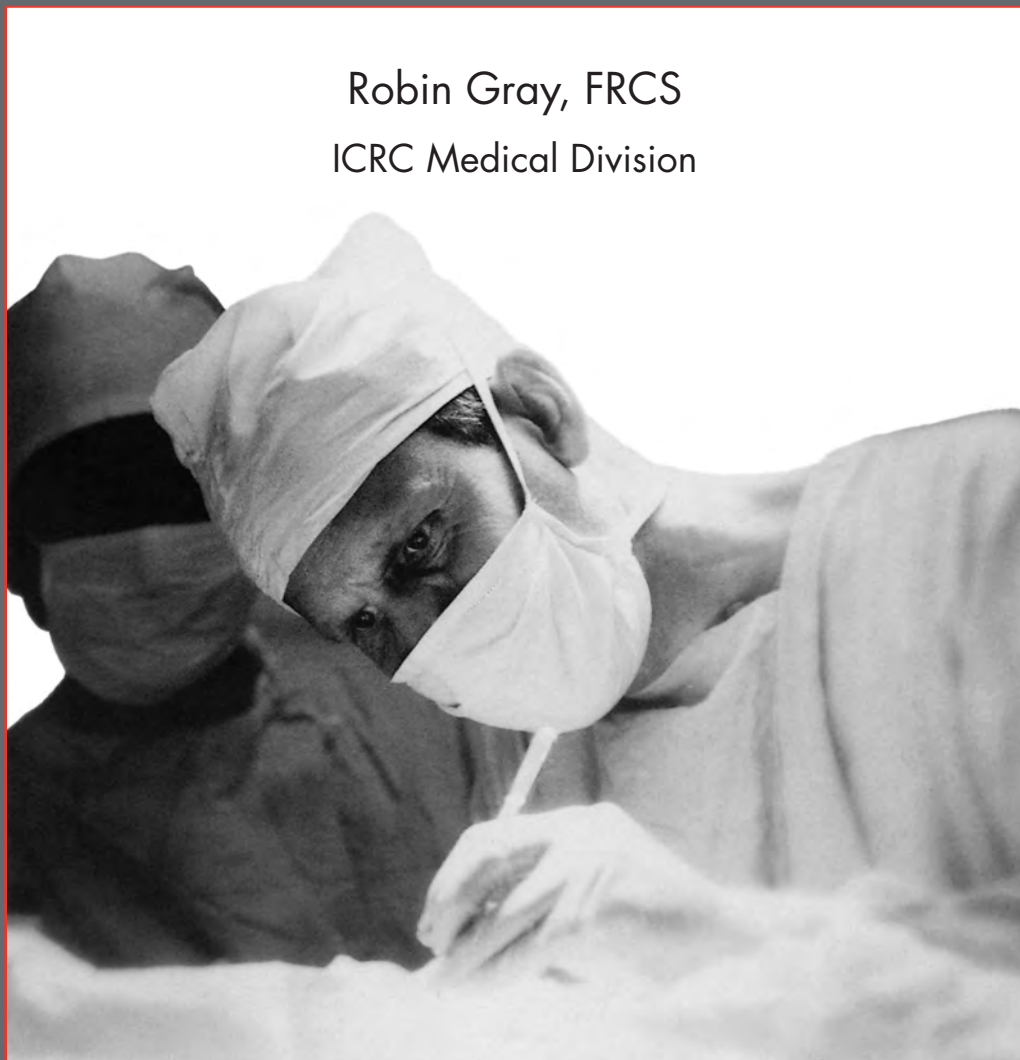


WAR WOUNDS: BASIC SURGICAL MANAGEMENT

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ICRC

WAR WOUNDS: BASIC SURGICAL MANAGEMENT

THE PRINCIPLES AND PRACTICE
OF THE SURGICAL MANAGEMENT OF WOUNDS
PRODUCED BY MISSILES OR EXPLOSIONS



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FOREWORD

The central issue for the doctor faced with the victim of a mine, a bullet or a metallic fragment injury is the wound: what to do about it and how to treat it. This booklet is intended to help doctors, whether military or civilian, who have to deal with penetrating war wounds.

It was the absence of treatment and facilities for the war-wounded which prompted the founding of the International Committee of the Red Cross and the signing of the original Geneva Convention in 1863. Today the ICRC promotes the 1949 Geneva Conventions and their 1977 Additional Protocols which afford protection for all victims of war: the wounded, the shipwrecked, prisoners and civilians.

Providing direct surgical care for victims of war, whether combatants or civilians, has occupied an increasingly important place in ICRC activities over recent years. This booklet represents the consensus opinion of the surgeons who work for the ICRC; it is offered in a spirit of sharing, to improve the treatment of all war-wounded.

Dr. Rémi Russbach,
Chief Medical Officer, ICRC.

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CHAPTER 1

UNDERSTANDING THE BASICS

Introduction

This booklet is intended for any doctor working within the context of a hospital treating war-wounded patients. It gives the basic surgical elements required for treating the war-wounded and is so structured as to facilitate decision-making.

The care of war-wounded from injury to discharge from hospital involves many people working within a system. The system is more important than the individuals concerned. In hospital, the wounded are looked after by a team and the doctor cannot function properly without the team. If there is no hospital organization, the care of the wounded suffers in consequence.

TEAMWORK AND COOPERATION ARE ESSENTIAL

The work of the doctor is to arrest haemorrhage, repair vital structures, or restore vital function, and in all cases to prevent infective complications.

War wounds are produced by fragments of metal, bullets or blast from mines. All are contaminated to a variable degree by bacteria from clothing, skin, and the environment. There is no uniform wound; the volume of dead and contaminated tissue varies. This tissue is a potential culture medium.

It is the removal of this variable volume of dead and damaged tissue, involving different structures and in different locations, which is difficult and new for the doctor unused to dealing with such cases.

ALL WAR WOUNDS ARE CONTAMINATED

THE LARGER THE VOLUME OF CULTURE MEDIUM THE MORE IMPORTANT IS ITS SURGICAL REMOVAL

These facts determine the fundamental principles of the surgical treatment of war wounds:

ALL DEAD AND CONTAMINATED TISSUE AND LOOSE FOREIGN MATERIAL MUST BE REMOVED

THE WOUND MUST BE LEFT OPEN PENDING DELAYED PRIMARY CLOSURE

Wound surgery

The basic operative procedures are incision, excision and haemostasis.

Definitions :

Incision means **cutting into**, and is used when a surgeon extends a wound by cutting into healthy tissue to gain visibility or to decompress tissue.

Excision means **cutting away** or **cutting out**, and is used to mean the surgical act of removing, with scissors or scalpel, dead and severely contaminated tissue.

Note on the word "débridement"

The word "débridement" has intentionally been omitted. In current English usage it has come to mean what surgeons do to war wounds. As surgeons do many things to war wounds the term has been dropped from this text in the interests of clarity. It is a word of French origin meaning to unbridle or release and the medical meaning is to incise or lance.

Incision alone for war wounds was used historically to allow discharge of pus, and incidentally also relieved tissue tension.

