Articles

The Surgical Treatment of Extremity Wounds and Non-Penetrating Wounds of the Trunk

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From their vast experience, gathered during several wars and from practicing and teaching surgery for many years, the authors suggest some common-sense approaches to the most frequently found extremity and non-penetrating wounds of the trunk encountered in combat. They discuss the first operation, wound excision, wound debridement, immobilization of fractures, the prevention of infection, amputations, management of wounds during evacuation, delayed primary suture and secondary suture. They conclude their paper by pointing out some lessons learned, suggesting some improvements to be made in future armed conflicts.

The planners of medical care for those expected to be wounded in Operation Desert Shield/Storm in the Arabian Gulf area of Southwest Asia envisaged a continuous chain of evacuation all the way back to North America for those most severely injured. Fortunately, the large number of casualties which were anticipated never materialized. Excellent plans were made to treat the large flow of wounded which could have occurred. Echelons of medical facilities from Southwest Asia through Germany and the United Kingdom, and ending in the United States were prepared to receive the casualties. In this paper we will briefly discuss the management of wounds which did not involve the major organs and cavities of the body.

Wounds of the extremities and non-penetrating wounds of the trunk are the most frequent wounds which arrive alive at a forward surgical center. From a military standpoint, extremity wounds have the special significance that after treatment many of the wounded can return to active duty.

In past wars, wounds of the extremities and surface of the trunk have far outnumbered other wounds. For example, in March 1944, a field surgical unit operated on 451 wounded soldiers. Three hundred eighty-eight (86%) had wounds which did not involve the major organs of the body, while only 63 (14%) involved the abdomen, chest, head, etc. Although the level of war intensity may vary these statistics somewhat, the ratio remains heavily weighted to extremity wounds over penetrating cavity injuries. This has been noted in the WDMET Vietnam battlefield data where approximately 77% did not have cavity penetrating wounds requiring open treatment (thoracotomy, etc).[1] Panama data showed a similar ratio, plus extremity wounds referred to the general hospital needing an average of six more formal procedures to complete reconstructive care versus one for the penetrating cavity type wound. Appropriate initial theater management can speed recovery and minimize additional procedures, thus helping to conserve the fighting strength.

The First Operation

Wartime management of extremity wounds and superficial wounds of the trunk is routinely a two stage procedure. The first operation is wound debridement, and the second operation is delayed primary or secondary wound closure. In every war this has been a difficult lesson for expert civilian surgeons to learn. A surgical consultant once stated, "The surgeon is not yet born who does not think that he is the one who can close a war wound primarily." There are exceptions to this rule. The following wounds can be sutured primarily: wounds of the face (not the neck), sucking wounds of the chest, head wounds and some potentially clean surgical incisions such as a laparotomy or thoracotomy. A strange fact of war surgery is that a soldier with a small wound to the face can return to duty in a week while an equivalent wound of the back or buttock may cause the individual to be off duty for a month or more.

Wound Debridement—Wound Excision

Most English-speaking surgeons think that wound debridement and wound excision are the same. To a French speaking surgeon, "debridement" means opening and decompressing the wound by incision of the skin and fascia. The word "debridement" is derived from the French word "debrider," which translates to "to remove constriction by incision."

In practice, military surgeons should open the wound widely by incising the skin and fascia and then removing foreign material and excising devitalized tissue. Extensive incisions to remove elusive metallic foreign bodies are not advised. Copious irrigation with pulsatile lavage should be done

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and hemostasis obtained. It is not uncommon for hemorrhage to be limited during initial treatment as the patient is peripherally vasoconstricted. Blind palpation in a wound is ill advised as sharp fragments can tear the surgical gloves and lacerate the hand. This is especially dangerous when chemical munitions have been in use because the surgeon can become a casualty. The procedure of wound debridement is well described in the United States revision of the *NATO Handbook of Emergency War Surgery* and will not be further discussed, except for two points.[2]

The first point is the management of the skin. Unfortunately, the skin can be easily removed, and frequently too much skin is sacrificed. The objective is to have a wound which can be closed four or five days later by delayed primary suture. At the time of the first operation of wound debridement, skin incisions should be planned with the second operation in mind, and should include removal of only a very small margin of skin from around the wound. Axial orientation of incisions can make later closure or reconstruction easier.

