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Foreword

At the turn of the millennium many young people around the world wish a renewal of some types of relationship which should characterise the society in the future. From mainly profit oriented we wish more human oriented types of relationship among nations. I think that these sciences should actively contribute to the promotion of a safer environment by increasing the level of knowledge skills and co-operation. The Handbook of the I.S.D.M. is certainly a decisive step forward on the way for better mastery of major risk factors such as natural disasters and technological ones.

Success in risk management and vulnerability reduction depends largely on the participation of the people at community level. Therefore the Handbook will be a useful tool for all those interested with education training and research at community level. The teachers and trainers should focus more and more on efficiency at community level for in many disasters local people provide decisive first aid to victims.

*Luke, 15 years old*  
*Denver, USA*

We denken dat er in het volgende millennium misschien wel ziektes zijn die zo vaak met hetzelfde antibioticum zijn bestreden dat de bacteriën een afweermiddel ontwikkelen tegen antibioticum.

Als het een hele erge besmettelijke ziekte is en veel mensen hebben het, dan kunnen ze steeds moeilijker geholpen worden. Op een gegeven moment is de ziekte niet meer te bestrijden en moeten de mensen snel een nieuw middel tegen die ziekte maken. Maar ondertussen blijven er mensen aan die ziekte sterven. En omdat de ziekte zo besmettelijk is, kunnen ze haast geen onderzoek doen. Maar het kan natuurlijk zo zijn dat er tegen die tijd onderzoek wordt gedaan met computers.

Wat je er aan kan doen, weet we niet precies, maar je moet dus zuiniger zijn met antibioticum, als dat kan. We denken dat je ervoor moet zorgen dat je wel onderzoek kunt doen, om zo de zwakke plekken te vinden van de bacterie die het virus veroorzaakt en daar kun je dan een middel voor ontwikkelen.

*Samuel en Hendrik-Jan, 12 and 11 years old*  
*Lochem, The Netherlands*

Wir jungen Leute wünschen, unter anderem, in einer Welt leben zu können, in welcher die verschiedenen Gefahren, die uns bedrohen, besser gehandhabt werden. Unsere Ausbildung ist uns sehr wichtig, deshalb verbringen wir viele Jahre in Berufs- und Fachschulen sowie Universitäten.

Das Handbuch der Internationalen Gesellschaft für Katastrophenmedizin wird sich sicher als sehr nützlich für die Studenten aber ebenfalls für den Lehrkörper

Hans-Ludwig, 20 years old
Dresden, Germany

L’arrivée d’un nouveau siècle, et m me d’un nouveau millénaire - fait rare et presque mythique - est porteuse d’une dynamique de renouveau, d’un espoir de changement. Quel est l’espoir de la jeunesse actuelle? Certainement la création d’un monde plus juste et plus convivial, d’un monde plus respectueux des droits humains. Mais, dans le même temps, l’espoir aussi de progrès technologiques dans tous les domaines.

Le présent livre de médecine de catastrophe, la fois complet car traitant des divers types de catastrophes et en même temps utilisable par une large gamme de professionnels ou de volontaires, sera certainement très utile pour améliorer non seulement la formation mais aussi pour promouvoir une meilleure coopération au plan national et au plan international. Je formule mes meilleurs vœux de succès à cet ouvrage et espère que, grâce à cet outil, de nombreuses vies pourront être sauvées dans le début du prochain millénaire.

Vincent, 18 years old
Geneva, Switzerland

Cuando enciendo la television y veo todas las cosas que estan pasando en el mundo me deprim, veo que el mundo ya esta cansado, ya no nos quiere. He notado que cada dia se suceden mas desastres naturales, por ejemplo los terremotos, empeorado por la corrupción, multiples inundaciones, huracanes, y todo esto esd consecuencia de nuestra manera de vivir.

Cada vez pretendemos hacerlo rodeados de más lujo y esto perjudica la naturaleza. No paro de buscar soluciones pero no encuentro ninguna, ya lo hemos destrozado demasiado y creo sinceramente que es muy tarde para solucionarlo.

Para poder vivir aqui mas tiempo tendriamos que hacerlo como le hacian en la Prehistoria, respetando el medio y moldeandose a el, y que no sea el mundo el que tenga que adaptarse a nosotros. La humanidad no podrá vivir junta y en harmonia por mucho mas tiempo.
La diferencia entre países ricos y pobres es muy grande, y a muchos países solo les mueve el ansia de lujo y poder. Debido a este problema se suceden gran cantidad de conflictos internacionales, derivando, en muchos casos, en terribles guerras con resultados desesperanzadores.

Entre todos deberíamos hacer algo por el mundo, y en definitiva por nosotros mismos, esta sería la única manera de intentar encontrar soluciones... Si es que estas son todavía posibles!!

Esperemos que haya una salida y de esta manera hacer un mundo para todos y no para unos pocos...

No nos damos cuenta que es lo único que tenemos y que nuestros hijos vivirán en el mundo que les hayamos dejado. Un mundo maravilloso es la mejor herencia que les podemos dejar. Intentemoslo!!

Inés, 18 years old
Living in Amsterdam, The Netherlands
Introduction

Man has always been intrigued by disasters. For many centuries, natural disasters were considered as acts of God, as retribution for perceived sins, and before the Industrial Revolution, it was only naturally occurring disasters that presented a menace to humankind. However, the increasing technology that has resulted from ever greater scientific discoveries has created a transition from an agricultural phase to an industrial one in human culture.

Technological development has not only introduced the ability to gain more prosperity, but has also provided humankind with more destructive power. As a complication of both, man-made disasters have been the consequence. Together with the explosion of world population, this has led to mass casualty situations, varying from traffic accidents to world wars. More than 200 million people have been killed in this way in the 20th Century - a cruel age without equal in the history of man. It is not surprising therefore that a young branch has sprouted from the old tree of medicine: disaster medicine. Primarily based on military medicine and more specifically on war surgery, this field of modern emergency medicine has evolved: and so a new medical specialism has been born in the 20th century with, regrettably in many respects, a great deal of experience having been gained.

Many medical schools and institutions created their own educational programs in disaster medicine, until it became apparent that many disasters have effects that cross traditional boundaries of medical specialism and nationality; thus, uniform guidelines were needed in education and training in disaster medicine.

This led to the foundation of the International Society of Disaster Medicine (ISDM) in 1970, who took the challenge to promote these ideas worldwide. The former president of this Society, Bernard Nemitz, initiated in 1990 a symposium in Amiens, devoted to the creation of uniform guidelines in disaster medicine. In the stained-glass window arches of the famous cathedral in Amiens, a beautiful rose inspired 35 international experts from 12 different countries to develop an international curriculum on education and training in disaster medicine. The Scientific Commission of the ISDM, chaired by Sten Lennquist, finally issued the first edition in 1992 and the second one in 1995. Both editions were disseminated
all over the world to governments, universities, institutions and international organisations.

As a logical consequence, the production of a handbook of disaster medicine, based on the ISDM curriculum, was started in 1995. This handbook, a product of international experts, lies now in front of you, just before the new millennium. Since our children will play a more significant role in the new millennium, various youngsters were asked to write several paragraphs about (the prevention of) disasters; and so, the preface of this book is slightly different from others. The contents of this book may show different opinions on various important topics. This reflects the fact that disaster medicine is a young specialism, which should settle itself in the near future. May this book contribute to this process.

