NOTES ON
CARE OF BATTLE CASUALTIES

War Department, Washington 25, D. C.   ●   ●   ●   **March 1945**

1. PURPOSE. In previous directives, certain broad policies and guiding principles on the care of the wounded in theaters of operations were present. Greater experience that has since accumulated has confirmed the soundness of these principles. It has also brought to light additional facts that indicate the need for re-emphasis of some of these principles, suggest the desirability of modifying others, and provide the basis for certain new developments the significance of which demand wider application. For these reasons and in order to assure continued improvement in the management of the wounded, this bulletin has been prepared for the guidance of all concerned. Certain details of the phases of wound management of especial concern to theaters of operations are outlined.

2. GENERAL CONSIDERATIONS. The care of the wounded must always be shaped by conditions and circumstances that govern the tactical situation at the moment. It is erroneous, however, to assume that the surgery of war is entirely molded by concessions to the need for haste and the confusion of caring for overwhelming numbers of patients. Military surgery is not to be regarded as a crude departure from accepted surgical standards, but rather as a development of the science of surgery to carry out a specialized and highly significant mission. Modern surgical treatment employs many adjuvants to operative techniques, such as chemotherapy, fluid replacement therapy, the transfusion of whole blood and fractions of blood employed as substitutes, potent anesthetic agents and narcotics. These tools are as important to

the military surgeon as his scalpel, but are equally dangerous to the patient if used without expert precision. One of the major responsibilities of the military surgeon is to make full use of these and similar measures and at the same time to avoid the dangers that may attend their usage.

a. The ever present necessity for evacuation of the wounded to the rear is in fundamental conflict with ideal surgical management of the individual patient. To minimize this conflict, *close coordination between the functions of administration and professional services is required.* It is the responsibility of the medical officer charged with the surgical management of the patient to place technical procedures properly, both in time and in space, with due regard to the tactical situation on the one hand and to the welfare of the patient on the other. Unless the surgeon visualizes his position and the function of his hospital in relation to other surgeons and other hospitals, he may become confused in the mission he is to perform. Although some needed operation may be performed correctly, the military effort may be impeded and unforeseen harm done to the patient if the operation is done at the wrong time or in the wrong place.

b. It is the *responsibility of administrative officers* charged with the establishment of evacuation and hospitalization policies to adapt the schedules of movement of patients to the maintenance of highest standards of surgical treatment. Priority of movement must be accorded to patients with certain types of injuries just as the duration of hospitalization in a given zone must be differentially adjusted to the urgent surgical needs of the patients. The term "nontransportable" as relating to the unfitness of battle casualties for interhospital transfer must, when military necessity permits, be extended beyond actual danger to life by a consideration of the likelihood of deformity, ultimate disability, and delay of recovery when these hazards exist.

3. PHASES OF SURGICAL MANAGEMENT. Just as the placement of various types of hospitals and consequently the provision of the facilities for surgery are determined by the geographic deployment of a military force, phases of surgical management exist that in general will conform with military echelons.

These phases of surgical management are: medical aid measures, initial wound surgery, reparative wound surgery, reconstructive surgery, and rehabilitation measures.

a. Medical aid measures. Within the divisional area, surgical management is limited to first aid measures and emergency resuscitation. Hemorrhage is controlled, splints and dressings applied, morphine administered for pain, plasma infused for resuscitation, a booster dose of tetanus toxoid is given, and chemotherapy initiated.

b. Initial surgery. Actual conditions of warfare will determine both the facilities provided for emergency wound surgery and their location with reference to the combat area. In general, initial surgery is concerned with complete resuscitation so that surgery may be performed, and with surgical procedures designed to prevent or eradicate wound infection. Many of the seriously wounded casualties can be resuscitated only by a surgical operation in conjunction with transfusion and plasma therapy. For this reason, it is important that delays for the purpose of resuscitation ahead of an installation equipped for major surgery be kept at a minimum. Placement of the advance surgical hospital in physical proximity to the divisional clearing station accomplishes this end.

c. Reparative surgery. The general hospitals of the communications zone receive casualties from the hospitals of the forward area for further surgical management. As the initial wound operation is by definition a limited procedure, nearly every case requires further treatment. Soft part wounds, purposely left unsutured at the initial operation, are closed by suture, usually at the time of the first dressing on or after the fourth day. Fractures are accurately reduced and immobilized until bony union takes place. Designed to prevent or cut short wound infection either before it is established or at the time of its inception, this phase in the surgical care of the wounded is concerned with shortening the period of wound-healing and seeks as its objectives the early restoration of function and the return of a soldier to duty with a minimum number of days lost. In addition, it affords the return of patients to the zone of interior at an earlier date and in better condition, and minimizes the ultimate disability

and deformity in the seriously wounded. The success of this important phase of surgery depends on the provision of an adequate period of hospitalization in addition to competent surgical care, particularly in specialized fields. It is not to be confused with the reconstructive phase of surgery, which may be postponed until return to the zone of interior. The ideal time for the procedures of reparative surgery will be found between the fourth and tenth days after wounding. The patient then becomes "nontransportable" for a period of time which, in the case of fractures, may extend to 10 or 12 weeks. Transfer of patients between fixed hospitals within the zone of communications must be regulated with these considerations in mind, otherwise the objectives of this phase of surgical management may be sacrificed. The establishment of special centers within general hospitals for certain types of surgery during this phase is highly desirable, as the procedures are oftentimes of considerable magnitude and call for mature and experienced professional judgment. Advancement of general hospitals in close support of Army or utilization of air evacuation from Army to more remote fixed installations are two measures that further the establishment of a program of reparative surgery. To use an oversea general hospital as a temporary custodial institution—a way station in a busy line of evacuation—where patients are held only if complications of the wound render them nontransportable, is to fail to utilize effectively and significantly one of the most highly integrated and specialized facilities of the medical service.

d. Reconstructive surgery. Early evacuation to the zone of interior is desirable for patients whose return to duty cannot be anticipated within the limits of the hospitalization policy of an oversea theater. The phases of reconstructive surgery and rehabilitation may then be integrated.

4. MEDICAL AID MEASURES. First aid measures have been adequately treated in revised editions of War Department Technical and Field Manuals.

5. GENERAL PRINCIPLES OF INITIAL WOUND SURGERY. *a.* In the preoperative examination of a battle casualty, X-ray examination is essential.

b. Adequate assistance and instruments, a good light, and access to the wound that is unhampered by faulty position of the patient are basic requirements. Ample preparation of a wide field by shaving the skin will allow for extension of the incision or counterincision.

c. Bold incision is the first essential step in an operation on a wound. Adequate exposure is necessary to carry out *excision* of devitalized tissues. On the extremity the line of the incision is placed parallel with the long axis of the limb; elsewhere it follows the natural lines of skin structure. Only the devitalized skin of the margins of the wound is excised in a strip rarely wider than 2 to 3 mm. The creation of circular skin defects is avoided.

d. Incision and excision of the fascial layers is performed in the same manner to give free access to devitalized muscle. Unrestricted exposure of successive anatomic layers permits the complete excision of devitalized muscle and the removal of foreign bodies.

e. The surgeon must be familiar with the blood supply of muscles, particularly large groups, like the gastrocnemius-soleus muscles of the calf, and respect these vessels in his dissection. Deep recesses of the wound containing foreign bodies may be approached by counterincisions planned anatomically rather than by sacrificing normal muscle structures.

f. Use fine hemostats. Use the finest ligature compatible with the procedure. Include the smallest possible amount of tissue in ligating a bleeding point. Do not repeatedly bite the wound with tissue forceps. Sponge gently with pressure instead of wiping. Remaining devitalized tissue produced by the missile or by the surgeon must slough before the wound can be closed by secondary suture.

g. Large wounds in regions of heavy muscles, particularly when complicated by comminuted fracture, require especial care. The depths of these wounds must be opened by a long incision with counterincision if necessary to allow free *dependent* drainage.

h. Only enough dry fine mesh gauze (bandage, gauze, roller, Item Nos. 2005000 or 2006000) is used to separate the surfaces of the wound.