Leaving wounds open

The reasons for leaving wounds open are:

- to permit unrestricted swelling of tissues adjacent to the wound, thereby allowing decompression and avoiding ischaemia;
- to permit exudation of serum;
- to avoid the creation of an anaerobic environment;
- as a security measure to ensure that no residual, incompletely excised dead and contaminated tissue is contained.

Delayed primary closure

Delaying closure allows time for tissue swelling to subside and for review of the contaminated war wound, to confirm that it is safe for closure. This is the fundamental approach used for the treatment of soft tissue injury in war wounds. It minimizes the risk of containing infection and is quicker and more anatomically and functionally correct than awaiting healing by simple granulation and epithelialization (see page 28).

Wound infection

In fresh wounds, failure to remove dead and contaminated tissue and loose foreign material is the principal cause of wound infection. If evacuation is delayed, infection becomes established and contributes to the difficulty of wound surgery. Mud and earth projected into tissues by mine blast are particularly likely to cause infection if not completely removed. Gas gangrene, tetanus and pyogenic streptococcal infection are the most serious infections which may follow inadequately treated or untreated wounds.

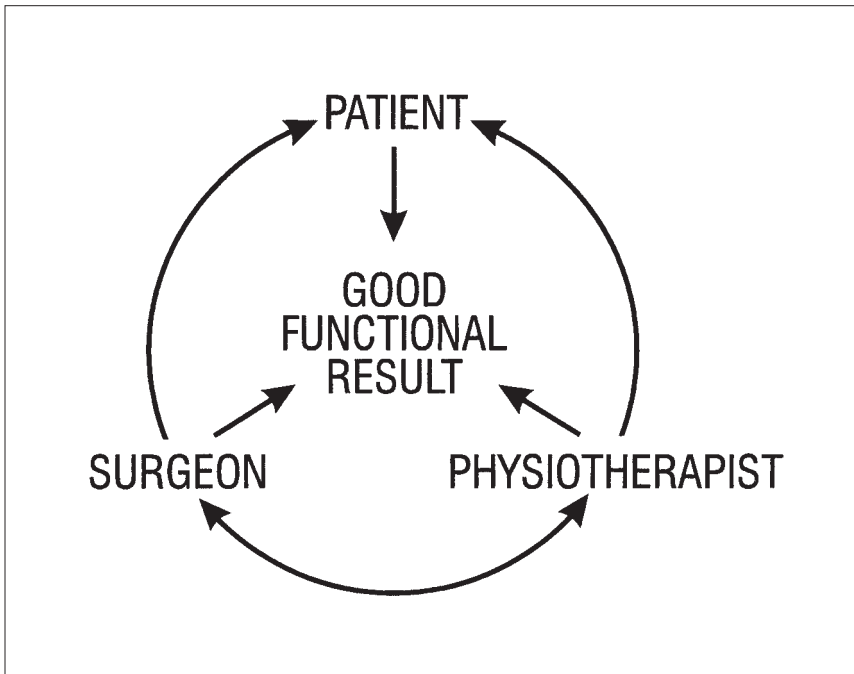
THE BEST "ANTIBIOTIC" IS A GOOD WOUND EXCISION



Primary closure and failure to perform a satisfactory wound excision results in wound infection.

Getting the patient going

Patients with limb injuries make up a large proportion of the injured who reach hospital. Early mobilization and movement increase local blood circulation, aid healing and stimulate normal physiological defence mechanisms associated with a good blood supply. Physiotherapy is essential to gain benefit from surgery and optimize residual function. Surgery without physiotherapy is a disaster; the goal is to restore the patients' physical capacities so that they can be reinstated in their communities. Only with a prosthesis can an amputee return to lead a relatively normal life in society.



SPECIAL POINTS.

GET IT RIGHT FIRST TIME: THE FIRST OPERATION IS THE MOST IMPORTANT FOR A QUICK AND UNCOMPLICATED RECOVERY AND DETERMINES THE ULTIMATE OUTCOME.

DO NOT THINK THAT SURGERY FOR WAR WOUNDS IS EASY.

FORESEE THE PLAN AND OBJECTIVES.

UNDERSTAND THAT THE OBJECTIVE OF WOUND SURGERY IS TO MINIMIZE INFECTIVE COMPLICATIONS.

IN FRESH WOUNDS, POST-OPERATIVE WOUND INFECTION IS DUE TO INCOMPLETE PRIMARY SURGERY.

THE SURGEON IS PART OF A TEAM.

CHAPTER 2

PATTERNS OF INJURY

Penetrating wounds are caused by bullets, by metallic fragments from bombs, shells, rockets and grenades, or as a direct result of blast into tissues. Tissue damage results from transfer of energy from the missile to tissues that impeded its progress. Tissues vary in their vulnerability to this type of trauma. The doctor conformed with a wounded patient must be concerned with the results and not theoretical considerations of missile velocity.

Bullets

Simple tracks result from bullets fired from hand-guns and from assault rifle bullets at the end of their trajectory. These are dangerous only when they hit vital structures. They have little damaging power. Assault rifles project bullets with initial high velocity and the potential damaging energy is considerable. Wounds differ, and the amount of damaged tissue is variable. The patterns produced by assault rifle bullets vary from simple in-and-out wounds with minimal tissue damage to wounds with large volumes of dead tissue. Shreds of clothing may be sucked into such wounds.

THE PATTERN AND VOLUME OF DAMAGE PRODUCED BY ASSAULT RIFLE BULLETS ARE VARIABLE

Metallic fragments

Tracks produced by fragments have a consistent pattern. Energy transfer is maximal on entry and progressively less as the fragment passes through the tissues. The wounds are conical in shape with the entry usually larger than the exit. The damage produced depends principally on the missile's velocity and mass.

FRAGMENT WOUNDS ARE VARIABLE AND MULTIPLE



Case A. A bullet injury to the left arm. The forceps show the entry.



Case A. The exit wound in the process of being excised.



Case A. X-ray showing a comminuted fracture of the radius and ulnar.



Case B. A bullet wound of the left elbow showing the entry and exit wounds.



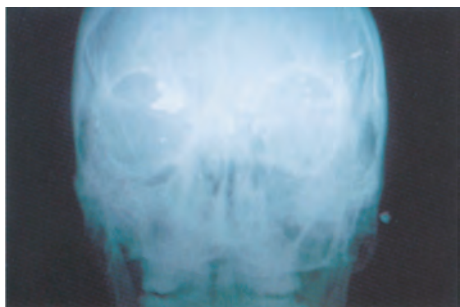
Case B. X-ray showing a comminuted fracture of the distal end of the humerus.



Case C. Multiple wounds from a fragmentation mine which exploded on the patient's left side. The principal injuries were to the left arm and the face.



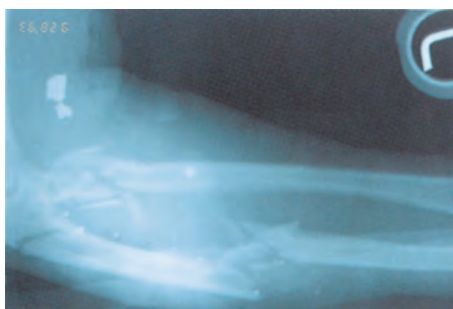
Case C. Multiple entries from metallic fragments. The patient was completely blind with fixed dilated pupils, indicating an injury to the optic chiasma.