The editors wish to express their gratitude towards the contributors of the various chapters and towards the publishers for their patience and understanding.

Summer, 1999

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Medical care
Surgery and traumatology: Surgical management of severely injured patients when resources are limited

STEN LENNQUIST

1 INTRODUCTION

The role of trauma as a cause of death and disability is increasing as the world develops. Today it is the most common cause of death in young patients in developed countries. Disability caused by trauma is associated with extensive costs to the community. The number of injuries caused by intentional violence is also increasing in previously peaceful places, where stab wounds and missile injuries used to be rare.

The risk of major accidents that result in severely injured victims is also increasing, because of ever faster modes of transport of people and goods, with vehicles carrying more and more passengers, and the concentration of larger numbers of people in limited areas - occasional or permanent. Terrorists exploit these risks for personal or political reasons and there is a continuous threat of armed conflicts.

In all trauma care, accurate decision-making is essential. A correct decision made and the correct action taken in the right moment can mean the difference between life and death or between disability and health, in a young patient with many active years ahead. Quite apart from the obvious human benefits, even seen from the cost-benefit point of view, putting emphasis on, and effort into trauma management is therefore a most effective way to use resources.

Management of trauma in major accidents and disasters involves specific problems that require special consideration:

- The large number of casualties make it necessary to involve non-specialists at different levels of trauma management.
- Many injuries may come to treatment after a long delay, at greater risk of contamination and complications.
- Many injuries may be caused by trauma involving high velocity impact, with varying amounts of devitalised tissue; this increases the risk of infection of necrotic tissue or circulatory disturbances with secondary systemic complications.
- Less optimal treatment in the prehospital phase because of lack of resources
increases the risk of late effects and complications that may lead to systemic reactions (intravascular coagulation, multiorgan failure or bacteraemia).

All this makes it necessary to use simple methods based on maximal safety. Usually there is no place for sophisticated methods of treatment that can be used in a well-equipped hospital by experienced experts within different fields (even if single patients can get access to such a treatment at such a time). It will also be necessary to set accurate priorities among patients and also among measures done for the same patient. There is no time, or resources, to do everything that is usually done and the (diagnostic and therapeutic) measures have to be restricted to those that will have the greatest effect on the patients chances of surviving without permanent disability.

Prehospital management of injured patients (organisational and technical) is dealt with extensively in special chapters in this book (part III: chapters 8 and 9) and will not be repeated here.

2 MANAGEMENT IN HOSPITAL

2.1 Initial management in hospital

The general principles for the initial management in the hospital do not differ appreciably from the principles valid for prehospital management, and the same management regimen can be used. There are many such regimens described by different authors in different textbooks, and they all have advantages and disadvantages.

The programme used in the ATLS (Advanced Trauma Life Support) courses has been adapted by numerous doctors (and also other medical staff) all over the world. It has been well tested and evaluated in numerous incidents and types of trauma and is considered accurate. To avoid confusion, the way of working should be as uniform as possible and a programme with such a wide application can be well recommended.

The ATLS regimen has not been accepted uncritically. Its applicability in centres that deal with a heavy load of trauma has been questioned. In such centres, the different steps in trauma management are usually run in parallel by a large team of specialised physicians, nurses and technicians. When it comes to more primitive conditions with less experienced people, however, the ATLS regimen is of benefit and it has been clearly shown that its wide application has resulted in significant improvements in trauma care.

It is very important not only in the prehospital care, but also in the initial phase in hospital, to use simple measures, so simple they can also be used in hospitals that do not have access to adequate staff or equipment for optimal management of
the patients. It is also important to train qualified staff in these simple measures as they may be called upon when there are many casualties, and they are often forgotten by doctors and nurses who are not used to working under primitive conditions. Such measures are:

- Simple diagnostic measures to evaluate breathing and circulation (clinical evaluation).
- Securing the airway by simple but correct positioning of the patient. There may not be resources for more advanced methods of airway control, and there may be no resources for continuous surveillance of the patient.
- Prevention of shock by correct positioning, avoiding cooling, and rapid control of every source of bleeding.
- Pain relief by proper immobilisation of fractures and careful and accurate management of the patient.

When there is a heavy load of injured patients, all these measures are applicable not only in the prehospital phase but also into the emergency room in the hospital. A simple regimen of management (such as the ATLS, which is known to all staff) should be followed.

2.2 Airway

The measures for control of a blocked, or potentially blocked, airway that are described for prehospital care (part III: chapters 6 and 7) should also be used in the primary management in the emergency room: clearing and suction of the airway, position of drainage, and nasopharyngeal tube. If airway control cannot be achieved in this way, ventilatory support should be started with bag - valve - mask ventilation, and the addition of oxygen (12 litres/minute) and endotracheal intubation should be considered.

In disasters or where there are many casualties, endotracheal intubation has to be done for more restricted indications. In patients with a poor prognosis (such as head injuries with no spontaneous ventilation) resources needed for endotracheal intubation and consequent surveillance may be better used for patients who have a better chance of survival. This means that in major accidents or disasters, consider the priority before doing an endotracheal intubation!

When doing endotracheal intubation, consider the risk of injury to the cervical spine (common in major trauma). If there is any suspicion or insecurity, apply a stiff collar before manipulating the neck (note that a stiff collar does not fully protect the neck!).

Inaccurate endotracheal intubation (insertion of a tube in the oesophagus or right main bronchus) are common errors among the less experienced. The position of the tube should always be carefully checked with auscultation of the chest, and (if possible) control of oxygenation. A cuff should always be used in adults,
and an oropharyngeal tube should be inserted in parallel. Deeply unconscious patients do not require drugs for intubation. In conscious patients, Ketamine is a good first choice, except in the case of head injuries when barbiturates could be the first choice.

If endotracheal intubation is indicated but is not possible because of severe maxillofacial injuries, oedema (burn) or severe bleeding, cricothyroidotomy should be considered. This can be done with simple instruments (knife, scissors) and the airway can be maintained and secured with simple devices.

If cricothyroidotomy is not done properly it can lead to strictures. Incisions should not encroach on the laryngeal or cricoid cartilages. Use a small horizontal incision in the membrane between the laryngeal cartilage and first cartilage, which can easily be palpated.

To gain time while waiting for more permanent securing of the airway with endotracheal intubation or cricothyroidotomy, a needle cricothyroidotomy could be done and oxygen given by the jet - insufflation technique: oxygen 15 litres/minute, intermittent insufflation with one second on plus 4 seconds off for a maximum of 30-45 minutes before permanent control of the airway can be achieved.

Note the risk of carbon dioxide accumulation, which merits special care with head injuries.

2.3 Breathing

Whenever possible, oxygen should be given to all severely injured patients who require assisted ventilation (see above). Pay attention to the chest: are there any
- Penetrating injuries?
- Contusions?
- Rib fractures?
- Subcutaneous emphysema?

Pneumothorax is common in severe trauma and may be immediately life threatening if it is turned into a tension pneumothorax (for example when starting assisted ventilation). Signs and measures: See under 'Chest injuries'.