It should be smoothly laid in the wound—not "packed."

i. Ether, white soap, and benzene have slight but definite necrotizing effects on living muscles. Green soap and various other substances used as detergents have greater necrotizing effects, whereas physiological saline solution is relatively innocuous. In general, progress in wound management points away from the introduction of any chemical agent into a wound for its supposed antiseptic effect.

j. Old wounds (48 hours or longer) are managed in accordance with the same principles, except that, in selected cases of established pyogenic infection and anaerobic cellulitis with toxicity, the general condition of the patient to withstand radical surgery may be improved by immobilization, penicillin, and repeated blood transfusions until an optimum time is selected for intervention. In postponement of surgery, the advantage that accrues from the immediate drainage of septic hematomas, large masses of dead muscle, and fascial plane abscesses is not to be forgotten. Postponement of surgery is not justified if clostridial myositis (gas gangrene) should be present.

k. Proper transportation-splinting is provided for skeletal and joint injuries. Soft part wounds are supported by firm pressure dressings and may, if extensive, be advantageously inclosed in a light plaster. Care is taken to avoid any constricting action of a pressure dressing placed on an extremity. Plaster casts must always be padded and split, or bivalved, before the patient is returned to the ward.

6. GENERAL PRINCIPLES OF REPARATIVE WOUND SURGERY. *a.* On arrival at a hospital where bed care can be assured for a period of at least 15 days (soft part wounds) the original dressing is removed in the operating room under aseptic precautions. X-ray films should be at hand. If the primary wound operation has been complete and has been properly done, all superficial wounds and many deep wounds may be closed by secondary suture at this time (4 to 10 days). Foreign bodies in soft parts adjacent to the wound are removed. Following suture, the part is immobilized, preferably by a light plaster, or if this is impractical, by bed rest.

b. The presence of residual dead tissue or established infection manifested by profuse discharge of pus, reddening and edema of the wound margins, persistent fever or toxicity is an indication for delay in secondary suture. When these manifestations are present but minimal, the wound is allowed to "clean up." This process can be hastened by moist dressings or by additional surgical excision of devitalized tissue remnants. Secondary suture can then be performed in a few days. If established infection is severe, or if the patient is toxic and anemic from deep-seated sepsis, a course of penicillin therapy and blood transfusions is instituted and followed by radical wound revision and staged closure.

c. Wounds that have been laid open properly at the initial operation tend to gape widely and give the impression of extensive skin loss. This appearance is actually due to loss of support of the deep fascia. Skin defects are more apparent than real in the majority of cases. Closure of a defect due solely to loss of skin is made from local tissue. Undermining with advancement or rotation of flaps provides sufficient skin in nearly all instances and is preferable to grafting.

d. Technical considerations that are important to the success of secondary wound closure are:

(1) Atraumatic handling of tissue.

(2) Avoidance of tension sutures.

(3) Accurate approximation of skin margins. The epithelial bridge is the main support of the wound for a considerable period of time.

(4) Obliteration of dead spaces by pressure dressings and immobilization. Stab-wound drainage may be instituted when desired and is preferable to drainage through the suture line.

(5) Leaving sutures in place for 12 days if stitch infection does not develop.

(6) Suture in straight lines rather than the creation of sharp angles.

e. Preliminary bacteriologic analysis of the flora of a wound does not provide information pertinent to making the decision to perform secondary suture or allow the prediction of the result. If the suture is not successful because of infection, appropriate studies and correc-

tive therapy are instituted before resuture is attempted.

f. The conditions that most often jeopardize results are:

(1) Suture of a wound that is discharging pus. This usually means dead tissue in the depths.

(2) Too early motion. (Wounds breaking down for this reason should be immediately resutured.)

(3) Unrecognized foreign bodies adjacent to the wound.

7. CONSIDERATION OF CLOSED PLASTER TREATMENT (methods of Ollier, Pirogoff, Orr, and Trueta).

a. The regimen of closed plaster management of war wounds is not considered as satisfactory as the method described above, when field conditions permit the use of the latter. It is advisable to remove the initial dressing for inspection of the wound in all cases at least by the fifteenth day.

b. While the necessity for the rapid turnover of large numbers of casualties might justify an adoption of the closed plaster method of management of compound fractures, a high penalty in the form of skeletal deformity would be the inevitable result. Results obtained by secondary suture do not justify the use of closed plaster for soft part wounds.

c. When it is desired to allow granulations to cover exposed bone in deep irregular wounds, the wound may be encased in plaster subject to infrequent changes. This is also an accepted method of management for established infection of bone, particularly when the wound has caused an extensive loss of overlying soft parts or there is a large bone defect. Before application of the plaster, all devitalized tissue and loose bone fragments are excised. There should be no pocketing or pooling of pus in the fracture site or adjacent fascial compartments. Small surfaces of bare cortical bone may be removed surgically when this permits closure of the defect by suture or skin graft.

8. CRANIOCEREBRAL WOUNDS.

a. Deep infection of penetrating wounds of the skull is almost always associated with incomplete removal of devitalized brain substance. The extent of the necessary débridement is oftentimes indicated by indriven bone fragments which are demonstrable by X-ray examination.

Stereoscopic roentgenograms are helpful. A reduction in the incidence of infection can be effected by extending the débridement so that *these fragments of bone and the tissue that surrounds them are removed* at the time of the initial surgical procedure.

b. Dura defects are repaired by living grafts of fascia or pericranium. The scalp is closed by suture.

c. When a patient arrives at the base following initial débridement and closure of the wound in the forward area, neurological changes are carefully noted. When compared with former observations these may suggest improvement or regression. Signs or symptoms of increasing intracranial pressrue usually indicate deep wound infection, hematoma, or a mass of residual necrotic tissue. The tension and healing in the scalp flap and wound are at once determined. Should stereoscopic X-ray studies disclose the presence of residual bone fragments, secondary wound débridement can then be more readily directed. Even in the absence of symptoms it is usually wiser to remove large or clustered bone fragments. On the other hand, if the fragments are small or in a dangerous location, operation may be withheld, provided the patient is doing well and can be held for a period of observation. If secondary operation is to be carried out, necrotic or infected tissue and hematoma are removed and wound closure effected, even though frankly purulent cerebritis has been encountered. At times a temporary drain to a large dead space is permissible, or repeated aspirations employed, but only rarely is it necessary to exteriorize the infected area.