Case C. Anterior-posterior X-ray showing multiple metallic fragments. The largest fragment entered through a wound just below the medial end of the left eyebrow.



Case C. Lateral X-ray showing the depth of penetration of fragments.



Case C. X-ray showing comminuted fractures of the left radius and ulna. The patient also had a comminuted fracture of the upper end of the left humerus.

Mine injury

Antipersonnel mines are constructed either to produce multiple fragment injury or to damage lower limbs by blast. Pressure-detonated blast mines blow off the foot or lower leg, often with considerable damage to the other leg, perineum and upper limbs. The particular danger and difficulty of these wounds is that earth, mud and debris are blown into the tissues and into the intermuscular planes.

WOUNDS FROM BLAST MINES ARE SEVERE



Case D. Multiple wounds from an antipersonnel blast mine triggered by another person walking on the right of the patient. The patient also received a penetrating abdominal wound which perforated the stomach, traversed the diaphragm and entered the left chest.



Case D. X-ray of the left knee region showing mud projected into the tissues lateral to the head of the fibula and gas which has entered interfascial planes of the lower thigh.



Case D. An incision has been made to expose the contents of the largest thigh wound. Mud is clearly seen in the muscle.



Case D. After surgery it can be seen that the wounds have undergone both excision and fasciotomy.



Case D. One week after initial surgery his recovery was complicated by a septic arthritis which was treated by arthrotomy and irrigation of the joint.

CHAPTER 3

TRIAGE

Introduction

A triage situation arises when large numbers of wounded arrive within a short space of time at a facility with limited resources to deal with them. Triage is the process of sorting wounded into categories of priority for treatment. The underlying principle is “to do the best for the most”. It is important to realize that it is not a once-and-for-all process, as patients require frequent reevaluation. Successful triage depends on realistic prior planning, good organization and clear thinking. Difficult decisions have to be made as to which patients take priority for surgical time and resources. Those with the most severe wounds are not necessarily the top priority for treatment; those with a more favourable prognosis may take priority for the limited surgical time available. Triage sorts out those patients who do not need surgery, those who can safely wait and those who will benefit from short rapid interventions. The severely wounded for whom surgery will take many hours, with little chance of success, will have to wait in the interests of helping a larger number of victims. The medical ethic and responsibility ingrained in doctors and nurses is oriented around the individual patient. A change of attitude is required in triage situations; their responsibility is to the whole group rather than to one wounded patient.

UNDERSTAND THE NEED TO CHANGE ATTITUDES, PRIORITIES AND EXPECTATIONS DURING TRIAGE

Triage may take place at any point along the line of evacuation when the number of casualties overwhelms or exceeds the capacity of the facilities available. The question is always the same: which patients take priority for the limited means available? In practice this means: which patients take priority for first aid, which patients take priority for transportation and which patients can safely wait?

Management of triage in hospital

The key to successful triage management is proper planning before the event. Every person involved within the system must understand his or her new role, which needs to be carefully thought out **in advance**. A written plan of action must be drawn up for the hospital and must be known by all staff. **It must be simple** and should clearly define responsibilities and the hospital reorganization required for the reception of casualties. There must be agreement as to when a triage plan comes into action.

PLAN FOR TRIAGE

Security

When large numbers of civilian casualties arrive it is often difficult to control who comes into the hospital. It is essential to have a guard at the gate. His function is to keep away from the triage area those who are searching for their injured relatives or who come out of curiosity. In ICRC hospitals, weapons are left at the gate. Under the terms of the Geneva Conventions any hospital marked with the Red Cross or Red Crescent emblem must be respected, as must all medical staff and patients.

Is there enough space?

Access for ambulances should allow for ease of unloading and the triage area should be near to but not obstruct the entrance of the hospital. The area should have good lighting, water taps, and ropes or wires strung out at a height of 2 m on which intravenous infusions can be hung. There should be easy access to radiology and to operating theatres. A separate area should be designated for the treatment of people with minor wounds who can wait and do not need hospital admission. Those who are not considered suitable for surgery because of the magnitude and severity of their wounds are segregated in a quieter area to leave space for those requiring active treatment. Arrangements must be made for extension of the mortuary or a place found to serve as a temporary mortuary.

What is needed?

The triage area should have essential equipment which is easily located and accessible. Stretchers, suction machines, sphygmomanometers, tourniquets for venesection, flashlights, splints, scissors, plastic bags for patients' clothing and valuables, and sets of documents are all needed. Antibiotics, analgesics, plasma expanders must be readily available, together with bandages, sticky tape and stethoscopes. Individual kits for setting up intravenous infusions are made up prior to the event.

Who does the triage?

It is essential that one person be in charge of the triage of patients. His or her decisions must be respected; otherwise chaos will ensue. A triage situation is not the time to discuss fine points; it is a time for decisive action. Whether the person doing the triage is an experienced nurse or a doctor is not important. The qualities of the person concerned must, however, include an understanding of the overall functioning of the hospital, clarity of thought under stress, experience and understanding of war wounds, an abundance of common sense and an ability to be decisive.

RESPECT THE TRIAGE DECISION

Categorization of wounded into priority groups

The major requirement for any system of categorization of patients into priorities is that it be simple. The wounded fall into one of the following four triage categories:

Category I: Serious wounds - resuscitation and immediate surgery

Those patients for whom urgent surgery is required and for whom there is a good chance of recovery. In practice many of these patients will have abdominal or thoracic injuries or wounds of peripheral blood vessels.

Category II: Second priority wounds - can wait for surgery

Those patients who require surgery but not on an urgent basis. In practice this applies to the majority of casualties: most compound fractures and penetrating head injuries.

Category III: Superficial wounds - ambulatory management

Those patients who do not require hospitalisation and / or surgery because their wounds are so minor that they can be managed on an ambulatory basis. In practice this includes superficial wounds managed under local anaesthesia in the emergency room.

Category IV: Severe wounds - supportive treatment

Those patients who are so severely injured that they are likely to die or have a very poor quality of survival. These include the moribund, or, patients with multiple major wounds whose management could be considered wasteful of scarce resources including operative time and blood.

Marking and documentation of patients

The patient's admission number may be marked on his arm in Arabic numerals and his category in Roman numerals on his forehead. The disadvantage of this system is that it is not easy subsequently to change the patient's category should the need arise. Triage cards and admission sheets may be used, but great care and attention is needed to ensure that they remain with the patient. In a triage situation proper documentation is particularly important to minimize chaos and calls for considerable self-discipline on the part of staff. Observations and treatments given must be documented.