Figure 1. Small entry hole of modern high velocity bullet wound sustained in Operation Desert Shield/Storm. Picture taken at 85th EVAC Hospital, Dhahran, Saudi Arabia.

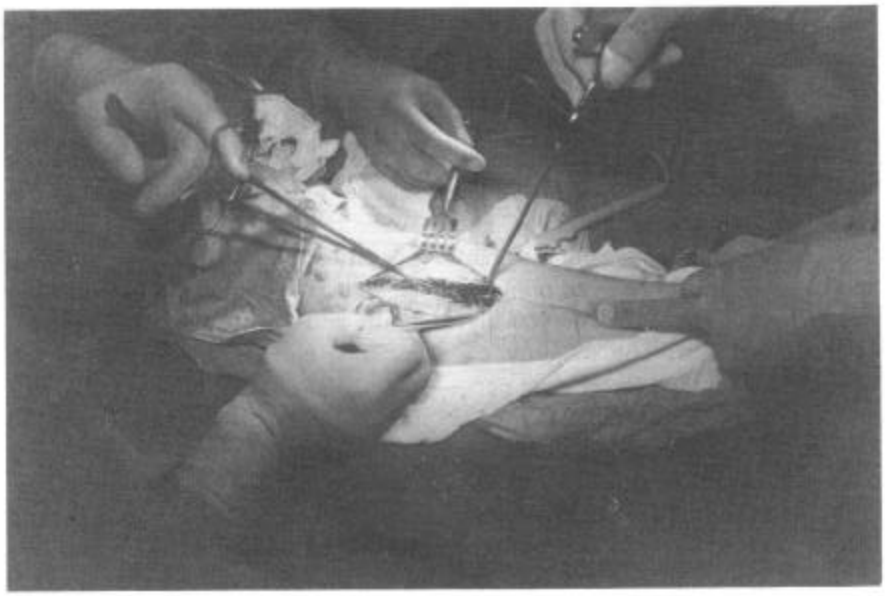

Figure 2. Leg fasciotomy and debridement of gunshot wound. Picture taken at 85th EVAC Hospital, Dhahran, Saudi Arabia.

The second point in the management is to avoid packing the wound. Gauze tightly packed into a wound will act as a plug. Rather, the dressing should be on the surface to protect the wound but not to constrict or limit drainage. The modern high-velocity bullet usually produces a large exit wound. Both the smaller entry and the large exit wound should be debrided and fasciotomies performed (Figs 1 & 2). It is important to stress that wide excision of the whole wound track by connecting these wounds is unnecessary and often harmful.

Immobilization of Fractures

Many extremity wounds will involve a long bone fracture. Long bone fractures and very large wounds of the soft tissues should be immobilized. Open fractures with small soft tissue wounds can be reduced and splinted with well padded bivalved casts. However, if there is a large soft tissue defect, external fixation is preferred to allow stabilization while continuing treatment of the soft tissue wounds during the evacuation and rehabilitation phases. Pins in plaster can be used when external fixation is not available. Skeletal traction can be used, but is quite troublesome to maintain during evacuation. Neurovascular status of all fractures should be checked before and after manipulation. This must be documented in the transfer summary.

The Prevention of Infection

Every war wound is contaminated. In World War I, the teachings of Joseph Lister were still on the minds of surgeons and, as a result, in the first years of that war, attempts were made to sterilize war wounds with chemicals. This, however, was a complete failure. In 1917, Major General Sir George Makins wrote "the complete failure of attempts at primary chemical sterilization of wounds led to increased resort to mechanical

cleaning of wounds by removal of devitalized tissue."[3] It is important to stress that antibiotics are better than chemicals in this role, but there is no substitute for thorough surgical debridement of the wound.