9. EYE INJURIES.

a. Conservation in the enucleation of eyes in forward installations is advisable. Inasmuch as sympathetic ophthalmia never develops before 10 days and usually not before 2 weeks after the initial injury, the first 2 weeks following the injury may be considered the "safe period." Therefore, in forward installations enucleations should be done only when there is extensive damage to the eye and orbit, and removal of the ocular remnants is a necessary procedure in the débridement of the area. Enucleation with a glass ball implant in Tenon's capsule is the operation of choice. Evisceration should be limited to those cases showing a purulent endophthalmitis.

b. Pending enucleation, or while awaiting the repair of an eye injury, the injured eye is atropinized, ophthalmic ointment applied, and both eyes bandaged. The immobilization of both eyes is particularly important, as movement of the eyes is minimized with lessening of the danger of wound gaping and further prolapse of the intraocular tissue.

c. Every case of perforating injury is X-rayed as soon as possible to determine the presence or absence of an intraocular foreign body. Patients suspected of having an intraocular foreign body are best transferred to an installation where a giant magnet and accurate methods of X-ray localization are available. The removal of an intraocular foreign body should be attempted as soon as possible unless an established iridocyclitis is present.

d. Tarsorrhaphy is indicated in certain cases for protection of the eyeball during evacuation. The lids should be sutured together whenever there is serious injury or burn of the eyelids, or an exposed eyeball. This is accomplished in most cases by "freshening" the nasal and temporal lid margins and sewing the lids together with fine silk. Where there is much destruction of one of the eyelids, the other can often be brought up to cover the eye. If both lids are destroyed, the eye should be covered by a skin flap as a temporary measure.

10. MAXILLOFACIAL WOUNDS. *a.* The hazards to life of initial operative management are oftentimes greater than those of the original wounding. There should be no hesitancy in performing tracheotomy when indications exist to relieve obstruction of the airway by that method. On the other hand, the care of a tracheotomy is difficult in a long evacuation line, frequently requiring a personal attendant. The choice of the anesthetic agent, as well as the technics of its administration, requires expert judgment and skill.

b. The procedures of initial surgery are based on the following principles in order of importance:

(1) Reduction and fixation of fractures of the bony foundation structures. This may be by temporary measures for transportation purposes, with the intent that it will be replaced by more elaborate and precise splinting at a rear installation.

(2) Isolation of the buccal cavity from the wounds of the bone and superficial soft parts by suture of the mucous membrane.

(3) Primary closure of the muscles and skin with provision for adequate drainage in anticipation of infection. If the defect is such that primary closure is not possible and the wound enters the buccal cavity, the edges of the skin and mucous membrane should be carefully approximated.

(4) Application of moist pressure dressings.

c. The management of the soft-part wound by primary suture, with or without plastic repair, must not tempt the forward surgeon to hold a patient for supervision of healing, with the result that precise and firm splinting of the bony parts is postponed.

d. Those cases with severely comminuted fractures or loss of bony substance, and with major soft-tissue defects, require evacuation to the zone of interior as soon as they can care for themselves and after the dangers of infection have passed.

11. THORACIC WOUNDS. *a.* It is important to recognize two distinct phases that may be encountered in chest wounds: disturbance in cardio-respiratory physiology, and infection. The former develops immediately; the latter is usually delayed. Accordingly, in the forward area efforts are directed toward the restoration of physiologic equilibrium, whereas the less urgent complication of infection, if it occurs, may be controlled adequately at the base. Thus, success in the management of penetrating wounds of the chest depends upon the judicious timing and selection of surgical measures.

b. Occlusion of open chest wounds with gauze and adhesive strapping is the preferred management until the patient reaches a hospital staffed and equipped to carry out intrathoracic surgery.

c. Patients with a chest wound suffering from shock may be more advantageously treated in the prone position with the foot of the litter elevated than in a sitting position. Control of urgent physiologic disturbances that attend wounds of the chest in both preoperative and postoperative periods can be achieved by— .

(1) Needle aspiration of air and blood. Early and repeated aspiration of hemothorax

without air replacement is essential in the proper management of chest wounds.

(2) Bronchoscopic or catheter aspiration of blood and mucus from the tracheo-bronchial tree.

(3) Infiltration of the intercostal nerves with procaine hydrochloride solution for relief of chest wall pain. This enables the patient to cough effectively and clear the air passages of blood and secretions.

(4) Insertion of a catheter with a flutter or water-seal valve for pressure pneumothorax.

(5) Administration of oxygen and whole blood transfusion. Autotransfusion of pleural blood should be used when practical. Care is taken to give the blood slowly in resuscitation after the systolic blood pressure has reached 80 mm of mercury, and the total amount administered should be only that essential to attain adequate resuscitation.

(6) Débridement of sucking wounds, with hemostasis of intercostal vessels and approximation of deep structures of the chest wall to close the pleural opening.

d. An anesthetist well trained in endotracheal anesthesia for thoracic surgery is an essential member of an operating team caring for war wounds of the chest. Endotracheal oxygen-ether, administered through a closed apparatus capable of maintaining positive pressure, is the form of anesthesia recommended in the management of penetrating and perforating chest wounds.

e. Early thoracotomy through an extension of the wound or by a separate incision at a site of election, is indicated in the presence of—

(1) Continuing intrapleural hemorrhage not controlled by hemostasis in the chest wall débridement.

(2) Anatomic likelihood of diaphragmatic penetration.

(3) A missile in the mediastinum or that has traversed the mediastinum with evidence of visceral damage.

(4) Large intrapleural foreign bodies or debris that is readily accessible by extension of the wound.

(5) Wounds of large bronchi or the intra-thoracic portion of the trachea.

f. The following conditions are not in themselves indications for early thoracotomy either by extension of the wound or by separate incision:

(1) Foreign bodies; that is, metallic fragments, rib fragments in the lung, or small fragments that may be in the pleural space.

(2) Hemothorax. (Evacuation of blood from the pleural cavity by suction at the time of chest wall débridement is not considered a thoracotomy.)

(3) Lacerated or contused lung, unless there is definite evidence of continuing hemorrhage.

g. The incision for thoracotomy, or an extension of the wound, should be placed in the postero-lateral area of the thoracic cage, rather than anteriorly. Difficulty has been encountered with the break-down of anterior chest wall defects. Following thoracotomy, closed drainage of the pleural space is instituted unless definite contraindications exist. The drainage catheter is removed as soon as the clinical course permits, usually at the end of 48 hours.

h. Rather than invite pulmonary edema by excessive intravenous fluid therapy, it is advisable to keep a patient with an injured lung slightly dehydrated.

i. Late complications include residual "clotted" hemothorax and empyema.

(1) The accumulation of massive clots of fibrin in the pleural cavity is suspected when clinical findings persist and only small amounts of blood can be withdrawn with the needle. In addition, serial roentgenograms show no improvement during the third to sixth weeks. In such cases thoracotomy is done for the removal of clots from the pleural cavity and the dense layer of fibrin from the underlying lung. Early decortication in these cases permits normal expansion of the lung and prevents chronic empyema and other complications that lead to chronic disability. Penicillin is used both systemically and locally in the pleural cavity at the time of operation.

(2) Empyema complicating hemothorax demands prompt surgical drainage or, when the patient's condition permits, radical thoracotomy with the evacuation of residual clots and decortication of the lung. The latter procedure should be performed preferably before the tenth week, because the surgical line of cleavage becomes obliterated after this time by organiza-

tion of inflammatory exudate. Systemic and local penicillin is used as an adjuvant.