DOCUMENT DURING TRIAGE

CHAPTER 4

ADMITTING THE PATIENT

Immediate first aid: A, B, C

- 1) Check the *airway*. Be prepared to pass an endotracheal tube, or to perform a tracheostomy.
- 2) Check the *breathing*. Place a chest tube or a wide-bore needle in patients with an evident tension pneumothorax. Cover and seal a sucking chest wound.
- 3) Arrest haemorrhage (*circulation*).
- 4) Place an intravenous cannula, take blood for blood grouping and possible cross-matching and start intravenous crystalloids.
- 5) Start treatment of shocked patients immediately.
- 6) Give benzyl penicillin 5 million units intravenously (see Chapter 6).
- 7) Give human anti-tetanus immunoglobulin (HAI) 500 IU intramuscularly, and start a course of tetanus toxoid.

DOCUMENT ALL TREATMENT GIVEN TO PATIENTS

History

The patient's name, age, sex and other relevant information are recorded on the admission chart. The surgically important information to be noted is:

- What weapon caused the injury?

Injury may be caused by bullets, metallic fragments or blast from bombs or mines. Patients do not always know what type of weapon caused their injury.

- How much time has elapsed since injury?

This is important because it influences surgical management. The longer the delay between injury and surgery, the greater the risk of infective complications which may necessitate more extensive and difficult surgery.

Assessment of the patient

The aim of the initial examination is to know whether the patient is shocked and requires resuscitation, and to assess the extent of wounds. This takes priority over lengthy examination or X-rays.

General systemic examination

Is the patient shocked?

Signs of shock are a rapid and possibly weak pulse, reduced blood pressure, pallor, sweating and cold skin. Severely shocked patients may complain of thirst, and may be excessively agitated, nauseated, confused and anxious, or quiet and apathetic. The respiratory rate is increased. Signs of shock may be misinterpreted as being secondary to head injury and shock can thus be missed in patients who have sustained a head injury.

Young patients compensate for hypovolaemic shock more readily than older patients. Signs may not be so easily detectable. The only sign may be a moderately raised pulse rate but normal blood pressure. They may rapidly decompensate, however, in which case blood pressure may fall only as a terminal event. Always record the blood pressure, pulse and respiratory rate and whether the patient is shocked. Start treatment immediately for those who are in hypovolaemic shock; blood volume must be replaced. Continue monitoring such patients by observing urine flow, by means of an in-dwelling Foley catheter.

Low blood pressure with no other signs of shock points to an injury to the spinal cord.

Signs of respiratory distress raise the possibility of an unstable segment of the chest wall or a haemo-pneumothorax.

MAKE CERTAIN THAT LOST CIRCULATING VOLUME IS REPLACED BEFORE PATIENTS GO TO THE OPERATING THEATRE. USE WIDE-BORE CANNULAE FOR SHOCKED PATIENTS

The prognosis for patients who are properly and rapidly resuscitated preoperatively is much better than for those who have been inadequately resuscitated or who have been shocked for any length of time.

Use of blood

Blood is a valuable commodity not to be wasted. It must be used only where the need is vital and for those with a good chance of recovery. Blood for grouping, cross-matching and haematocrit is taken at the time the intravenous cannula is inserted. Any blood given must be cross-matched and screened for malaria, syphilis, hepatitis B and HIV. Ungrouped and uncross-matched blood should never be used.

Assessment of the wound

It is wise to take down dressings to look at wounds before the patient goes to the operating theatre. Dressings on traumatically amputated limbs or very large wounds

may be left in place as the extent of injury and the necessity for operation are evident. All wounds must be assessed; the doctor must observe their site and size and consider what deeper structures may be involved.

EXAMINE THE WHOLE PATIENT, PREFERABLY REMOVE ALL CLOTHING, AND ALWAYS EXAMINE THE BACK

Remember:

- Small entrance wounds from bullets can be associated with extensive internal damage.
- Missiles do not always travel in straight lines.
- Chest wounds may be associated with abdominal wounds.
- Entry wounds in the buttocks, thighs or perineum can be associated with intra-abdominal injury which may include the bladder, urethra and rectum.
- Entry wounds in the groin raise the possibility of major arterial or venous injury of the femoral vessels.
- A haematoma may mean a major vascular injury.
- Any injury of the leg may be complicated by a compartment compression syndrome.
- With a chest wound, surgical emphysema is usually accompanied by a pneumothorax or a tracheo-bronchial lesion.
- A bubbling or sucking sound with a chest wound indicates an open pneumothorax.
- Multiple wounds are dangerous because of the risk that any one of them may have injured a vital structure.
- In patients with multiple wounds, the largest wound may not be the most important.

Radiological assessment

X-ray films are taken in two planes and can provide a great deal of information. Chest and abdominal X-rays are best taken with the patient upright. The absence of X-rays should not prevent sound surgical treatment of war wounds.

Look for:

- 1) The position of metallic bodies: but remember that X-rays can be misleading and difficult to interpret unless it is known exactly in which planes the films were taken.
- 2) The presence of fragments of a bullet which has broken up: this indicates that there will be extensive tissue damage.
- 3) The type and exact position of a fracture: this will indicate the best method of fracture immobilization.
- 4) The extent of bone destruction: this may help decisions about the need and level of amputation.
- 5) The presence and amount of air and blood in the pleural cavity: this will help the decision as to whether to place chest tubes and on which side to place them.
- 6) Intramuscular or intrafascial gas.

Caution: gas in the tissues is not pathognomonic of gas gangrene or infections by gas-producing organisms. In cases of traumatic amputation by mines, air as well as debris and other foreign material may be blown into the intermuscular compartments of the leg. Gunshot wounds are not infrequently accompanied by air between muscles; this is sucked in as a consequence of the negative pressures occurring in the process of cavitation.

**NOT ALL FOREIGN MATERIAL IS VISIBLE ON X-RAY.
PLASTIC USED IN MINES, MUD, CLOTHING AND MANY OTHER TYPES
OF FOREIGN BODY MAY HAVE ENTERED THE WOUND.**

X-rays are an aid to precise diagnosis especially in the case of complicated fractures but they are not indispensable to the practice of sound surgery for war wounds.

CHAPTER 5

SURGERY

Anaesthesia

It is essential that the anaesthetist and the surgeon discuss beforehand the type of anaesthesia to be used, the position of the patient on the operating table and the order of operation for multiple wounds. The surgeon should indicate the likelihood of a longer operation such as laparotomy or vascular repair being needed. Wounds of the head, neck, thorax and back may present considerable anaesthetic challenges.

SURGEON AND ANAESTHETIST MUST DISCUSS THE OPERATION

Ketamine

The majority of wounded patients can be managed safely with ketamine which, when used correctly, has few unpleasant side-effects. To prevent hallucinations during operation and post-operatively the patient should receive either diazepam or midazolam as well. Ketamine can be used for hypovolaemic patients. The doctor should be aware that it makes normovolaemic patients hypertensive and that movement and phonation are not uncommon.

Operative planning

Before starting surgery the doctor must have a clear idea in mind as to what is to be achieved. The desired outcome is a clean, healthy wound which is suitable for closure by direct suture or skin grafting in four to six days.

Remember:

- The primary objective is to remove all dead and severely contaminated tissue, and all loose foreign material. (Please also refer to Chapter 8: "Special Cases".)
- A thorough wound excision involves display of all structures in the wound cavity.
- A completely divided muscle retracts away from the wound, and unless actively sought may be missed.