The administration of systemic antibiotics should be initiated as soon as possible following injury. Antibiotics are a useful adjunct to wound debridement. Furthermore, prophylactic active immunization against tetanus should be used in every soldier. Tetanus immunization should include a booster shot given to every war casualty presenting with a penetrating wound.

Amputations

The decision to perform an emergency amputation is a grave one. Amputations should only be performed in the forward area to save life and should be done as distally as possible using the open circular technique.

Informed consent in forward war surgery is rarely required. It is a curious fact that a wounded soldier both expects and welcomes an operation, perhaps because he feels that something is being done for him to alleviate his discomfort. However, an amputation is different. In most cases, the need for an emergency amputation is obvious, but in some the decision is not so clear. Under such circumstances a second opinion should be obtained if possible from another surgeon and the patient informed of the recommendation. The techniques used to perform an emergency amputation in the field are fully described in the *NATO Handbook of Emergency War Surgery* and will not be further discussed here.[2]

Management of Wounds During Evacuation

In war, the patient may pass through several medical units during his evacuation to a fixed hospital where delayed primary or secondary suture of the wounds can be carried out. It has been shown that inspection of the wound, except under operating room conditions, will increase the rate of wound infection and slow healing. This was reported initially by Dr. Winnett Orr in World War I.[4] He noted the difference in healing rates between officers whose wounds were redressed daily and enlisted men whose wounds were covered with a cast for the duration of the transatlantic boat ride. It is therefore recommended that the first dressing be left in position until it is removed in the operating room at the time of the second surgical procedure. Exceptions demanding removal of the dressing and inspection of the wound during evacuation include: unexplained fever, hemorrhage, unexplained pain and peripheral ischemia. It is difficult for medical personnel to do nothing except speed the transfer of the patient, but this is what they should do.

Delayed Primary Suture (the Second Operation)

Delayed primary suture is best performed on the fourth day after debridement, but can be performed as late as the seventh day. The wound is inspected under full aseptic conditions in the operating room. At this time the decision is made for or against delayed primary suture. Unfortunately, some wounds cannot be closed because too much skin was lost at the time of wounding or during wound debridement. Wound infection is not a contraindication to delayed primary suture. However, inflammation of the wound is a contraindication to delayed primary closure, as is the presence of gas in the tissues and obvious evidence of an incomplete wound excision. Associated fractures or blood vessel injuries are not contraindications, but in open fractures of the tibia and fibula complete delayed primary closure may be impossible, particularly at the distal end. The majority of wounds are suitable for at least partial delayed primary wound closure, and this is recommended to better protect exposed tendons and bone.

The delayed primary suture operation is performed with appropriate antibiotic coverage and consists of undercutting the skin edges by blunt dissection and trimming any redundant tags of skin or fascia. The skin is then closed with interrupted sutures with a fair degree of tension being permissible. Drainage should be considered by either bulb suction or penrose whenever there is concern over hemostasis or dead space. Placing deep sutures in the wound to close dead space is not advised. In open fractures of the femur, it is often wise to leave the posterior wound open for drainage. If no such wound exists, an incision can be made at the back of the thigh for postural drainage.

Secondary Suture

As an army gains in experience, secondary suture operations are performed less often because improved medical administration and surgical technique insures that most wounds are closed by delayed primary suture. The experience of the Allied armies in Italy in World War II illustrates this. In May 1944, 10.7% of 3845 wounds were closed by secondary suture. One year later in the spring of 1945, only 1.2% of 1876 had to be closed by secondary suture.[5]

For those patients who arrive too late for delayed primary suture or in whom it has failed or was impossible, skin coverage must be provided. Secondary suture is the best method for skin coverage with skin grafting second best. Free pedicle flaps should be performed as a last resort, but when required can lower morbidity if performed within two weeks.

The operation of secondary suture can be performed any time after the seventh to tenth day when delayed primary suture has become impossible. It is best carried out between the tenth and 14th days after debridement. It consists of excision of the granulation tissue, removal of a very narrow strip of the skin edge and undercutting of the skin for sufficient distance to make wound closure possible. The procedure is really a second superficial wound excision and has two major disadvantages when compared with delayed primary suture. First, it is more complicated and sec-

ond, there may be considerable loss of blood.