Multiple rib fractures may cause instability of the chest and cause respiratory insufficiency. Signs and measures: See under 'Chest injuries'.

2.4 Circulation

Severe trauma always implies a risk of the development of circulatory shock.
Observation of clinical signs of shock and potential sources of bleeding is therefore vital. Regardless of whether such signs are present, measures to prevent shock should be undertaken in all patients with severe injuries. These involve

- Inserting at least one intravenous catheter, as wide as possible and as central as possible, if necessary with a cut-down. Central venous catheters inserted as early as possible are of value and often used under normal clinical conditions, but they have no place when resources are limited.
- Laboratory tests: if possible, as a minimum measure, haemoglobin and creatinine concentrations, packed cell volume, platelet count. If blood is available, group and cross match.
- Start an intravenous infusion with a balance of crystalloid and colloid solutions (see below).
- Constantly check rate and quality of pulse, blood pressure, skin and peripheral circulation.
- Identify any sources of internal bleeding (clinical examination): if there is access to it, do a pulmonary radiograph, ultrasound scan or computed tomogram (CT); if there is no such access, do a diagnostic peritoneal lavage (DPL) or thoracocentesis, or both, on suspicion: see further below.

If the patient has clinical signs of shock, start more active treatment (parallel to immediate efforts to identify and control the source of bleeding):

- Lower the patients head
- Give effective ventilation: Clinically obvious shock is an indication for endotracheal intubation if the conditions so permit. Give oxygen if possible.
- Start rapid infusion of crystalloid (Ringer's lactate 2-4 litres to adults plus plasma-expanders, such as high molecular weight dextran). The fluid replacement should not be based on crystalloid alone: only 20%-25% of it stays in the intravascular space and the colloid-osmotic pressure will be reduced, which will exaggerate pulmonary and cerebral oedema. On the other hand, giving more than 1-1.5 litres of colloid during the first 24 hours may impair the coagulation system, which is why a balance between crystalloid and colloids is essential.
- Insert a urinary catheter and continually measure urinary production.

The loss of less than 15% of the total blood volume (which can be estimated to about 7% of body weight in men and 6.5% in women) can usually be managed without giving blood. Clinical signs of shock after trauma usually means losses of 30-40% or more of blood volume, which if possible should be treated by blood transfusion.

Large amounts of fluid, particularly of crystalloid solutions, in the prehospital phase may increase bleeding, so such treatment should be given with care, even if it justified or necessary as when there is delayed evacuation and a long period of transport.

Precautions should be taken not to ‘overload’ the patient in the emergency
room. The most important, particularly when resources are limited, is to identify and control the source of bleeding as soon as possible.

If a massive transfusion is to be given, the blood should be heated before transfusion. More than 8-10 units of blood can cause disturbances in coagulation, which can be compensated by the addition of at least some fresh blood.

If possible, blood gases should be monitored. Prevention of acidosis can be achieved with 0.6 M bicarbonate solution.

If blood is not available, autotransfusion can be considered if the equipment is there; for example reinfusion of blood from chest drains.

2.5 Disability

'D' in the ATLS management scheme stands for 'disability', which represents a neurological state. An early and continuous control of the degree of consciousness, response to talk and pain, continuously recorded according to a standard scale, is of utmost importance in the identification of focal neurological symptoms (see below under 'Head injuries').

2.6 Exposure

'E' in the ATLS management scheme stands for 'exposure'. In the emergency room, the patient should be totally undressed (do not hesitate to cut clothes) and the whole body, front and back, carefully inspected.

Most patients with major trauma have multiple injuries: in most series, the mean number of organ systems affected is 2.5, and limb injuries are the most common (around 70%), followed by a wide variety of injuries to the head, spine, and trunk depending on the type of accident, effectiveness of primary management, and time for evacuation and transport to hospital. Note particularly:

• The most difficult injuries to detect can be the most dangerous
• After exposure to missiles, fragments, and shells, do not miss injuries in the scalp, nasopharynx and genitoreal regions.
• After exposure to blast injury, always suspect pulmonary contusion and injury to the intra-abdominal organs by the pressure wave.

A simple routine can be used for systematic examination of the whole body after securing vital functions:

<table>
<thead>
<tr>
<th>Chest</th>
<th>Head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdomen</td>
<td>Spine</td>
</tr>
<tr>
<td>Pelvis</td>
<td>Limbs</td>
</tr>
</tbody>
</table>

Whatever routine is used, it should be taught to and consequently used by all staff.
3 HEAD INJURIES

3.1 Blunt injuries

Blunt injuries are defined here as injuries to the brain or its vessels or both, without penetration of the skull bone. The trauma causes a primary cerebral injury; Commotio (reversible injury with a short, usually less than 30 minutes, loss of consciousness) or contusion with a longer period of unconsciousness and more severe, sometimes irreversible or lethal, cerebral injury.

This primary injury can, after a varying period of time, develop into a secondary injury: tissue oedema, (expanding contusion) or bleeding outside (extradural) or inside (subdural) the dura.

The secondary brain injury leads to a rise in intracranial pressure, a life threatening condition that can lead to impairment of cerebral function and reduced oxygenation of brain tissue, which results in swelling and further increase of pressure; this is a vicious circle that has to be interrupted rapidly if the patient is to survive.

Between the initial loss of consciousness and the loss of consciousness caused by the rise of intracranial pressure, there can be a free interval when the patient is more or less awake. Knowledge and recording of this interval is important in decision making, and repeated recording of the degree of consciousness is therefore essential in all head injuries, even under primitive conditions.

The final stage of the rise in intracranial pressure is incarceration of the brain, a rapidly lethal condition with dramatic symptoms; rapidly reduced consciousness, dilated or non-reacting pupils, falling pulse rate and rising blood pressure, irregular breathing, and finally coma, respiratory insufficiency, and death.

The treatment of severe blunt injuries should be devoted to the diagnosis of a developing or threatening rise in intracranial pressure and measures to prevent or reduce this rise in pressure.

3.2 Penetrating injuries

Most penetrating injuries (over 80%) in war are caused by fragments, and only a few by bullets. The conditions for temporary cavitation in the brain (see under: 'Effects of high energy', Section 6.1.) are favourable, which is why few - if any - patients can survive a hit from a high velocity missile, while many patients have survived hits from low velocity missiles after being treated by relatively simple procedures.

This makes it worthwhile to operate on such patients even if resources are limited, and all surgeons should be familiar with the principles of debridement in penetrating head injuries.
Penetrating injuries are associated with a lesser risk of rising intracranial pressure, because they are already to some extent drained. However, this drainage is often not sufficient and there is also a risk of rising intracranial pressure in penetrating injuries. These patients should therefore be investigated and observed as after blunt trauma.

3.3 Diagnosis

Examination of patients with head injuries should include:

**Level of consciousness**
A standard scale should be used for simple recording of the level of consciousness. Different scales are used in different parts of the world, the most common being the Glasgow coma scale 3-15, where low scores indicate the most severe injury, and the Reaction level scale (RLS) 1-8, where the highest scores indicate the most severe injury. To avoid confusion, neither of these scales is given in this text. Most trauma scoring systems are based on the Glasgow coma scale, but conversion formulas are available. The same scale should be used for mass casualties as in normal clinic practice, and all staff dealing with trauma should be aware of that scale for simple, accurate, and uniform recording.