The wound is further assessed when the patient is under anaesthesia, and the operation is planned accordingly. A wound can be thought of as a cavity lined to a greater or lesser degree by dead and contaminated tissue. There may be loose foreign material inside this cavity which has been pushed or sucked in at the moment of injury. An understanding of the depth and course of the missile may be gained if the

missile is visible on the X-rays. Having assessed the wound the doctor is in a better position to predict the nature and extent of the operation. It may be clear at this point that the wound will need to be further extended by incision of healthy skin. Conversely, it may be evident that extension of the wound will not be necessary in order to visualize all damaged tissue. There must be no hesitation to make extension incisions to see what needs to be done. The extent of damaged tissue should not be underestimated; for the inexperienced it is often much greater than anticipated.

For distal limb wounds, a pneumatic tourniquet is invaluable in the initial surgery. Application before removal of field dressings minimizes blood loss and produces a bloodless field which facilitates wound excision. It may, however, make discrimination between healthy and doubtful muscle more difficult. It is advantageous to plan incisions for distal limb wounds so that they do not interfere with later soft tissue coverage with fascio-cutaneous or muscle flaps, should they become necessary.

WOUND SURGERY: OPERATIVE TECHNIQUE

Instruments

A basic set of instruments for wound excision includes a scalpel, large curved scissors, toothed dissection forceps, a curette, six haemostats, two medium-sized lipped retractors, and a self-retaining retractor. Diathermy is not necessary. Suture material should be absorbable.

Skin preparation and draping the patient

The skin is prepared with an antiseptic solution and the operative field is draped in accordance with the planned procedure. Drapes with holes should be used only for the smallest and most superficial wounds when there is no likelihood of the wound being widely extended. It must be borne in mind, however, that the surgical wound is always more extensive than the initial wound. Provision should be made for possible extension of the wound by incision.

What the surgeon does

The surgical objective is the removal of all dead and severely contaminated tissue and all loose foreign material which would serve as a culture medium for bacterial growth. An important consequence of wound surgery is that it allows decompression of adjacent healthy tissues. Failure to remove dead and contaminated tissue causes most post-operative wound infection.

Skin: As little skin as possible should be removed. It is an elastic tissue which resists damage. Non viable skin only should be removed around the edges of the wound. If retraction of the skin edges is insufficient to visualize hidden and deeper damaged structures, then the wound may have to be extended by incision. Extension incisions should be in the axis of the limb, and obliquely or transversely across joints.

An incision in the line of the limb allows decompression of muscles. **The commonest mistake is to make incisions too short.** Swelling is an inevitable consequence of injury and can be sufficient to compromise the local circulation and lead to further tissue death; extension incisions prevent this. With through-and-through wounds the skin incisions and muscle dissection are based on both the entry and the exit and may meet. The entry site of some wounds may, however, not need surgery.

Subcutaneous fat: Fat has a poor blood supply and contributes nothing to healing. Dirty, contaminated fat should be generously excised, especially around the buttocks and posterior aspect of the thighs.

Muscle, tendon and fascia: All heavily blood-stained and contaminated fascia, either on the surface or between muscles, should be excised. Incisions of muscle fascia may be required to see the extent of damage. Individual muscles and tendons are bluntly dissected and their damaged part excised back to healthy tissue. Viable muscle is recognized by its colour, bleeding, texture and contractility. Dead muscle fails to bleed, fails to contract when pinched, is darker than normal and feels different in consistency; it often disintegrates when held with forceps.



A wound in the process of excision. The dead muscle is darker than the viable muscle. The distal part of the wound has been excised and the proximal part awaits excision.

Fasciotomy: The muscles of the leg, and to a lesser extent the forearm and thigh, are enclosed in fascio-osseous compartments. With traumatic swelling of the muscle within these compartments, the raised tissue tension may be sufficient to compromise the circulation, resulting in muscle death; distal pulses, however, may still be present. Pain may be elicited on passive stretching of the muscles which are compromised. This may be difficult and the wisest practice with war wounds is to **take anticipatory action by fasciotomy.**

Incisions are made longitudinally through the skin, subcutaneous tissues and muscle fascia, and need to be long. The skin incision must be long enough to divide, with certainty, the fascia along the whole length of the muscle.

Bone: When the wound includes a fracture, that part of the bone must be displayed. Unattached bone fragments must be removed: if left in situ they act as a nidus for chronic wound infection and will not serve as a bone graft. Exposed medullary bone must be curetted back to firm marrow. Exposed cortical bone can be left in situ if not stripped of its periosteum by the injury.

**ONLY REMOVE LOOSE, UNATTACHED BONE FRAGMENTS.
LEAVE BONE FRAGMENTS WHICH ARE ATTACHED TO HEALTHY TISSUE.**

Major nerves and vessels: repaired vessels should not be left exposed but need covering by viable muscle and may require a muscle flap. Nerves exposed after wound excision can be left without soft tissue cover until delayed closure.

Foreign material: Within the wound there may be pieces of metal, plastic, clothing, extraneous bone fragments, mud, earth and other debris. All that is loose must be removed. Foreign material and loose bone fragments can be felt in the wound depths. As part of the excision, remove all mud, earth and clothing which are embedded in tissue, as they are potent sources of infection if left behind. Mine injuries often contain mud and earth which have been projected into the tissues and are particularly troublesome if not completely removed. Small embedded metallic fragments, however, are not only difficult to find but their removal is unnecessary and hazardous. If they come away with tissue which requires excision this is good, but an exploration should not be made for them. Prolonged surgery to locate bullets and fragments that have come to rest in undamaged tissue is unnecessary and dangerous; they should be removed later if symptoms subsequently occur.

Haemostasis

This is best achieved by ligation with absorbable material and application of a compress. During major amputation of a limb, doubly ligate the large vessels with absorbable material. Haemostasis using diathermy, bone wax or absorbable foam haemostatics is unnecessary. Very rarely, adequate haemostasis cannot be achieved because of difficulty of access. This is the only indication for packing a wound.

Lavage

The wound is generously washed out with saline. This is all that is required. Access and effect are improved with an improvised jet lavage using a syringe. Antiseptic solutions in a fresh wound after excision are of doubtful value. If hydrogen peroxide,

sodium hypochlorite (Dakin's solution) or povidone-iodine are used they must be applied in diluted form and the wound then washed out with saline. Undiluted antiseptic solutions are harmful to the tissues.

What should the wound look like at the end of the operation?

The wound should be a cavity of healthy tissue all of which, with retraction, can be fully seen. Care should be taken not to leave contaminated tissue in intermuscular compartments. This is important when operating on blast mine victims who have sustained large wounds.

LEAVE WOUNDS OPEN

Definitions :

Healing by first intention: The healing process after a surgeon has cut and then closed a wound by stitching is known as healing by first (or primary) intention.

Primary closure: The immediate closure of a wound produced either surgically or as a result of injury with the expectation of healing by first intention is called primary closure.

