricting apparatus fails, with resultant profound, and possibly irreversible, shock. In such instances it is safe to loosen an applied tourniquet only after the blood volume had been brought up to some extent by plasma or, preferably, by whole blood transfusions.

Patients may lose more blood than is first apparent on loosening a tourniquet, particularly in the thigh. The arterial system fills up more or less uniformly on the release of a tourniquet, and if the vascular injury is some distance below the tourniquet the injuried area will continue to drain off this blood, even though the blood supply is reoccluded promptly at the first sign of hemorrhage. A very appreciable amount of blood may be lost in this manner.

Experimental work by others has shown that the release of a tourniquet may be followed by a transient drop in blood pressure, even without the loss of blood. A discussion of this phenomenon is outside the scope of this paper. It may be stated, however, that clinically significant changes have not been noted as a result of this factor in the cases we have seen.

We wish to reiterate, with emphasis, that tourniquets should not be loosened when patients are in shock, unless measures are present to replace any additional blood loss. To do so may jeopardize a patient's life.

TOURNIQUETS IN RELATION TO INTERNAL BLEEDING

A tourniquet should be applied to any extremity which shows evidence of developing, or which has developed, a large, pressure-producing hematoma from injury to a large artery. In general, more damage is done to an extremity from pressure and extensive infiltration of blood from this type of lesion than from the application of a tourniquet for a reasonable time. It seems very dubious that enough collateral circulation is present about such a hematoma to affect materially the viability of the distal tissues. And if a tourniquet is applied early, the chance of firm, occlusive clotting is probably increased. Certainly, the surgery for release of tension and repair or ligation of the damaged artery will be simpler, and the clots and infiltrated blood will be more satisfactorily handled if bleeding has not been permitted to progress unchecked.

THE TEMPERATURE FACTOR

Temperature has been shown by experimental workers to play a vital part in the speed with which necrosis of a bloodless extremity takes place. The metabolic demands of tissues of a bloodless extremity vary directly with its temperature. It seems reasonable that a cold extremity survives longer than a warm extremity when a tourniquet is applied. In general,

therefore, a tourniquet applied in the heat of the tropics or of the desert should be loosened at shorter intervals than one applied in a cool climate. It is suggested that an extremity on which a tourniquet has been placed should be left uncovered, and no attempt be made to warm the extremity by artificial means until the tourniquet is ready to be removed, care being used, of course, to prevent frostbite in sub-freezing weather. The temperature factor, at any rate, should be borne in mind when dealing with tourniquets.

PLAN FOR THE HANDLING OF TOURNIQUETS

In lieu of the dictum, "Release tourniquets every twenty minutes to one-half hour," the following plan is suggested for handling the tourniquet problem in war injuries:

1. Tourniquet cases should have the highest priority for transportation to the nearest available hospital, with the presence of a tourniquet plainly indicated on the record.

2. An adequate tourniquet should be placed on an actively bleeding extremity at the earliest possible moment.

3. At the end of two hours or so, provided that the patient is not in shock and depending on the circumstances of the temperature, the tactical situation, and primarily on the judgment of the medical officer the tourniquet should be cautiously loosened. If bleeding recurs, the tourniquet should be reapplied. If no bleeding or negligible bleeding results, the tourniquet should be removed, but the patient must be kept under observation for some time thereafter.

4. Loosening of a tourniquet should always be done under the supervision of a medical officer except in exceptional circumstances.

5. Patients in shock from hemorrhage should, on no account, have the tourniquet removed within the first four to six hours after its application unless the blood volume has been at least partially replaced by plasma or whole blood. As ruthless as it may seem, the possible loss of three or four inches of a badly damaged extremity should not compromise a patient's life. After the four- to six-hour period has been reached, subsequent loosening or removal of the tourniquet should be a matter of individual judgment. One would hesitate to leave a tourniquet on after eight or ten hours even with a chilled extremity. In all likelihood, sufficient spasm and clotting will have developed by this time to prevent further bleeding.

6. Extremities having tourniquets applied should, we believe, have the temperature lowered as much as feasible, short of actual freezing.

This plan is only suggested tentatively and will necessarily have to be modified in many cases.

Repair of Fixed Bridges and Acrylic Dentures in the Field

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and
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The dental officer in the field has only an M.D. Chest No. 60, which has no equipment for repair of dentures; however, by picking up a few extra items—plaster of paris, base-plate wax, acrylic, a few Steele's facings, a wood clamp, and one half of a hollow rubber ball for a plaster bowl—certain repairs can be effected without sending a man to the rear.

CASE ONE

A soldier, aged 27, was admitted to our field dental clinic for repair of an anterior fixed bridge with one facing missing.

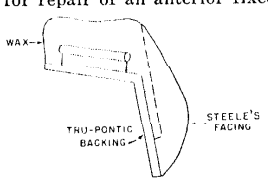
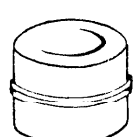


FIGURE 1

The bridge extended from R-2 to L-3 and R-1; L-1 and L-2 were replaced by tru-pontic facings. A Steele's facing was ground in to fit the tru-pontic backing. With the facing in position, base-plate wax was placed on the lingual and in the groove of the facing (figure 1). The wax was then slightly softened and the entire assembly placed in the mouth to get an accurate adaptation to the gingiva. After trial in the mouth, the entire bridge was invested in a large bottle cap filled with plaster. The bridge was embedded completely except for the waxed-up area. A few notches were cut in the plaster around the edges of the bottle cap to get an accurate fitting of the two bottle caps. Cocoa butter was used as a separating medium. A second bottle cap was filled with plaster and set on the lower cap. Then the two bottle caps formed a miniature dental flask (figure 2). The caps were separated and the wax boiled out. Acrylic was then mixed and packed into the



"BOTTLE CAP" FLASK

FIGURE 2