It is extremely important to record changes in the level of consciousness throughout the chain of management and surveillance, particularly when there are many casualties and the number of the staff is limited so that the same staff cannot follow the patient.

**Respiration**
Less than 10 breaths/minute indicates massive brain damage or haematoma (if it is not influenced by drug depression). Rapid breathing (50-60/minute) may also be a sign of poor prognosis indicating brain stem damage.

**Pupils**
Dilated pupils that do not respond to light usually indicates irreversible, fatal injury (which implies low or no priority, if not caused by oculomotor injuries). Unilateral dilatation may indicate massive intracerebral bleeding or brain damage. Unilateral dilatation associated with hemiparesis on the other side indicates temporal lobe herniation through the tentorium.

**Limb movements**
Hemiplegia indicates massive hemispheric, and spastic hemiparesis mild hemispheric injury, contusion, or oedema on the opposite side. Spastic paraplegia indicates parasagittal injury.
Reflexes
Undetectable reflexes are a bad prognostic sign (consider hypothermia, since reflexes disappear when the body temperature is below 28 °C, and the patient may still be saved).

Cranial nerve function
Injuries to nerves III and VI indicate fractures at the base of the skull. Lesions of nerves VII and VIII indicate injury to the temporal bone.

3.4 Priority
When setting priorities between patients, consider the relatively poor prognosis in patients with severe head injuries even after treatment. This means that even if patients in whom intracranial bleeding is suspected should as a general principle have high priority. When resources are limited they may have to be left in favour of patients whose injuries make it more likely that they can be saved to return to a normal life, such as abdominal and chest injuries.

3.5 Management in the emergency room

Securing of airway
Indications for endotracheal intubation of head injuries in the emergency room are insufficient respiration or deep unconsciousness. In conscious patients with regular and adequate breathing and normal response to pain or increasing level of consciousness, early intubation is not necessary but the patient has to be carefully surveyed.

In all monitoring of unconscious patients, remember that head injuries are often combined with cervical spine injury (see below). A good rule is that every unconscious patient should have a stiff collar on the neck before any monitoring is started.

Positioning of the head
Position the head in the neutral position, 30° head up (no flexion of the neck!) taking account of the circulatory state. This can reduce intracranial pressure by increasing venous return.

Controlled hyperventilation
Hyperventilation reduces PACO2, which causes cerebral vasodilatation, decreases intracerebral blood volume, and lowers intracranial pressure. However, note that hyperventilation down to PACO2 less than 20 kPa may cause accumulation of
lactate leading to cerebral vasculature. This means that hyperventilation should be controlled. If possible, monitor PACO2 and keep it between 30-20 kPa. If this is not possible, be careful that the hyperventilation is not too aggressive.

It must be realised that ventilation absorbs considerable facilities and must in these situations be reserved only for patients with a relatively good prognosis (see above).

**Control of circulation**
See considerations under ‘Treatment of shock’. ‘Maintenance of good brain perfusion and oxygenation is vital and it is essential that the systemic blood pressure and blood gases are kept at normal levels. Dehydration of brain injuries is no longer recommended.

**Prevention of oedema**
The key to prevention of brain swelling is maintenance of good oxygenation and good tissue perfusion. It is vital that the airway is protected, a good blood pressure is maintained and the oxygen carrying capacity of the circulation is as high as possible. Once cerebral oedema has developed and is causing secondary herniation, treatment is almost impossible in a situation where facilities are limited.

**Control of intracranial pressure**
In severe or inoperable cerebral contusions, an intraventricular drain (if available) may be used for monitoring and control of intracranial pressure. If all these measures, including drainage, fail, high dose barbiturates (pentobarbital 5-10 mg/kg) can be used in patients with normal blood pressure and no evidence of an operable lesion.

### 3.6 Surgical treatment of penetrating head injuries

1. The whole scalp should be shaved and cleaned thoroughly.
2. A few millimetres of skin around the holes should be excised and the excision extended in a curve (facilitating skin closure without flaps).
3. Injured fascia, muscles and loose bone fragments should be excised according to the principles described under ‘Debridement’ (Section 6.2.).
4. The hole in the bone should be widened with a craniotome.
5. Foreign material and dirt are removed carefully and contaminated dura excised (preserve as much as possible - the dura should be closed).
6. The wound track is cleaned under irrigation with gentle removal of injured and damaged brain tissue around the hole.
7. Careful haemostasis with ligation, suture, cautery, or clips. Local haemostatic agents such as fibrin glue (Tisseel®) are helpful.
Bleeding from the venous sinuses can be difficult to control. Impressed fragments might have acted as tamponade and removal will cause bleeding. To help control bleeding raise the top of the operating table but note the risk of air embolism. Small lesions in the sinuses can be packed with haemostatic agents, larger requires suture (non-absorbable 4 0). Larger defects can be repaired with an autologous graft from, for example, the saphenous vein, but this is difficult and time consuming.

8 The dura should be closed in a watertight fashion with non-absorbable sutures. If necessary, use grafts from adjacent fascia or pericranium.

9 Close the scalp in two layers.

3.7 Management of blunt injuries

*Indications for computed tomography (CT) in blunt head injuries*

If available, CT, skull and cervical spine radiographs should be done for blunt head injuries for the following indications:

a Persistent unconsciousness since the injury

b Diminishing degree of consciousness or mental state since the injury, including those with a 'free interval'

c Developing focal and neurological symptoms, or neuromuscular impairment

d Apparent fractures or impressions

e Periorbital or perimastoid haematomas

*Management*

Conscious patients with no neurological symptoms should be monitored and the degree of consciousness recorded according to a simple protocol. (With reduced consciousness or development of neurological symptoms, see below). *Skull fractures with dislocation of bone (impression) that is more than one bone thickness should always be operated on.*

Permanently decreased or diminishing degree of consciousness should be managed by, or treated in collaboration with, a neurosurgical unit if possible, and CT should be available (see above).

If this is not possible (war or mass casualties), suspicion of possible intracranial bleeding must be based on clinical examination and lead to exploratory burr holes. Indications for this are:

1 Diminishing consciousness after a free interval

2 Persistent unconsciousness + one or more focal neurological symptoms:
   - Neuromuscular impairment
   - Seizures
   - Unilateral positive Babinski sign
   - Aphasia or asthenia
- Impaired pupillary reactions
- Tonic eye movement or paresis of eye muscles

3 Other signs of rapid rise in intracranial pressure: dilated pupils, impaired breathing, hyperthermia, or bradycardia.

Lateral dislocation of a calcified pineal body might be of help, as might echoencephalography (EEG), if this is available.

Patients with signs of increased intracranial pressure should be given high priority for surgery, if they require operation (see below).

As a pressure-reducing measure while waiting for surgery, 15% mannitol 200 ml can be given.

**Surgical strategy**

Exploratory burr holes are best done under general anaesthesia, but may in an emergency (threatening incarceration) be done under local anaesthesia.