In this instance the body's natural capacity for healing is enhanced by approximating tissues which have been divided at operation.

Clean wounds produced by a surgeon or by injury will heal naturally if left alone, but lack of surgical approximation may result in unsatisfactory anatomical and functional alignment.

Healing by second intention (delayed healing): The healing process of a non-approximated wound, which remains open until re-epithelialization, is called healing by second intention or healing by granulation.

Primary closure of penetrating war wounds, which attempts healing by first intention, carries an unacceptable risk of dangerous infection. There are certain areas of the body, however, in which primary closure is permissible or necessary. These are discussed later. Awaiting the natural processes of healing by second intention takes a long time, and the repair may be unsatisfactory anatomically and functionally.

Delaying primary closure still allows early closure, which presents the advantages of healing by first intention. Early soft-tissue coverage is important for the optimal healing of bones, tendons, nerves and vessels, and for later mobility.

The dressing applied by the surgeon

LEAVE WOUNDS OPEN

All wounds are left open and covered with a dressing with the exception of wounds of the face, scalp, neck, buccal mucosa, dura, peritoneum, pleura and synovium of joints, which are closed primarily.

A large quantity of dry, bulky, loosely applied, fluffed up gauze is placed on the wound. Gauze moistened with normal saline can be used over tendons, joints and exposed bone. Cavities are not packed. The function of this dressing is to absorb blood and serum which exudes from the raw surface of the wound. Vaseline gauze, with or without antibiotics or antiseptics, and special non-adherent dressings should not be used.

NEVER PACK WOUNDS

Bandages

Non-constrictive bandaging techniques should be used. Adequate dressing material and cotton wool prevents the bandage being too tight. Never use adhesive dressing tape circumferentially on a limb, as it causes constriction.

Plaster of Paris (POP)

Large wounds and wounds near joints should be supported by the use of POP slabs. Circumferential plasters are best not applied; if they are, they must be split completely down to skin. There is always a risk that plasters may not be split sufficiently to avoid the risk of constriction. (The ICRC Medical Division has published a booklet on fracture management.)

Documentation and post-operative orders

The doctor must make notes and write orders; not to do so constitutes professional negligence. It is often clearer and more explicit to make a diagram or drawing than to write in words. At minimum the notes should include:

- What was found
- What was done
- What is to be done afterwards

As a consequence of the policy of not changing the dressing in the ward between the primary operation and delayed closure, it is necessary to plan for the date of wound closure.

WRITE DOWN THE DATE PLANNED FOR DELAYED PRIMARY CLOSURE

Red Cross wound classification

Wounds can be described numerically with great ease and simplicity using this system. Using the scoring system gives a deeper understanding to those unfamiliar with war wounds and adds only seconds to the doctor's work.

The classification facilitates surgical communication, establishes a scientific approach to war surgery, helps with surgical audit, and is a useful method for retrieving wound information from the field.

Necessary and permissible primary closure after excision

Face, scalp, neck and buccal mucosa:

These tissues have in common a good blood supply, small volumes of muscle and the capacity to expand freely without impeding the circulation. After wound excision, which usually involves a minimal volume of tissue, they are closed with interrupted, non-absorbable sutures. It is important to have good skin apposition and correct alignment of all facial features, such as skin creases, eyebrows, eyelids and the vermilion border of the lips.

Dura:

Brain wounds require primary closure to minimize the risk of meningeal infection and to prevent leakage of cerebrospinal fluid. It is ideal to close the dura directly if possible, or to use a patch of fascia lata aponeurosis or pericranium. The primary aim is, however, to cover the brain and not leave it exposed.

Most wounds can be closed by direct suture of scalp tissue, though subgaleal mobilization may be necessary with incisions of the galea itself. Occasionally, when there is considerable loss of scalp skin, a scalp flap (rotation or transposition) is the only means of achieving immediate brain cover.

Pleura:

The chest wall requires direct closure to prevent an open pneumothorax and to allow expansion of the lungs. The skin of the wound can be left open and local muscle closed to include the pleura. Large defects in the chest wall will require immediate cover and support, and this may be provided only by mobilization of muscle, or very rarely by a muscle flap (latissimus dorsi or pectoralis major).

Peritoneum:

While repair or closure of the peritoneum itself is not indispensable, some form of barrier to hold the abdominal contents in place is essential. The peritoneum has considerable power of regeneration, and if possible it should be directly closed. This is not, however, vital. What is essential is that muscle is in place to stop intestines escaping. Apposition of the locally available muscle fascia is performed with interrupted sutures and the skin is left open.

Joints:

The synovium is closed to prevent leakage of synovial fluid and to minimize the risk of joint infection. The capsule is left open provided the synovium is closed. Should it not be possible to close the synovium, then some form of closure must be achieved using either capsule or available adjacent tissue. When a large area of cartilage is exposed, a reconstructive procedure may be required.

IN ALL SITUATIONS, AVOID TENSION

Inappropriate arguments used by doctors for primary closure of all soft tissue wounds.

ICRC surgeons working in many parts of the world are in a position to see the results of inappropriate primary closure of soft tissue wounds. The reasons given by some doctors for closing soft tissue wounds include:

- * to achieve haemostasis;
- * to save the surgeon and patient time by avoiding a second operation;
- * to save the materials and anaesthetics that would be needed for a second operation;
- * antibiotics sterilize contaminated and dead tissue and prevent infection;
- * only very severely contaminated wounds need be left open;
- * if a sound wound excision has been carried out then the wound can be closed;
- * all patients seen within six hours of injury can have their wounds safely closed with antibiotic cover;
- * some surgeons like to judge each wound on its merits and act accordingly.

These arguments are unacceptable. The policy of leaving wounds open not only allows tissue swelling to subside but also accepts the fact that complete wound excision is not always achieved even by the most experienced hands. **Delayed closure is safe and allows for a margin of error.**

CHAPTER 6

POST-OPERATIVE MANAGEMENT

Post-operative orders

Post-operative orders are essential and include antibiotic protocols, intravenous fluid regimes, nursing positions, and instructions about physiotherapy. Patients with head or chest wounds should be nursed sitting up. Legs and amputation stumps are best elevated on pillows or Braun frames and passive mobilization of joints should be started early. Arms may be placed in slings or elevated using a sling and a drip stand.

COMMUNICATE INSTRUCTIONS: WRITE DOWN ORDERS

Antibiotics

All penetrating wounds: all patients receive penicillin intravenously and human anti-tetanus immunoglobulin intramuscularly, and start a course of tetanus toxoid.

An intravenous cannula is placed for administration of penicillin, except for patients with such minor wounds that they would not be admitted to hospital.

Five million units of benzyl penicillin are given intravenously on admission and repeated 6-hourly for 24 hours. This is followed by oral penicillin V 500 mg 6-hourly until the fifth day. In particularly severe limb wounds, the intravenous penicillin may be continued for 48 hours. Erythromycin, chloramphenicol or a cephalosporin is substituted in case of penicillin allergy. All patients receive 500 IU of human anti-tetanus immunoglobulin (HAI) intramuscularly and begin a course of tetanus toxoid.