12. ABDOMINAL WOUNDS. *a. Resuscitation.* Surgical management of penetrating wounds of the abdomen demands rapid resuscitation with adequate amounts of whole blood and plasma and early operation. Continuing internal hemorrhage or advancing peritonitis frequently prevents a satisfactory response to blood transfusion, forcing the surgeon to proceed with operation and rely on support of the patient by transfusion during and after surgery.

b. Preoperative measures. Nasogastric intubation, with removal of gastric contents, is an important measure to prevent the aspiration of this material during anesthesia. It is a fortuitous event when passage of the tube provokes vomiting. Testing of the nerve function of the extremities and rectal examination to determine the presence of fresh blood indicative of injury to the rectum are the two most commonly overlooked features of the preoperative examination.

c. Anesthesia. Ether-oxygen anesthesia with a closed system, and preferably with an intratracheal tube, is the method of choice. Supplemental block of the field either by local infiltration or injection of the lower intercostal spaces in the axillary line may minimize the necessity for carrying these patients into the deeper levels of general anesthesia. Facilities should be available for bronchoscopy during or subsequent to the operation if there is reason to believe that gastric contents have been aspirated into the tracheo-bronchial tree. Postoperative aspiration pneumonia ranks with peritonitis as a life-endangering complication.

d. Incisions. The vertical paramedian incision affords the most useful approach and is least liable to complications. Fecal contamination of the peritoneal cavity will be reflected by postoperative infection of the abdominal wall incision in a considerable number of instances. The principles that apply to the management of heavily contaminated soft part wounds also apply to abdominal wall incisions, provided steps are taken to prevent evisceration. The peritoneum is closed, usually including the posterior rectus sheath in the suture line. The rest of the abdominal wall is loosely approximated, preferably with stay sutures of braided silk or wire. The skin is left unsutured. The provision of adequate drainage for the abdominal wall incision, the avoidance of buried sutures and ligatures, and a loose rather than taut approximation of the stay sutures are the most effective measures in the prevention of infection. When it is necessary to exteriorize segments of bowel or to provide intraperitoneal drainage for or in anticipation of localized sepsis or a fecal fistula, secondary incisions are made. These are short, laterally placed incisions that follow the direction of the fibers of the external oblique muscle. In the upper abdomen, incision for exteriorization of bowel must not impinge on the costal arch.

e. Small bowel injuries. Depending upon the extent of damage, repair is done by suture or by resection and anastomosis. Exteriorization of small intestine or double-barreled enterostomy is avoided as productive of serious life-endangering complications.

f. Large bowel injuries. It is important to note the distinction between exteriorization of a wounded segment of bowel and construction of a colostomy to divert the fecal stream. At times both purposes may be accomplished by one and the same procedure, but a clear understanding of the purpose of the operation is essential to the selection of technics involved. For either purpose the basic technical requirement is adequate mobilization of the segment of the large bowel that is brought to the surface of the abdominal wall. Insufficient mobilization with dependence upon suture or clamps to maintain the bowel in its abnormal position will result in retraction. Retraction leads to a fecal fistula that may be difficult to repair or, in the case of a defunctioning colostomy, defeats the purpose of the operation by allowing fecal matter to enter the distal segment. Early in the convalescence, retraction is productive of abdominal wall infection or intraperitoneal sepsis.

(1) *Exteriorization.* Exteriorization of the damaged segment through a laterally placed muscle splitting incision is the established procedure in the management of wounds of the large intestine. The loop of bowel must lie comfortably on the abdominal wall without tension and with proper orientation of its proximal and distal limbs; that is, not twisted upon itself.

The mesentery falls naturally into a fold on the medial aspect of the loop, leaving the bowel walls in contact on the lateral side. Properly performed, this simple procedure is adequate in the majority of instances when exteriorization is all that is required. Closure is made by suture or the application of a spur clamp in the area when the two limbs of the bowl are in contact. When the injury is larger than one-half the diameter of the bowel or a segment has been resected because of damage to the mesentery, exteriorization takes the form of a double-barreled spur. Sutures may be placed to approximate the antemesenteric borders of the intraperitoneal portions of the limbs for subsequent crushing by a clamp. Care must be taken not to penetrate the lumen of the gut or strangulate vessels by sutures.

(2) *Sigmoid colostomy.* Colostomy to divert the fecal stream is required for: injuries of the pelvic colon below the level where exteriorization is possible (in such an instance the perforation is repaired by suture and proximal colostomy done); wounds of the rectum; and certain perineal and buttock wounds as an adjuvant to wound healing and secondary suture. An appraisal of the length of time that may be necessary to defunction the distal bowel segment guides the technical details of construction of the colostomy, as well as determines the site chosen for the artificial anus. A tube cecostomy or partial exteriorization of the cecum does not divert the fecal stream from the remainder of the colon, and is never used for this purpose. Colostomy in the left half of the transverse colon is a useful procedure in the face of extensive pelvic injuries that may require subsequent repair by the abdominal route. This is particularly the case if a suprapubic cystostomy is also indicated, or if the missile has produced damage to the abdominal wall in the left lower quadrant. Usually, however, a left sigmoid colostomy will be satisfactory for injury of the pelvic colon or rectum and for perineal injuries. Placement of the colostomy in a defect produced by the missile, or in the laparotomy incision, is to be avoided. Formation of a loop with proper lateral orientation of the bowel, assured if desired by the placement of a few absorbable sutures on the antemesenteric borders or approximation of appendices epiploicae, provides an adequate sigmoid colostomy. Formal construction of a long spur is not necessary and may be undesirable. Extensive damage to the lower bowel segment, associated injury of the bladder and urethra, and wounds that extensively compound the bony pelvis, as well as the rectum, are examples of injuries that require a prolonged and complete defunctioning artificial anus. Under these circumstances the exteriorized loop is made sufficiently long to allow for complete transverse section of the bowel and some separation of the two stomata. As ultimate closure will be by end-to-end suture, formation of a spur is undesirable. Construction of a skin bridge between the arms of the loop would, in fact, be preferable. Small perforations of the rectum, or instances in which the perforation cannot be demonstrated but is thought likely, may not require prolonged or even complete diversion of feces. Small wounds of the rectosigmoid may heal promptly if suture is technically satisfactory. Under such circumstances, formation of a loop colostomy with a tentative partial opening on the antemesenteric border will suffice until a complete appraisal can be made at a fixed hospital. Many of these cases can be restored to duty within an overseas theater by extraperitoneal repair of the incompletely divided loop. If the need for long and complete diversion of feces is demonstrated, the loop is completely transacted to form an artificial anus. Colostomy as an aid to the healing of wounds of the buttocks and perineum need not be performed in the forward area unless laparotomy is being performed for other purposes. If done solely for management of the external wound, the patient will be rendered nontransportable because of a procedure that could have been postponed until arrival at a fixed hospital.

(3) *Cecostomy.* Tangential perforations of the cecum may be managed by a tube cecostomy or, preferably, by exteriorization. Single perforations require mobilization of the bowel to look for retroperitoneal perforation. Cecostomy, even when necessary because of direct injury to the cecum, is never to be used as a substitute for a proximal colostomy when indications for the latter are present.