The whole head should be shaved and the operation begun on the side on which bleeding is suspected. If no radiography is available, but focal neurological signs are present, start on the same side as the dilated pupil or on the side opposite to a paresis.

A straight vertical incision 5-6 cm should be made starting from the upper border of the zygomatic arch and extended upwards. The muscles are divided in the direction of the fibres, and a hole is made with a trephine (simple hand-driven models are available in disaster equipment).

If an *extradural haematoma* is present, old or coagulated blood will bulge out when it is released. The hole in the bone should then be extended with a craniotome (or similar instrument) to a diameter of about 5 cm. The haematoma can then be evacuated with suction, followed by haemostasis (which can be time consuming) with ligation, cautery, clips and possibly local haemostatic agents (i.e. Tisseel®). For complete haemostasis, it may be necessary to 'plug' the foramen venosum with a gauze sponge.

A passive drain should be applied after evacuation of the haematoma and removed after 24 hours.

If it is not possible to achieve haemostasis, put in a wide drain, adapt the wound with single stitches, and send the patient to a neurosurgical team as soon as possible.

*If no extradural haematoma is found* on exploration, the dura should be inspected carefully. If it is blue or dark blue underneath it is a sign of *subdural haematoma*.

The hole should then be widened as before, and the dura cut in a cross incision. The edges of the dura can be adapted to the periosteum. Blood and clots should be evacuated.

Subdural haematomas are often spread widely over the surface of the brain.
Inspect it carefully, and if it cannot be adequately evacuated through the hole, make one or more additional burr holes.

Irrigate with isotonic saline solution and achieve haemostasis as before. Leave the dura open in this case and put in a drain, but close the galea and the skin carefully.

*If no haematoma is found* either outside or inside the dura but there are signs of contused brain tissue, a *focal expansive contusion* is present. Evacuation of such a lesion is difficult and often requires a bone flap; this should not be attempted without neurosurgical experience.

*If no haematoma or contusion is found*, a burr hole should be made posterior to the first, at the level of the post-auricular line. If this also fails to show any abnormality, the procedure should be repeated on the opposite side.

A haematoma or contusion may also be present in the infratentorial space or cerebellum. Operations here are difficult and are not recommended without neurosurgical knowledge and experience.

*Fractures or impressions* of bone should be treated with a curved incision over the impressed fracture. A hole is drilled in the edge of the impressed fragment, which can then be raised. Look carefully for underlying haematomas that should be evacuated (see above). If necessary, relocated bone fragments can be adapted with wire sutures.

### 4 CHEST INJURIES

#### 4.1 Introduction

Injuries to the chest can be immediately life-threatening. Rapid diagnosis and management of such injuries should therefore be included in the assessment of vital functions and are among the measures that have the highest priority in the management of severely injured patients.

Experience from mass casualties such as those from war zones has shown that chest injuries can be successfully managed by relatively simple measures. For example, more than 80% of penetrating chest injuries usually do well with just a chest drain, and of the 20% that require thoracotomy (if that is possible) most can be successfully treated with simple haemostasis and debridement. The rest, however, may need extensive operations that require experience and resources. When resources are limited or there is a heavy load of casualties, a strategy could be considered where injuries that are not treatable by simple procedures (such as drainage) should be given low priority. More advanced procedures are described in textbooks of chest or trauma surgery.
4.2 Management in the emergency room

**Diagnosis**
The diagnostic procedure in chest injuries should include:
- Inspection: Front and back. Penetrating injuries? Contusions?
- Palpation - Fractures? Instability?

**Management**
1. **Pneumothorax**
Penetrating injuries: Occlusive bandage and chest drain. If a chest drain is not available, an occlusive bandage may involve a risk of developing a tension pneumothorax and should not be used. Instead, use a non-occlusive or semi-occlusive bandage (a plastic dressing secured on 3 sides).

A chest drain may be inserted with minimal risk in the so-called 'safe' triangle between the medial and lateral axillary lines and mamillary line. Trocars can be used by experienced people but are risky if the operator is inexperienced. If so, the semi-open method (a small skin incision and insertion of the drain with haemostatic forceps) should be used to avoid injuries to intrathoracic and intra-abdominal organs.

If permanent suction is not available, the drain can be connected to a Heimlich valve that will let air out but not in.

2. **Tension pneumothorax**
Leakage of air from an injured lung, if it is not drained, may cause increased pressure on the affected side of the mediastinum. This leads to rapid collapse of the lung and dislocation of the mediastinum on the other side, leading to increased pressure on the great vessels which, in turn, causes impaired circulation and respiratory insufficiency that will also affect the lung on the opposite side.

The clinical picture is dramatic with progressive respiratory insufficiency, anxiety, cyanosis, dilated jugular veins, and circulatory impairment. Clinical findings are: reduced respiratory sounds from the affected side; 'hollow' percussion tone, dilated jugular veins and, in some cases, also visible expansion of the affected part of the chest.

Tension pneumothorax can be lethal if not dealt with immediately and therefore it has the highest priority in the management of injured patients.

The immediate measure is needle thoracotomy on the affected side, or insertion of a drain (see above) if immediately available.

If pulmonary radiography is available in the emergency room and the patient's condition permits, it is as well to have the diagnosis and side confirmed on an x-ray picture. If a clear tension pneumothorax has developed or is developing, however, there is no time to send the patient for a radiograph and needle thoracotomy has to be done on the clinical diagnosis alone.
Needle thoracotomy or drainage usually leads to dramatic improvement. Chest drains should be connected to an evacuation system or a Heimlich valve.

3 Haemothorax
If a haemothorax is diagnosed on clinical examination, on a pulmonary radiograph, or at thoracocentesis, the blood has to be evacuated by a large calibre chest drain, always inserted by the 'semi-open' method (see above). Blood should not be evacuated in the prehospital phase as it can aggravate shock, which will require more effective circulatory stabilisation.

As mentioned above, insertion of a chest drain (connected to an evacuation system) is sufficient to manage more than 80% of penetrating injuries in war - and when there are mass casualties. With regard to the amount of evacuated blood, however, there is a limit at which thoracotomy has to be considered (see below).

Indications for thoracotomy
1 Extensive haemothorax with a litre of blood or more in the chest (evaluation on x-ray film or evacuation during a short period of time).
2 Continuous bleeding of more than 1500 ml during the first few hours or more than 200 ml/hour during the continuing course.
3 Suspicion of cardiac tamponade: high pulse rate, paradoxical pulse, and raised central venous pressure (dilated jugular veins). The diagnosis is best made by ultrasonography (rarely available outside hospital), paraxiphoid percutaneous puncture of the pericardium, or, as a more safe and accurate procedure, opening of the pericardial sac through a small paraxiphoid incision.
4 Penetrating injuries with cardiac arrest on arrival (or just before arrival) at hospital. Emergency thoracotomy in the emergency room with control of bleeding can lead to a successful outcome in some cases of penetrating trauma (rarely after blunt trauma). Whether this should be done when there are mass casualties is a matter of judgement and priority.
5 Signs of tracheal or bronchial lacerations with haemoptysis, subcutaneous and mediastinal emphysema, and major (or continued) air leak through the chest drain. Thoracotomy on this indication may result in more time-consuming procedures and can be questioned when resources are limited.
6 Rupture of the diaphragm, rarely seen on a pulmonary x-ray film, often diagnosed during laparotomy. In most cases, it can be handled without problems through the laparotomy. If there are no associated abdominal injuries, repair through the chest gives better access.
7 Oesophageal rupture or perforation. This is a difficult diagnosis during primary management but, when it is diagnosed, urgent thoracotomy should be done, as early effective drainage is most important.
**Surgical management**

In penetrating injuries, the wound should be excised (debridement) according to the principle described below (Section 6.2.).