Penicillin is used because the dangerous organisms *Streptococcus pyogenes*, *Clostridium welchii*, and *Clostridium tetani* are always sensitive to it.

Haemothorax

Ampicillin 1 gm IV X 4 for 48 hours,
followed by Amoxycillin tab 500 mg X 4 to be continued until two days after removal of the chest tube.

Penetrating Cranio-cerebral Wounds

PNC-G 5 MIU IV X 4 &

Chloramphenicol 1 gm IV X 3 for at least 72 hours,

Continue IV or oral according to condition of the patient for a total of 10 days

Abdominal Wounds

A: SOLID ORGANS ONLY; LIVER, SPLEEN, KIDNEY (and isolated bladder)

PNC-G 5 MIU IV X 4 for 3 - 5 days depending on drainage

B: STOMACH, SMALL INTESTINES

Ampicillin 1 gm IV X 4 &

Metronidazole 500 mg IV X 3 for 3 - 5 days

C: COLON, RECTUM, ANUS

Ampicillin 1 gm IV X 4 &

Gentamycine* 80 mg IV X 3 &

Metronidazole 500 mg IV X 3 for 3 - 5 days

(If IV Metronidazole or Gentamycine are not available give IV Chloramphenicol.)

Children. All the above dosage regimes are recommended for adults with an assumed weight of 70 kg. Proportionally smaller doses are recommended for children, based on their weight.

Wound management

The policy of leaving operative dressings undisturbed until delayed closure is dependent on the use of bulky dressings. Outer soiled dressings are changed but never the dressing in contact with the wound surface. Examining the wound is unnecessary, meddlesome, and painful for the patient. Dressings on primarily closed wounds may be changed as and when necessary.

DO NOT EXAMINE WOUNDS ROUTINELY. LEAVE DRESSINGS UNDISTURBED

The reasons for and benefits of a policy of non-interference with a wound are:

- to reduce the risk of cross-infection;
- to avoid disturbing the process of wound healing;
- to avoid an unnecessary procedure that is painful for the patient;
- to avoid wasting valuable nursing time;
- to maximize limited hospital resources.

Ward rounds

When doing ward rounds the doctor must have a clear idea of what he or she wishes to learn. The aim is to ascertain whether the patient's progress indicates that wound excision has been complete.

- Is the patient's general condition, state of alertness, and behaviour satisfactory?
Is the patient toxic?
- Does the patient have a raised temperature?
- Is there excessive tenderness or skin redness proximal to the wound?
- What is the state of the dressing and is there an offensive odour?

Should the doctor decide that progress is **not** satisfactory, the patient **should be taken back to the operating theatre and anaesthetized** for re-assessment of the wound and re-operation.

The wound dressing may develop an odour, particularly in hot countries, which is not necessarily a sign of wound infection. A faint, dry, ammoniac smell is frequently detectable, and may be associated with a satisfactory excision and a clean, healthy wound. A heavy, slightly sickly, pungent smell is an indication of infection arising from retained dead tissue.

Do not make a decision on the smell alone: look at the patients' general status.

Caution: Some doctors find it difficult to accept a policy of leaving dressings undisturbed. Those unfamiliar with the policy of leaving wounds undisturbed have an urge to look at the wound to "check" that all is going well. This is due to lack of confidence that the primary operation has been done satisfactorily. It is not necessary to clean the wound frequently with antiseptics and re-dress it. This does not remedy inadequate excision.

THE TREATMENT OF WAR WOUNDS IS SURGICAL AND NOT CHEMICAL

CHAPTER 7

DELAYED PRIMARY CLOSURE

Timing

The ideal time for wound closure is between four and six days after primary surgery. Post-traumatic swelling has diminished and the early processes of wound healing are under way. Wounds left longer than this are indurated and inelastic, making apposition of tissues difficult.

Is the wound ready for closure?

SEE THE DRESSING TAKEN DOWN IN THE OPERATING THEATRE

Good signs are:

- The wound is clean and red with bleeding which indicates early granulation tissue formation.
- The exudate in the deeper dressings has dried and the dressing itself is hard, a little like plaster of Paris.
- The gauze dressing on the raw wound is adherent and resistant to being gently peeled off.

Bad signs are:

- a fever;
- a wet dressing that floats off, leaving a shiny, moist appearance with little bleeding;
- frank pus;
- skin erythema and dead muscle.

The doctor should distinguish between a dressing which is moist from pus and a dressing which is moist because the wound involves a large area from which there has been considerable discharge of serum. The inability to close a fresh wound owing to

infection is usually a consequence of incomplete wound excision. Sometimes small areas of unexcised dead tissue remain in an otherwise healthy wound. Good judgement is essential to decide whether to close the wound or leave it open.



The dressing removed from an inner thigh wound which was excised 5 days previously. The dressing does not look particularly clean but was adherent to the wound before removal. The wound itself is clean and healthy and ready for closure.

Direct suture and skin grafting are the most frequently employed methods of restoring integrity of skin cover. The decision to revert to healing by second intention should be a deliberate one. Very rarely are reconstructive procedures required.

Direct suture

Wounds in which there has been little skin loss can usually be brought together without undue tension. The wound should be manipulated as little as possible and ideally no fresh planes should be opened. Undermining the skin may help to free the skin edges for apposition but has the disadvantage of causing further bleeding. If a haematoma results, closure may fail. Leaving a drain in place may help reduce the problem of haematoma.

A balance has to be found between undermining the skin edges, with the risk of a haematoma, and the need to close the wound with minimal tension. It is advisable to limit the undermining of skin to a 2-cm wound margin on limbs and a 3-cm margin on central wounds.

CLOSE THE WOUND ONLY IF IT IS CLEAN

Skin grafting

The two requirements for a successful skin graft are a healthy recipient area and lack of movement of the graft after the operation. Provided the wound is entirely healthy, skin grafting may be performed at the first dressing change, i.e. at 4 - 6 days. There is no need to await further formation of granulation tissue unless there are doubts as to whether the wound is clean. Some surgeons prefer to wait for more granulation tissue. The depression and tissue defect which often follows excision of large volumes of muscle fills with time after grafting. Grafts will take on periosteum and paratenon (the tissue which covers a tendon), but not on large areas of naked bone or tendon. Plaster slabs may be required to stop movement in the post-operative period. Care must be used to take a thickness of graft skin which allows the donor site to heal; the skin taken should be sufficiently thin to be transparent to light. The donor site will take a long time to heal if the skin graft has been taken too deeply. Worse still, it may itself have to be grafted.

Removal of sutures

Wounds should be examined before sutures are removed. There is no need to look at a wound before the fifth post-closure day. The better the blood supply to the skin, the earlier sutures may be removed.

Guidelines for removal of sutures after closure are:

- 1) Face, neck and scalp: 5 days.
- 2) Abdomen, chest and limbs: 10 days.
- 3) Major amputations and back wounds: 14 days.
- 4) For skin grafts, the recipient site is usually examined and sutures removed 5 days after operation, and the donor site is left undisturbed for 10 days.