(4) *Right-colostomy.* In extensive injuries necessitating resection of the cecum and ascending colon, the most important principle to ob-

serve is complete separation of the ileostomy from the laparotomy incision or from a large abdominal wall defect. The most satisfactory method for dealing with the end ileostomy is separation of the ileum and the proximal end of the colon by creating a terminal ileostomy in a separate incision in the right lower quadrant and exteriorization of the end of the colon below the coastal margin. Every effort should be directed to the early anastomosis of the ileum to the transverse colon.

(5) *Perforations of rectum.* Wounds of the rectum are characterized by inaccessibility, difficulty of diagnosis, frequent damage to other structures and the hazard of pelvic and ascending retroperitoneal cellulitis. Deviations from the principles established for the management of wounds of the rectum continually lead to serious complications. Colostomy (not cecostomy) is mandatory, as also is free posterior drainage, best established by incision of the fascia propia exposing the rectal, sacral, and lateral paramedian spaces. Attempts to drain the retroperitoneal space by utilizing the missile wound of the buttock have been disastrous. In establishing posterior drainage it may be desirable to increase the exposure by removal of the coccyx. This is done as a disarticulation of the coccyx from the sacrum by sharp dissection and erasure of exposed articulating cartilage—not by incomplete amputation with a bone forceps.

g. Postoperative care. The postoperative care of patients with abdominal wounds is of the utmost importance and is the personal responsibility of the operating surgeon. Among the most important considerations are:

(1) Holding of the patient until his equilibrium is established, oftentimes a minimum of ten days.

(2) Nasogastric suction for 48 hours or more following operations.

(3) Whole blood and plasma.

(4) Parenteral fluid therapy is controlled by measurement of fluid intake and output and by determinations of cell volume and plasma protein concentration by the copper sulphate method. A daily urinary volume of 1,200 to 1,500 cc is maintained, a point of particular importance in connection with the use of sulfadiazine.

(5) Aspiration of tracheo-bronchial secretions. Postoperative pulmonary complications including pneumonia, atelectasis, and pulmonary edema are common in this group of patients. Oxygen therapy by means of an indwelling nasal catheter and aspiration of tracheo-bronchial secretions by catheter or bronchoscope are important measures and may be required frequently.

h. Postoperative complications. In cases that develop sepsis, small intestinal fistula, intestinal obstruction, and other complications or sequelae, it is essential to—

(1) Maintain nutrition by supplemental feedings.

(2) Correct the tendency toward vitamin depletion.

(3) Promptly diagnose and drain localized sepsis.

(4) Close small intestinal fistulas at the earliest moment that operative intervention can be tolerated.

i. Closure of colostomy. A defunctioning colostomy deteriorates into a useless fecal fistula when it no longer diverts the feces from the distal bowl. Reappraisal of the purpose of its continuation must be made and it should either be closed or reestablished as an effective artificial anus. Spillage of feces into the lower segment results in fecal impaction and delays healing of the wound of the bowel wall. In oversea theaters it is desirable to close certain colostomies and repair exteriorized segments, when this can be done, by suture of a partial defect of the bowel or by crushing a spur. Formal end-to-end suture is not recommended for oversea theaters unless the patient can be returned to duty in the theater.

13. PERIPHERAL VASCULAR INJURIES. Peripheral vascular injuries are of special importance, particularly where major vessels are involved. In many of these cases ligation or end suture will be necessary. Ligation in continuity should not be done. In the presence of thrombosis, the thrombosed segment is excised. Localized segmental spasm of the artery should be distinguished from thrombosis. Such cases, also termed "concussion" or "stupeur" of the artery, may follow various forms of trauma to an extremity, especially

when the traumatizing agent passes near a vessel. In such cases the limb is cold, pale, and pulseless, but evidence of hemorrhage or hematoma indicating that the vessel has been lacerated is lacking. These cases respond well to débridement of surrounding traumatized tissue and to periarterial sympathectomy or sympathetic block. Postoperatively, in all cases with peripheral vascular injuries, vasodilatation may be induced by daily sympathetic block using 1 percent procaine hydrochloride solution. Body warmth is carefully maintained but heat should not be applied to the involved extremity.

a. The *position of the extremity* is important, as elevation may accentuate ischemia. A dependent position is preferable even if a moderate degree of edema appears to be the result. A plaster cast on an extremity threatened by ischemic gangrene is bivalved and the anterior half removed. Continuous observation is essential to detect impending anaerobic infection. Repeated transfusions to establish a normal blood volume and maintain a high red cell volume is an important phase of management.

b. A patient with *impending ischemic gangrene* should be held at the initial surgical installation until a favorable result is assured or amputation is performed.

c. Operation for the extirpation of an *aneurysm* or an *arteriovenous fistula* is rarely an emergency procedure. Since wounds causing aneurysms may be infected, and since extravasation of blood into the tissues surrounding the wound usually occurs, delay in operation will diminish the chance of secondary infection and secondary hemorrhage. Moreover, *operation should be postponed until such time as collateral circulation has been established, so that major vessels may be safely ligated and divided*. This will usually require 3 or 4 months. Early operations are undertaken not for the cure of aneurysm but to arrest certain complications; namely, hemorrhage, impending rupture, nerve paralysis caused by pressure, or threatened gangrene of the extremity. In such cases, repeated sympathetic block using 1 percent procaine hydrochloride solution (or sympathectomy, if indicated) should be done both preoperatively and postoperatively to assure maximum vasodilatation and thus increase circulation in the involved part. Oversea patients with aneurysms should be evacuated to the zone of interior where, upon arrival, they should be sent to vascular surgery centers in accordance with paragraphs 1*k* and 3*c*, War Department Circular No. 140, 1944, and War Department Circular No. 235, 1944.

14. PERIPHERAL NERVE INJURIES. *a. Complete palsy with anatomic division of nerve.* (1) *Primary suture* of peripheral nerve injuries is advisable only during a period when small numbers of casualties are being handled or expected. In selected cases of soft part wounds uncomplicated by extensive muscle damage or skeletal fracture, complete or partial severance of a nerve may be repaired by formal suture following a meticulous initial débridement. Closure of the soft parts over the suture line without tension is advisable with primary or staged closure of the skin. This procedure should be undertaken only if the patient may be held under observation of the operating surgeon for a period of ten days, and is not recommended if the wound is heavily contaminated by debris or if evacuation from the field has been delayed. Primary nerve repair must never be undertaken at the expense of delay in débridement or neglect of concomitant injuries.

(2) The *more usual method of management* will be by undertaking formal nerve suture as a phase of reparative surgery in the following stages:

(*a*) It is the responsibility of the surgeon at the time of the initial débridement to make a careful record of the injury as he observes it. Preoperative appraisal of nerve injury is notoriously difficult and inexact in patients with multiple wounds, particularly if they are suffering from shock. The most precise information comes from anatomic observations at operation. Here again, it is not desirable to embark upon a painstaking dissection with extension of the field of operation beyond the zone of devitalized tissues.

(*b*) No attempt is made to repair the nerve by suture or to fix the nerve ends. Exposed nerves are covered with muscle so that the dry fine mesh gauze used in the wound is not in contact with the nerve. Petrolatum gauze is not recommended.