In most cases that require thoracotomy after penetrating trauma, the bleeding can be controlled by relatively simple measures (ligation of intercostal or mammary arteries).

Injuries to the major vessels are often fatal, but a few patients may arrive at the hospital alive. In some cases it is possible to repair small injuries by simple suture (using the finger or over a curved vascular clamp). Repair of larger injuries to the thoracic aorta may also be done without extra-corporeal circulation using a temporary shunt (the so-called Gott shunt) from the proximal to the distal aorta or to the femoral artery (procedure described in text books on trauma and chest surgery).

Smaller penetrating wounds of the heart leading to cardiac tamponade, may be simple to close: open the pericardial sac (in front of the phrenic nerve), put a finger over the hole, suture with part of a vascular graft as 'buttons' (pay attention to the coronary arteries) and leave the pericardial sac open with a drain.

Lesions in the trachea, major bronchus and oesophagus are closed and covered with pleural flaps. Effective drainage after oesophageal injuries is important. If there is an oesophageal defect, do a proximal oesophagostomy in the neck and distal closure as a primary measure, leaving reconstruction for later.

Severely damaged or necrotic lung should be resected. Mildly contused lung should be left (with effective drainage), as there is a high probability of recovery. There are rarely indications for pulmonary lobectomy or pulmonectomy.

The chest wall should be closed carefully, but skin and subcutaneous fascia may be left open for delayed primary closure. Postoperatively basal and apical drains should be connected to a Pleurovac or underwater seal drain.

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5 **ABDOMINAL INJURIES**

5.1 **Introduction**

The incidence of abdominal injuries requiring treatment in hospital units in war, armed conflict, or major disasters with many casualties has been reported as being 7%-15%. The real incidence of these injuries is considerably higher, but they have a high immediate mortality. When management is rapid and the prehospital phase short, the incidence of abdominal injuries coming to treatment will increase and today, in many civilian trauma series, is as high as 30%-40%.

Abdominal injuries are easily overlooked for two reasons:
- they can be missed because other injuries (head or limb injuries) are more obvious and therefore attract more interest.
- they can be severe but primarily have few symptoms and clinical signs: for example, considerable intra-abdominal bleeding can have few signs or symptoms in the initial phase.

With this background, it is important to keep in mind that an intra-abdominal injury can be a rapidly or immediately life-threatening condition that - if discovered early and managed properly - can be successfully treated, resulting in a return to full health.

Therefore:

- Do not miss abdominal injuries ('in the severely injured patient, abdominal injuries should be suspected until proved otherwise').
- Give abdominal injuries high priority. Because of the good prognosis after accurate treatment, the priority for abdominal injuries should be high except in extreme conditions (no facilities for surgery or volume replacement).

5.2 Primary management in the emergency room

**Diagnosis**

- Expose the whole abdomen (front and back).
- Signs of penetration? Fragments? Contusions?
- Low rib fractures?
- Pain/tenderness?
- Abdominal distension?
- Signs of intra abdominal fluid (percussion?)

In unconscious patients unable to react with pain and tenderness, the diagnosis is, of course, difficult.

Conscious patients, however, may also have few symptoms in the initial phase of an intra-abdominal bleed, or even intra-abdominal perforation.

In a patient with impaired circulation and no obvious signs of major external bleeding, the abdomen should always be suspected.

**Management**

If an abdominal injury is confirmed or suspected, the following measures should be taken:

- Oxygen, assisted ventilation, and endotracheal intubation if the patient is shocked;
- Large, centrally placed intravenous lines (it is of little value to give fluid in the
lower extremities in the patient with intra-abdominal bleeding);
- Gastric tube;
- Bladder catheter (contraindicated in a patient with a suspicion of urethral injury. If possible take a sample of urine before inserting the catheter);
- If the patient has circulatory instability, start intravenous infusion (see under treatment of shock). Note: To give extensive volume replacement without control of the source of bleeding may increase the blood loss and also cause impairment of coagulation with the risk of systemic reactions. Therefore, remember that identification and control of the source of bleeding as soon as possible is the most important measure.

5.3 Penetrating injuries

Missiles and fractures
Series of selected patients managed conservatively after missile wounds have been reported, but such a strategy should be used only if the resources are extremely limited. Under other conditions, all such injuries should be explored.

A minimally invasive technique might be used if it is available and there is good access to resources, but is a time-consuming way of exploring the abdomen and has little or no place when there are mass casualties.

Stab wounds
Many series have been published of good results after successful conservative management of stab wounds and when there are mass casualties, these injuries could be managed by the same regimen as blunt abdominal injuries. The minimally invasive technique is (if experience is available) a good way of diagnosing penetration of the abdominal wall and intraabdominal bleeding.

Blunt injuries

Patients with circulatory instability
If the patient has circulatory instability, there is no place for time-consuming diagnostic measures like CT, even if it is available.

An ultrasound scan (US) can (if experience and equipment is available) rapidly confirm if there is blood or fluid in the abdomen. If US is not available, diagnostic peritoneal lavage (DPL) should be done.

If US or DPL suggest continuous bleeding, laparotomy should be performed. If no intra-abdominal bleeding can be confirmed with these measures, other sources of major bleeding should be suspected (chest? limbs?).

Patients with circulatory stability
If the circulation is primarily stable, or rapidly becomes stable on minor fluid
replacement and shock management, a CT or US should be done if possible. These may show injuries amenable to conservative treatment, which has advantages, such as injuries to the parenchymatous organs (liver, spleen or kidney), without serious continuing bleeding, while an unnecessary operation may result in a bleeding that requires major surgery.

A CT or US may also show a large retroperitoneal bleeding that may be better managed by conservative treatment such as external pelvic stabilisation and (if available) percutaneous embolisation.

A prerequisite for conservative (that is, non-surgical) treatment of such injuries is that there is no serious continuing bleeding requiring repeated fluid replacement or transfusion (limit depending on conditions, normally not more than 2 units/24 hours), or showing progress on repeat examination.

If CT or US are not available and there are clinical signs of abdominal injury (abdominal pain, tenderness or a history of severe abdominal trauma) a DPL should be done followed by laparotomy if DPL shows appreciable, continuous bleeding. This simple strategy of safety will result in some unnecessary laparotomies, which of course consumes resources and the strategy has to be selected with regard to time and competence.

5.4 General surgical strategy

The incision of choice in obvious or suspected abdominal injury is a long midline incision that, if needed, can be extended with a sternotomy (need of proximal vascular control) and even with a thoracoabdominal incision which, however, is rarely needed.