Reconstruction

Reconstructive procedures are best not attempted by inexperienced doctors. Muscle flaps using gastrocnemius or soleus muscles are most commonly needed to fill large muscle defects around the knee and upper tibia. Scalp flaps are used to cover exposed brain.

Wounds unsuitable for delayed primary closure

Wounds are unsuitable for closure when there is infection, which may or may not be accompanied by residual evident dead tissue.

Re-excision

It may be obvious from examination of the wound that further tissue needs excision. The operation is often associated with more blood loss than the primary operation, and the tissues are oedematous and hard. After re-excision an attempt at delayed closure may be made earlier than the 4 to 6 days recommended for closure after primary wound excision.

Infected wounds and ward dressings

A wound may be infected because of delayed presentation or incomplete excision, or may subsequently break down after delayed primary closure. It may be difficult to decide whether an infected wound is best managed by re-exploration and excision or by ward dressings.

If the patient is pyrexial and receiving antibiotics, then surgical exploration and re-excision is required with removal of any remaining dead tissue which is found. If the patient is afebrile and there is good drainage, a wound with a purulent or seropurulent discharge will benefit from dressings every day or two.

Wounds which become infected after closure may require removal of stitches to allow discharge of pus. The doctor must then decide whether this can be managed by ward dressings alone, which is usually the case.

For heavily infected wounds sugar or honey may be directly applied to the wound, which is then dressed with bulky gauze. Such wounds usually require healing by second intention.

Old and mismanaged wounds

Many of the wounded who come to the ICRC for treatment travel for a long time before reaching medical help. Often they have received inappropriate first aid. These factors complicate injuries and necessitate a modified approach. Elimination of the culture medium, however, remains the goal.

If there is putrefaction or gangrene as a consequence of the delay in reaching medical attention, the doctor will have to do a more extensive operation. Conversely, if wounds have started to heal less extensive procedures are indicated. Blood loss when operating on old wounds may be great because the surgeon is working through oedematous and inflamed tissues, and it is more difficult to identify viable muscle. There is a place for complete wound excision and delayed primary closure of these old wounds provided systemic infection is controlled. The anatomy is less clear-cut, blood loss may be great and the resulting tissue defect is more difficult to cover.

Patients with putrefying wounds develop anaemia and a poor nutritional status and are often dehydrated; all these factors lead to poor healing after wound excision, and a longer period may be required before delayed closure.

Despite the lessons learned this century, in many conflicts wounds continue to be sutured without excision. This frequently leads to putrefaction. The sutures should be removed and the wound excised, dressed, and closed after a delay.

Field tourniquets

Tourniquets applied unnecessarily high on limbs result in higher amputations than necessary. A life may be saved but a limb is lost. Haemorrhage from limb injuries can be controlled by firmly applied bandages over field dressings, and limb elevations. Similarly, dressings and bandages applied distally can control the haemorrhage from traumatically amputated limbs.



Photograph of a right thigh; the leg has been severely injured. The situation has been made worse by an occlusive, above-knee tourniquet which has been in place for many hours. Necrotic muscle in the thigh is due to the tourniquet and not the injury; the patient ended up with an unnecessarily high above-knee amputation.



The effects of handling an antipersonnel blast mine. Control of haemorrhage by a field tourniquet before admission was not achieved; in consequence the patient became irreversibly shocked and ultimately died.

Field tourniquets applied high on a limb present the surgeon with a problem. It is reasonable, where there has been complete vascular occlusion for more than six hours, to recommend amputation above the site of the tourniquet. In such cases it is wise to leave the tourniquet in place for the operation.

CHAPTER 8

SPECIAL CASES

Identification of patients who do not require surgery

Some soft-tissue wounds are best treated by penicillin, human anti-tetanus immunoglobulin and dressings without surgery. Not all wounded benefit from surgery, as in some cases the natural processes of healing can do the job adequately. This course of action can be taken provided the patient can be observed for complications and the criteria below are observed. Selecting those who do not require surgery avoids unnecessary operations, saves surgical time, economizes energy and is of paramount importance in triage situations where limited resources are stretched beyond their normal capacity.

Wounds which may reasonably be considered for non-operative treatment are low-energy transfer wounds from small metal fragments, from hand-gun bullets or from assault rifle bullets at the end of their trajectory. They must be examined thoroughly and show:

- no evidence of haematoma;
- no sign of significant tissue disruption;
- no comminution of bone;
- no vital injury.

Examples to consider:

- Small metal fragment wounds with an entry of less than 1 cm in diameter. This never applies to blast mine injuries.
- Bullet wounds with entry and exit less than 1 cm in diameter and with no metallic fragments on the X-ray.
- Bullet wounds with entry of less than 1 cm and no exit, and in which the bullet on X-ray is intact and un-deformed.



1) A boy aged 10 with a small entry on the left shoulder from a hand-gun bullet. The boy was standing at the time of injury. The bullet was non-targeted and was at the end of its trajectory. The photograph was taken one week after injury. No operative treatment was indicated.



2) X-ray showing the bullet, which was not palpable. The patient had a full range of movement of the shoulder.

- If it is thought that the wound can be excised with local anaesthetic then it is probably best treated without operation at all. Such a small volume of culture medium does not require excision.

It is not necessary to look at or re-dress these wounds until the fourth or fifth day unless there is increasing pain, adjacent swelling, erythema or pyrexia. Only a minority of wounds require later operation. The complication to be looking for is infection, which is the indication for operation. The patients should be reviewed daily.

DOES THE PATIENT NEED SURGERY?



An in-and-out wound of the right thigh.

The wounded patient with a hopeless prognosis

Those about to die or who clearly cannot be helped by surgery should be made comfortable. They require analgesics, wound dressings and a comfortable bed, and relatives should have access to them. They should be allowed to die with dignity.

Such patients must be reviewed frequently. A patient who appears near death may on review not be as seriously injured as was initially thought.

Especially difficult wounds

Wounds in certain areas of the body cannot be adequately excised because of the impossibility of access or the proximity of vital structures. Excision of all non-viable tissue would result in irreversible loss of function of that part or even loss of life. Such areas are the neck and para-pharyngeal spaces, the retro-peritoneum, and the pelvis. Complete excision would result in massive blood loss and the creation of an irreparable defect, and the best that can be achieved is the repair or avoidance of vital structures, haemostasis, and, if the patient survives, repeated wound dressings.

The tarsus is a difficult area in which access to all damaged tissue and bone fragments would involve complete tarsal disruption. Repeated vigorous curettage along the track is recommended.

FURTHER READING

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The author thanks the many people who have helped with the preparation of this booklet, particularly Dr. Robin Coupland, FRCS.

MISSION

The International Committee of the Red Cross (ICRC) is an impartial, neutral and independent organization whose exclusively humanitarian mission is to protect the lives and dignity of victims of war and internal violence and to provide them with assistance.

It directs and coordinates the international relief activities conducted by the Movement in situations of conflict. It also endeavours to prevent suffering by promoting and strengthening humanitarian law and universal humanitarian principles.

Established in 1863, the ICRC is at the origin of the International Red Cross and Red Crescent Movement.



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