(c) Dusting of the wound with sulfonamide after débridement should not be done in the area of the nerve trunk.

(d) The joints above and below the point of injury are immobilized to minimize retraction of the nerve.

(e) A firm pressure dressing supported by a light plaster of paris cast is applied to reduce wound exudation.

(f) Penicillin therapy is maintained by the systemic route.

(g) On reaching a general hospital the original dressing is removed under aseptic precautions in the operating room. This usually is possible on or shortly after the fourth day after injury. Appraisal at this time is based upon the ultimate functional restoration of the extremity, taking into consideration muscle damage and bone or joint lesions in relation to the nerve injury. Electrical tests may be made if desired. Oftentimes a more deliberate examination will correct or supplement the initial notes made in the forward area. Procedures such as muscle suture or even shortening of the limb by removal of the devitalized comminuted bone fragments may be carried out at this time. The divided ends of the nerve may be approximated by a single fixation suture or otherwise identified with metallic sutures. The wound is closed if sepsis is not present, or if, after further excision of sequestrating tissue, the wound appears adequately prepared for closure. Closure of the skin may be further staged, or, if a large skin defect exists, a skin graft is applied at once, or as a staged procedure.

(h) When first intention healing has been secured—and this results in 80 to 95 percent of cases—formal suture of the nerve is performed under the protection of systemic penicillin. This should be feasible in many cases during the third or fourth week after injury.

(3) Patients with major nerve injuries, whether suture has been performed or not, should be transferred to the neurosurgical centers in the zone of interior with the least possible delay. It is important that splints or casts be removed at the earliest possible date. Cases are being received in the zone of interior with muscle atrophy and joint fixation resulting from unduly long periods of immobilization by casts.

b. Partial or transient palsies make up perhaps one-fourth to one-third of the nerve lesions arriving at the base. Recovery from simple contusion often begins within a few days, while more extensive injuries may proceed over a much longer period of time. In these cases it is desirable, though not imperative, to visualize the injury to the nerve trunk at the time of primary débridement or secondary wound suture.

15. AMPUTATIONS. The most important phase in the management of amputations is the functional rehabilitation of the patient by the fitting of a prosthesis. Amputation centers have been established in the zone of interior for this purpose. It is the expressed desire of The Surgeon General that the early management of amputations in overseas theaters conform with policies that have been set forth in numerous bulletins and circular letters.

a. In the forward area, amputations will be performed at the lowest possible level except that a proximal amputation may be done in preference to a disarticulation. The technic for the performance of amputations is as follows: An incision is made through the skin at the lowest level compatible with viable tissue, and the skin allowed to retract; the fascia is then incised at the level to which the skin has retracted. The superficial layer of muscle is then cut at the end of the fascia and permitted to retract. At its point of retraction, the deep layers of muscle are cut through to the bone. After the deep muscles have retracted, the periosteum of the bone is cleanly incised and the bone sawed through flush with the muscles. No cuff of periosteum is removed as in a closed amputation. Bone denuded of periosteum will sequestrate if infection is present, and a ring sequestrum often results when the periosteum has been removed. It is important also that no periosteum be elevated or torn from the bone in the stump by rough handling. The stump following a properly performed open amputation exhibits a slightly concave open cross section of the extremity and the skin can be pulled down gradually by traction to cover the end of the stump.

b. The proper dressing of the stump is important. The end of the stump is dressed with fine mesh gauze in such a manner that it does

not overlap the skin edges. Skin traction is applied immediately by a stockinette cuff attached with ace adherent or by adhesive tape. Traction is obtained preferably by a light plaster cast incorporating a wire ladder banjo splint. The cast always incorporates the joint above the amputation; for example, a spica for an amputated thigh. The Army Hinged Half-Ring Splint may be utilized as an alternative. Medical Supply Item No. 3661400, Cord, Elastic, for Traction, is available and is preferable to plasma tubing for the elastic traction. Before evacuation, the traction is examined and if doubt exists as to its effectiveness, it is reapplied. The tension of the elastic cord should be maintained by adjustment during transit.

   c. *At the base areas*, skin traction is continued until the stump is healed or the case is evacuated. Closure of stumps by sliding flaps, plastic resection with sacrifice of bone length, or formal reamputation are procedures to be carried out in the amputation centers in the zone of interior rather than in an oversea theater. Skin grafting in lieu of traction is not indicated. Vertical incisions in the stump made for control of infection or as part of the initial débridement should be closed by secondary suture while skin traction is being maintained to cover the defect at the end.

   d. *In the communications zone* continuous skin traction is maintained in all cases. After removal of the cast or splint, maintenance of traction using 4 to 6 pounds in below-knee and 6 to 8 pounds in thigh stumps over a pulley at the foot of the bed is indicated. Traction is continued until maximum healing of the wound is obtained. Traction in similar fashion is indicated in upper extremity amputations. Priority air evacuation to the zone of interior should be available for amputation cases as soon as they are able to be transported. Traction during evacuation is the same as in *b* above. Patients with injuries requiring amputation will benefit by an explanation of why the amputation is necessary prior to the operative procedure. They should be informed further that additional surgical treatment of the extremity will be required before fitting the prosthesis.

16. COMPOUND FRACTURES. The management of a compound fracture is divided into the following phases: first aid splinting in the field; débridement and the application of transportation splinting in a mobile hospital; final correction of the deformity and attainment of wound healing and bony union at a fixed hospital (reparative phase); reconstructive or corrective surgery (bone grafting, osteotomy, sequestrectomy, etc.) in the zone of interior. In every phase attention is directed to the *ultimate function of the extremity* which is dependent on muscles, nerves, blood vessels, and joints, as well as on skeletal integrity.

   a. *Transportation splinting* applied subsequent to initial wound surgery for evacuation from mobile to fixed hospitals is not designed to provide anatomic reduction or prolonged fixation in suitable reduction. Except in rare instances it is by plaster of paris. Plaster bandages are adequately padded and bivalved or split through all layers to the skin. Skeletal fixation by the incorporation of pins or wires into the plaster is not recommended. The only indication for the use of internal fixation in the forward area is to preserve the vascular integrity of the extremity. Methods of transportation splinting that have proved safe and comfortable are:

   (1) *Femur.* A low-waisted "one and one-half" double plaster spica with the knee slightly flexed and minimal abduction. The Tobruk plaster and the Army leg splint with skin traction provide temporary immobilization for transportation over short distances. While not as effective or comfortable as a spica, they may be used as emergency measures or when large numbers of casualties demand concessions to operating time, or for special indications such as the presence of a colostomy or suprapubic cystostomy. When restricted to lower third femoral fractures or knee joint injuries, the Tobruk splint provides adequate immobilization.

   (2) *Humerus.* Comfortable and effective splinting is provided by a thoraco-brachial plaster with the arm forward in internal rotation or a plaster Velpeau bandage binding the arm to the trunk. The Army humerus splint designed for field (first aid) use is not designed for postoperative transportation splinting. A hanging cast is both uncomfortable and ineffective as a method of transportation splinting.

(3) *Forearm.* A split or bivalved circular plaster cast that extends to the midbrachial region with flexion of the elbow or a plaster slab in the form of "sugar tongs" is recommended. The forearm should be held in midpronation.