In the case of a major intra-abdominal bleed, the abdomen should be packed with one big pack of gauze sponges in each quadrant. If the bleeding is controlled by this manoeuvre, give the anaesthetist a chance to achieve optimal monitoring of the circulation and wait for optimal equipment and competence.

Then remove the pack step by step, looking for the source of bleeding: first the two lower quadrants, then the left upper (spleen? kidney?) and finally the right upper quadrant (liver? major veins?).

If it is difficult to achieve control of a major bleeding from the liver or big veins, replacement of the packs and temporary closure of the abdomen is a possible and useful way of gaining time and resources when capacity is limited or the load of casualties is heavy.

At laparotomy for abdominal trauma a complete, systematic inspection of the whole abdominal cavity and adjacent structures is essential. The golden occasion to identify and deal with an injury is the first laparotomy, and delay in management is associated with considerably increased morbidity and mortality. When this has been done, the staff taking over the care of the patient (which, if there are mass
casualties, are usually not the same) have the right to assume that nothing has been overlooked.

Therefore, a routine should be followed:
- Sources of bleeding: major vessels, parenchymatous organs, mesenteric vessels, and retroperitoneum;
- Intestinal leakage: careful systematic inspection of the whole gastrointestinal tract, starting with the most contaminated parts and going upwards. Do not forget the retroperitoneal parts of the rectum and duodenum;
- Duodenopancreatic injury: easily missed and lethal if missed. It is essential to open the lesser sac for complete inspection;
- Diaphragm: easy to miss;
- Retroperitoneal space: haematomas around the pancreatic head should be explored; otherwise, major haematomas should be investigated non-invasively and treated conservatively.

The general surgical principles for management of some of the most commonly occurring injuries will be dealt with briefly.

5.5 Major vessels

Patients with injuries to the abdominal aorta can rarely live long enough to reach the operating theatre, but delayed dissections can occur. Control of bleeding may require clamping of the aorta with a straight vascular clamp, applied below or within the diaphragmatic crus, or, above the diaphragm through an anterolateral thoracotomy (5th - 6th intercostal space).

Bleeding from mesenteric arteries may be considerable and after repair or ligation, pay careful attention to the intestinal circulation. Bleeding from pelvic arteries is best controlled by non-invasive methods (external stabilisation of the pelvic ring and percutaneous embolisation). Unilateral ligation of the internal iliac artery is harmless and can be of some help in control of bleeding.

Injuries to the vena cava are often the most difficult to handle. Repair distal to the renal veins is usually not too difficult but requires careful and complete free dissection of the vein proximal and distal to the injury with proper attention paid to the wide and short lumbar veins, which are easily torn off and will increase the bleeding. When there are defects in the vein (such as from missile injury) it can be ligated at this level as a life-saving procedure (but not without complications). A way to repair the vena cava at this level is to use a spiral vein graft from, for example, the saphenous vein, but this is a time-consuming procedure.

Injuries proximal to the renal veins, often combined with liver injuries, is a major challenge to the trauma surgeon. Repair of these injuries requires extensive
mobilisation of the liver and sometimes an intracaval shunt as well, which is best
done from the right atrium through thoracotomy. This requires experience, time,
and resources and usually has no place when there are mass casualties. Careful
packing of the liver can be successful, at least as a temporary procedure in most
cases.

5.6 Liver

Around 80% of injuries to the liver are simple ones that require only minor or no
intervention. These are usually only small tears in the capsule or minor intraha-
patic haematomas. If suture of such a tear is needed to control bleeding, different
techniques can be used to avoid the sutures 'cutting through' the parenchyma (for
example, using parts of a vascular graft as 'buttons'). Drains should be used liber-
ally, mainly for possible bile leakage.

More severe injuries may require more extensive operations. These require both
good access and temporary reduction of bleeding for visualisation. Access is
achieved by maximal proximal extension of the incision, cutting the ligaments,
and retracting the liver downwards with packing above. Temporary reduction of
blood flow is achieved by the Pringle manoeuvre (vascular clamp on the hepato-
duodenal ligament, opening it every 20 minutes). After that, carefully separate the
edges of the injury and achieve haemostasis by ligation, suture or clips. If part of
the liver is smashed or partly 'torn off', it can be resected as a debridement with
removal of severely damaged or devascularised tissue and careful haemostasis
(according to the principles above) on the surface of the resection. Drains should
always be used.

The most severe injuries may require major (formal) resection or repair of the
major vessels. These are difficult procedures that require experience and time and
therefore have little or no role when there are mass casualties. For technical
descriptions, see textbooks in advanced liver and trauma surgery. A better proce-
dure when there is a heavy load of casualties and staff with limited experience, is
packing alone (see above under 'Injuries to the major vessels').

5.7 Spleen

Increased knowledge about the role of the spleen in immunological defence, in
combination with access to minimally invasive techniques and new methods of
splenic preservation, has led to a more conservative approach to removal of
splenic tissue, which of course is justified if it is severely damaged. However,
splenic preservation is usually more time consuming and when there are mass
casualties, or in severe trauma with multiple intra-abdominal injuries with consi-
derable blood loss and contamination, time and blood should not be lost in attempts to preserve the spleen. If safe splenic preservation is not possible with a rapid procedure (simple suture or local haemostasis), splenectomy should be done for wide indications.

Autotransplantation of splenic tissue has no confirmed immunological effect and patients whose spleens have been removed should, if and when possible, be vaccinated against pneumococcal infections.

5.8    Pancreas

Opening of the lesser sac and inspection of the pancreas is essential in laparotomy for trauma.

Injuries to the pancreas distal to the mesenteric vessels without involvement of the major duct can just be drained (do not make any attempts to close the capsule, which will result in cyst formation).

Injuries with involvement (or suspected involvement) of the major duct are best treated by resection, which with attention to the splenic vein can be done with preservation of the spleen. The pancreatic duct should be identified and closed with non-absorbable material.

Injuries proximal to the mesenteric vessels without involvement of the main duct can just be drained.

The difficult pancreatic injuries are those proximal to the mesenteric vessels with ductal involvement. A Whipple procedure in trauma is associated with a high mortality and morbidity and has no place here. Traditional covering of the injury with a Roux-en-Y anastomosis has been recommended. However, this is not an easy procedure and involves a relatively high risk of complications (leakage). Proper drainage as the only procedure has been recommended in modern publications on trauma and is therefore a reasonable option when there are heavy casualties.

5.9    Duodenum

Duodenal injuries should be identified and repaired, which is usually possible with an extensive Kocher mobilisation. Severe injuries, big contusions of the duodenal wall, or combined duodenopancreatic injuries, can be managed by pyloric exclusion: opening of the ventricular wall, closure of the pylorus from the inside with absorbable sutures, and gastroenterostomy using the incision in the ventricular wall.
5.10 Small intestine

*Careful systematic inspection of the whole small intestine is essential during laparotomy for abdominal trauma.* In high velocity trauma, it is important not only to identify penetrations or defects in the intestinal wall, but also contusions (intramural haematomas). Some of these contusions will lead to ischaemia in the intestinal wall and secondary perforation (a particular risk when they are large, associated with a palpable defect in the intestinal wall, or located in the distal part of the small intestine or colon). These should be identified, and if they are close to an open lesion they should be included in the resection; otherwise, if they are considered to be a risk, they should be invaginated or resected.