It cannot be stated too often and too strongly that the ideal goal for wound care is delayed primary closure of all extremity and superficial wounds of the trunk. Secondary suture operations are the next best approach. Closure by skin grafting or pedicle flaps are inferior procedures necessary in some patients, but hopefully only a small percentage. The secondary closure of open fracture wounds and the management of these patients should be done at a general hospital and not in theater.

SUMMARY

Fortunately, the Desert Storm War was short and rapidly victorious. One must not criticize a success, but it is acceptable to make suggestions for improvements particularly for a future war.

We were fortunate that the war was fought at a time of year when diseases were infrequent. If it had lasted into the summer and moved to the Euphrates and Tigris river estuaries, the outcome of the war might have changed dramatically.

We are reminded of a remark made after the large but mostly forgotten Burma Campaign of 1942-45. This war was fought in a tropical jungle. In 1943 in the Allied armies, the ratio of hospital admissions for sickness (malaria, dysentery, skin disease, etc.) to war wounds was 121 to 1. By the early fall of 1945, this ratio had become 12 to 1. The Japanese never came near to achieving such an improvement. The report states that in a tropical country, the medical services constitute the most important branch of the fighting services, because given anything like equality, the side with the better medical services will win—it will have more men fit to fight.[6]

Similar to previous wars, most of the surgeons of Operation Desert Shield/Storm were bored for most of the time before and during the War. However, the orthopaedists generally had busy clinics and plenty of training injuries to treat. Unfortunately, many training injuries could not be treated in theater for lack of appropriate resources. Arthroscopic surgery is a case in point. The advent of the arthroscope is post-Vietnam. Since our equipment was based on Vietnam experience, arthroscopes were not included in the DEPMEDS package. Patients requiring arthroscopic surgery were evacuated stateside for their surgery which was unfortunate since, had arthroscopes been available in theater, many of these patients would have been returned to active duty much sooner. If available, arthroscopes could probably be best used at the combat support, evacuation and field hospital levels. Similarly, a physical therapist could be used at the evac and field hospitals to conserve fighting strength by reducing short term air evacuation.

Armies have traditionally marched, and even in our highly technical wars this is still true. The soldiers' feet and footwear must be in top condition to meet this requirement. Mobilization usually means issuing new equipment to soldiers going to faraway places. Southwest Asia was no exception. Foot problems, including acute trauma below the ankle joint, were a substantial portion of everyday sick call. A supply of orthotics and a podiatrist should be considered at an evac hospital.

Another point is the need for medical consultants in any large theater of war. They play many roles, particularly when the planned area for the evacuation is nearly half-way around the world as it was in Desert Storm. One critical role of the consultant is to provide rapid feedback to the field surgeons on the results of their surgery. A good consultant can do this tactfully and greatly improve the care of the wounded. These reports should be educational. For example, the field surgeon should be told if he/she was removing too much skin, making delayed primary suture difficult or impossible, or whether wounds were unnecessarily packed and/or dressed during evacuation or whether plaster casts or dressings were applied too tightly. Of significant concern is the evacuation of casualties with inadequate or absent medical/surgical records. This occurs in most wars and is inexcusable. The consultant can also disseminate knowledge and act as a father confessor to those in his area of special competence.

We understand that consultants in the various medical specialties were not widely employed in the Gulf War. The war was short and so this did not greatly matter. The absence of a method of educational feedback to the forward surgeons could have caused unnecessary suffering if we had a long war with many casualties. At least in surgery and the surgical specialties, consultants should have been employed. Their presence as clinical advisors but not as executive officers need not threaten the medical command structure in the theater. Experience from past wars has shown that as time passes, all branches of the military improve their performance. A good consultant can insure that the surgeons will improve and be doing a better job at the end of a campaign, thereby aiding the primary medical mission; the optimal care of our sick and wounded.

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