(4) *Tibia and fibula.* A split or bivalved circular plaster cast should be applied from toes to groin. The knee is slightly flexed (15°), and the foot held in neutral position at 90° to the axis of the lower leg.

b. Reparative surgery of compound fractures (cf. par. 7c). Reparative surgery in compound fractures is made necessary by leaving unsutured the large incisions made for débridement and the recognized fact that splinting suitable for transportation is inadequate for complete reduction and fixation of the fracture. The goal is functional restoration of the extremity and demands treatment of muscle and nerve injury as well as skeletal damage. Observance of certain basic principles are important to the success of this phase of management.

(1) *Preoperative correction of anemia by whole blood transfusion.* Despite whole blood transfusion for resuscitation in the forward area, a high percentage of compound fracture cases will arrive at a fixed hospital in the communications zone with low red cell volume (hematocrit) and hemoglobin. An approximate estimate of the quantity of whole blood needed to restore red cell volume may be deduced from the rough rule of 500 cc blood for each 3 points of the hematocrit or 0.9 gram of hemoglobin. In the use of whole blood transfusion for correction of secondary anemia or hypoproteinemia the total volume administered in a 24-hour period should not exceed 1,000 cc, except to replace blood lost at operative procedures. This is in contrast with the larger volumes that are administered for resuscitation when the total circulating blood volume may be greatly reduced. No correlation exists between the hematocrit or hemoglobin levels and circulating blood volume, and care must be taken not to precipitate pulmonary edema by overtransfusion of a patient in whom the blood volume has been restored by dilution but who still shows a greatly reduced cell volume (hematocrit) and hemoglobin.

(2) *Surgical elimination of residual necrotic tissue.* No available chemotherapeutic agent can "sterilize" an open wound containing devitalized tissue or blood clot. A properly managed clean wound requires no local antiseptic.

(3) *Control of invasive infection by systemic chemotherapy.* Systemic penicillin therapy in a dosage of 25,000 units every 3 hours is recommended as a routine adjuvant for secondary operations on compound fractures. Treatment is continued postoperatively until the likelihood of invasive infection is passed.

(4) *Reduction or closure of soft tissue defects.* Exposed cortex of bone, nerves, and tendons are vulnerable to the necrotizing effect of wound suppuration and are protected by the apposition of adjacent soft parts. Transversely divided important muscle groups are united by suture. Fascial compartments are restored, to minimize scarring and improve muscle function. Certain of these procedures may be staged operations. Emphasis should not be placed on early or complete skin closure, as in most cases any remaining cutaneous defect will heal before bony union occurs.

(5) *Provision of drainage for residual exudate.* Severely comminuted fractures may require dependent drainage in association with the apposition of soft parts over exposed bone. Fascial plane incisions and separation of muscle bundles with fine mesh gauze to exteriorize the fracture site have proven superior to stab wounds or rubber drains. Upper extremity fractures rarely present a drainage problem. The thigh may be drained by a postero-lateral incision between the vastus lateralis and the biceps. An adequate posterior drainage route for the shaft of the tibia does not exist and such an injury may necessitate a period of nursing in the prone position ("on the face").

(6) *Internal fixation of battle fractures* is not feasible commonly because of extensive comminution. Further, the method demands periosteal stripping and surgical trauma to the wound. Limitation of the use of this method to cases carefully selected by specialists fully experienced in the technics and hazards of its usage is strongly advised. An example of sound usage is the employment of screws for restoration of the articular surface of a major joint. Reduction of the fracture—not the use of internal fixation—is part of the goal of reparative surgery.

(7) *Use of suspension traction.* The application of suspension traction in the treatment of

fractures, particularly those of the femur, is the safest and most satisfactory method of management. In fixed hospitals, fractures of the femur should be treated by skeletal traction for 10 to 12 weeks, until enough union has been obtained to permit safe transportation to the zone of interior in a plaster spica. The use of suspension traction promotes the maintenance of joint and muscle function and prevents angulation or overriding deformity. Overpull and resulting distraction must be avoided at all times, particularly in cases associated with injury or division of the thigh muscles. Certain cases of this type require very expert attention and delay in the application of traction until firm fibrous union of muscles has been attained by suture.

17. JOINT INJURIES. Early complete débridement is the keystone of success in the management of wounds that compound a joint. The wound of the soft part is excised and the bone and cartilage damage assessed through incisions that provide complete exposure. Comminuted fragments of bone and cartilage are removed from the joint and a careful search made for foreign material. When it is necessary for badly comminuted fractures of the patella to be excised completely as a step in the débridement of a knee joint wound, every effort should be made after cleansing the joint cavity to close the capsule and to approximate the fibers of the quadriceps and patella tendons. The skin is left unsutured. Penicillin is inserted into a joint at the end of the operation. In joints that are accessible to needle aspiration, accumulating exudate may be withdrawn and penicillin injected during the postoperative period.

a. *Closure of the joint* is especially difficult in the face of extensive loss of soft parts. When it is impossible to close a joint by suture of synovia or capsule, an occlusive dressing is applied. On arrival at a fixed hospital, effort is directed toward closing the defect by advancement of a skin flap or other plastic procedure.

b. Adequate exposure of the *hip joint* is a specialized procedure that requires precise anatomical orientation. The same principles of management must be applied to improve the results after injury to this particular joint.

c. Wounds of the *ankle joint* with comminution of the os calcis or astragalus are peculiarly liable to sepsis. Initial débridement of comminuted bone fragments must be minimal if function is to be preserved. Efforts are made early in the reparative surgical phase to reduce or close the skin defect with split thickness graft when necessary. When sepsis is established, subperiosteal excision of necrotic bone fragments, followed by early wound closure by graft or suture, should not be delayed.

18. URINARY BLADDER INJURIES. a. Perforating wounds of the urinary bladder require repair. Drainage of the urine should be accomplished by suprapubic cystostomy, not by perineal urethrostomy. The space of Retzius should be drained always.

b. Certain technical details in the performance of suprapubic cystostomy are essential to successful subsequent management of the cystostomy. A number 34F Malecot or number 20F Pezzer type of tube *should be placed as high in the fundus of the bladder as possible* and brought out through the upper end of the wound. This placement is to avoid pressure necrosis and infection of the pubic bone and periosteum as well as trauma of the trigone by the proximal end of the tube. The suprapubic tube may be held in place by adhesive after the sutures have been removed.

19. BURNS. Progress in the treatment of burns is reflected in the more liberal use of whole blood transfusions during convalescence and the excision of third degree eschars to facilitate earlier skin grafting.

a. Medical aid or emergency treatment of the burned area is accomplished by the application of a sterile pressure dressing. The burned area is covered with strips of sterile dry fine mesh or petrolatum gauze and a thick layer of sterile gauze. This is held in place by firm bandaging.

b. Initial surgical treatment is instituted as soon as possible.

(1) Resuscitation or prevention of circulatory failure is achieved by the adequate use of plasma. In extensive burns, quantities of plasma up to 12 units may be required in the first 24 hours.

(2) Pain is relieved by morphine in dosage of gr. 1/4. Pain should be differentiated from the restlessness and apprehension of anoxia. Barbiturates may be an effective supplement to morphine.

(3) The dressing is changed in an operating room with full aseptic precautions. If the burned area appears clean, no further preparation of the wound is indicated. Small blisters should be left alone, but larger ones may be drained by simple puncture. Gentle washing and débridement are reserved for grossly soiled burns. General anesthesia should be avoided if possible. The burned area is covered with dry fine mesh or petrolatum gauze and a pressure dressing. On burns of the extremities the pressure dressing should include the entire extremity distal to the burn. Immobilization of the part by splinting is desirable when feasible.

(4) Systemic penicillin therapy is instituted in preference to sulfonamide therapy.

(5) The prevention of anemia demands liberal use of whole blood transfusions as soon as the initial hemoconcentration is corrected. Protein depletion is offset more effectively by increased dietary intake and whole blood transfusion than by continued dependence on plasma.

c. Reparative surgical management seeks to prevent contractures and excessive scarring by proper splinting and early skin grafting.

(1) Unless complications develop, the initial dressing is not disturbed for 10 to 14 days.

(2) The excision of devitalized tissue may be begun at this time. If this is associated with minimal blood loss, the area may be grafted immediately. More usually the wounds will be dressed again with fine mesh gauze and pressure dressings in anticipation of skin grafting 3 to 5 days later. The adoption of staged procedures in the removal of devitalized tissue is especially recommended for patients with extensive burns.

(3) Systematic penicillin therapy should be continued until skin grafting is effected.

(4) The hematocrit (or hemoglobin) value should be maintained by repeated transfusion of whole blood until all grafting has been concluded.

20. GAS GANGRENE. The bacteriologic demonstration of Clostridiums in a war wound is a minor contribution to diagnosis and clinical management. *Evaluation of the patient* and *examination of the wound* are necessary to distinguish between anaerobic cellulitis and clostridial myositis (gas gangrene).

a. *Diagnosis.* Anaerobic wound infection should be suspected in battle casualties failing to respond to resuscitative measures. After initial surgery, the patient should be observed especially for pain in the wound, increasing pulse rate and disordered sensorium, either apathy or euphoria. In any suspected case the wound should be examined in an operating room with adequate light and instruments to permit thorough inspection and surgical treatment.

(1) *Anaerobic cellulitis* is characterized by the septic decomposition of tissues devitalized by trauma. Gas and pus may infiltrate fascial planes. The pus may produce necrosis of the surface of tissue exposed in the wound but there is no extensive invasion of living muscle. The patient may show signs of nonspecific toxemia in association with wound putrefaction.

(2) *Clostridial myositis* is characterized by the invasion and necrosis of living muscle tissue adjacent to the wound. The infection may be wet (edematous) or dry (emphysematous). The affected muscle is avascular, noncontractile and presents a variety of color changes. These findings are usually present in addition to those described for anaerobic cellulitis. The toxemia is more profound.

b. Predisposing factors are listed in relative order of importance:

(1) Delayed or inadequate initial surgical treatment of the wound.

(2) Interruption of arterial blood supply to a limb by trauma, thrombosis, ligation, or spasm.

(3) Constrictive bandages, especially unsplit plaster casts.

(4) Persistent circulatory failure and severe anemia.

(5) Certain muscles derive their blood supply from one or two main sources. This is especially true for the gluteus maximus, hamstrings, rectus femoris, vastus intermedius and gastrocnemius. Special care should be exercised in the surgical management of wounds of these muscles in order to preserve the blood supply.

c. *Prophylaxis.* The early application of sound principles of initial surgery is the most important factor in prophylaxis. Blood transfusion and penicillin therapy in selected cases supplement this program. The *wound should*

be left open at the time of initial surgery. Prophylactic gas gangrene antitoxin is not recommended.

d. Treatment. Anaerobic cellulitis responds to the secondary excision of devitalized tissue and the free incision of fascial planes. The same surgical procedure frequently will suffice to treat the infection and prepare the wound for later secondary closure. Clostridial myositis demands a more vigorous therapeutic program:

(1) *Surgery.* The most important factor in treatment is the prompt excision of all affected tissue. Local excision of a single muscle or group of muscles should be practiced in the interest of conservation of functional extremities. Amputation is advised for more extensive infection or where removal of the involved tissue implies loss of function of the limb.

(2) *Resuscitation.* The surgical excision of affected tissue contributes to resuscitation. Peripheral circulatory failure is frequently present, and whole blood transfusion is indicated. A severe anemia is usually present but hemoconcentration may occur in "wet" infections. Plasma is reserved for the correction of persistent hemoconcentration in selected cases. The demand for whole blood is considerable in the average case.

(3) *Chemotherapy.* Systemic p e n i c i l l i n therapy should be maintained in dosage of 200,-000–400,000 units per day. (See par. 21.)

(4) *Thrombophlebitis* is an established hazard of anaerobic infection. Pulmonary embolism contributes to the mortality rate in gas gangrene. Aspiration of trombi and vein ligation should be practiced at the time of amputation or during convalescence upon indication.

(5) *Naso-gastric intubation* with suction is necessary to combat abdominal distention and gastric dilatation.

(6) *Anuria* occurs with sufficient frequency to warrant especial consideration of fluid balance and urine volume. The exact mechanism of the anuria is not known. The vulnerability of the kidney to tissue anoxia secondary to protracted circulatory failure should not be forgotten.

(7) *Gas gangrene antitoxin* is of doubtful therapeutic value. It is clinically impossible to distinguish the specific toxemia due to clostridial exotoxins from the nonspecific toxemia due to products arising from the septic decomposition of devitalized tissue. Current enthusiasm for therapeutic antiserum is restricted largely to the use of the trivalent serum containing antibody to the *Cl. oedematiens* toxin in the treatment of "wet" types of infection.

(8) *Retroperitoneal cellulitis* and abscess may demand drainage early in the convalescence from gas gangrene.

21. CHEMOTHERAPY (see TB MED 9, 12 February 1944). No presently available chemotherapeutic agent can sterilize a contaminated or infected war wound. Neither penicillin nor the sulfonamides can prevent the ultimate septic decomposition of dead tissue or contaminated blood clots. Sulfonamides administered systemically are effective in the prevention and control of invasive hemolytic streptococcal infection but are ineffective in the control of staphylococcal or invasive clostridial infections. Penicillin is effective against hemolytic streptococci and staphylococci and, in addition, prevents the spread of clostridial infection from a focus of affected tissue. The effectiveness and limitations of chemotherapy are established sufficiently to attribute poor results to errors in surgical technic or judgment rather than to drug failures.

a. The concomitant use of sulfonamides and penicillin is unnecessary. The use of sulfonamides as a supplement to penicillin therapy contributes only the risk of untoward reactions and complications. There is no clinical evidence of synergism with the two agents.

b. The routine local use of chemotherapeutic agents has been abandoned. Penicillin may be instilled into serous cavities or major joints to complement the initial or subsequent surgical management of injuries in these regions. Repeated dressings solely for the purpose of application of antibacterial agents contribute to persistent wound suppuration with aerobic wound pathogens.

c. Systemic chemotherapy is an adjuvant to the surgical management of a contaminated or infected wound. It does not offset the hazard of residual dead space or improper drainage.

[AG 300.5 (28 Feb 45)]

By order of the Secretary of War:

OFFICIAL: G. C. MARSHALL
    J. A. ULIO   *Chief of Staff*
    Major General
    The Adjutant General

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