End-to-end anastomosis is in most cases safe after resection of the small intestine.

5.11 Large bowel

Management of colon injuries is controversial. During and after the second world war, the golden rule was never to do a primary anastomosis after resection of the colon after missile or high velocity injuries. Since then, several studies have been published that have shown that it is quite possible to do a primary anastomosis under certain conditions: patient in good condition, limited number of associated injuries, limited contamination and reasonable surgical experience. During the last few years, many surgeons have reported good results of primary closure even after missile and high velocity injuries.

When there are heavy casualties or resources are limited, the safest plan is not to do a primary anastomosis but an enterostomy with mucous fistula or, alternatively, primary anastomosis with a proximal enterostomy. This may cause some problems in the postoperative course and may even lead to some increased morbidity, but the patient will not die of peritonitis from postoperative leakage with limited possibilities for postoperative care and surveillance.

5.12 Retroperitoneal haematoma

Haematomas around the pancreatic head should be explored to identify or exclude pancreaticoduodenal injuries, which are associated with a high morbidity and mortality if not discovered primarily.

Haematomas around the kidneys should be managed conservatively: most renal injuries can and should be handled in this way. Unnecessary exploration may lead to bleeding with an unnecessary resection or even nephrectomy.
If possible, CT or angiography (intra-operatively, if the finding is unexpected) should be done to exclude injury to the renal artery.

5.13 Injuries to the urinary tract

Renal injuries, see above.
Small ureteric injuries can be managed with a drain alone. If the ureter is ruptured, the serosa should be adapted with absorbable sutures, local drainage, and percutaneous nephrostomy.
Bladder injuries should be closed in two layers, with a percutaneous cystostomy.
Urethral injuries: Never attempt to insert a catheter if a urethral injury is suspected. No primary repair should be attempted, just percutaneous cystostomy and later reconstruction by a special team.

5.14 Closure of the abdomen

In heavily contaminated injuries (missile injuries and injuries coming late to treatment), skin and subcutaneous tissues should be left open for delayed primary closure. In missile injuries, it is important to make a final debridement of entry and exit holes, removing dead and contaminated tissue and leaving skin and subcutaneous tissue open.
If there is a defect in the abdominal wall, artificial material should not be used. The abdomen can be left open primarily and the intestines covered by large moist gauze sponges, kept moist by irrigation. The abdomen should be closed before adhesions form.

5.15 Pelvic injuries

The important consideration with regard to pelvic injuries is to identify whether they are unstable - that is, disruption of the pelvic ring involving at least two sites (two fractures, or one fracture plus dislocation in a sacroiliac joint or the symphysis). Such injuries are dangerous: there is a high risk of vascular and visceral injuries, dislocation, and pain from every movement together with the risk of systemic complications such as adult respiratory distress syndrome (ARDS).
If there is suspected or obvious instability, the patient should not be moved without effective splinting (a vacuum splint or other whole-body splint). If there is severe bleeding from an unstable pelvic fracture, a bandage carefully compressing the pelvic halves together can be used. If the patient is unable to urinate, do not insert a bladder catheter but do a percutaneous cystostomy.
As soon as possible the pelvic ring should be fixed externally. It is important that simple devices for this are available at all times and that all surgeons are capable of applying them (the procedure is technically simple). Stabilisation can be an effective haemostatic measure to control intrapelvic bleeding, if necessary combined with percutaneous embolisation of the source of the bleeding identified by angiography, if this technique is available. Note however that anterior external stabilisation does not eliminate the vertical (posterior) instability and has in such injuries to be combined with a compressing bandage (or, if available, pelvic clamp or osteosynthesis, the latter procedures requiring considerable resources and experience).

6 LIMB INJURIES

6.1 Introduction

Around 70% of the casualties in major accidents and disasters have injuries to the limbs. Even if they are often associated with injuries to the trunk and cerebrospinal system, this makes them the most common injuries. The incidence of limb injuries is an astonishingly constant figure in all circumstances, whereas the incidence of injuries to other parts of the body varies widely depending on the type of violence, quality of prehospital management, distance to hospital and transport capacity.

When the number of casualties is limited, regular methods can be used in the treatment of limb injuries: primary reconstructive surgery for soft tissues and internal fixation of fractures for exact reconstruction and rapid healing.

When there are heavy casualties or resources are limited the situation is different. The injury is often high velocity, resulting in extensive devitalisation of tissue and more severe contamination. In addition, treatment of the injuries is often delayed, so the patient's general condition is poor and there is even more contamination and devitalised tissue. Access to experienced surgeons and to facilities is limited.

All these factors together create a need for simple and safe methods, the primary goal of which is to minimise infection after the primary treatment and leave the wound open for later definitive reconstruction. Avoid the temptation to achieve a cosmetically attractive result from the primary treatment, as it will involve the risk of infection with associated systemic complications, which may not only cost limbs but also lives. Always remember: it is not you as a treating doctor that 'takes the chance', it is the patient.

That is why advanced methods of primary reconstructive surgery and internal fixation of fractures are not mentioned in this text. If such methods should be used at all, they should be used only by surgeons with extensive knowledge and experience of such methods.
The simple and safe methods described below may lead to a longer time for healing, a second operation, and even increased morbidity during healing. Under these conditions, however, they are never wrong and they do not kill the patient, which an advanced procedure under such conditions can do.

**Effects of high energy**

The extent of injured tissue is proportional to the amount of energy transferred to the tissues - the more energy, the more extensive the damage. In missile and fragment injuries, the energy is increased by increased impact velocity of the missile or fragment according to the formula $E = \frac{1}{2} m V^2$, where $E$ stands for energy, $V$ for velocity and $m$ for mass. However, many other factors influence the energy delivered to the tissues: instability of the missile or fragment (which can be achieved by pre-fragmentation of the missile) or high density of the tissue, depending on what tissue the missile or fragment hits (such as bone).

The conditions for high-velocity injuries are different in different parts of the body. They are harmful in muscles and in body compartments with fluid (abdomen, major vessels and skull) and less harmful in tissues with more elasticity, such as lung tissue (which is the reason why many missile injuries to the chest can be relatively harmless if they do not hit the heart or major vessels).

If a missile or fragment hits a limb, releasing a low amount of energy (low velocity, stable missile, low density), the injury may be harmless with little or no devitalised tissue, and require no extensive treatment (inspection for devitalised tissue, minimal debridement, even primary closure in favourable conditions). Under primitive conditions the wound can just be left open for delayed primary closure.

However, if a fragment or missile hits a limb releasing a high amount of energy (high speed, unstable missile, high density) the effect will be entirely different. An expanding cavity will be created; causing a zone of irreversibly devitalised tissue outside the missile track. This wound expands intermittently, sucking in contaminated material ('pulsating wound'). The pressure wave may cause injuries to nerves and vessels distant from the missile track. Secondary fragments from missile or bone may penetrate the abdomen or chest. If these injuries are not properly treated there is a high risk of severe infections leading to loss of a limb and even life.

### 6.2 Debridement (wound excision) in soft tissue injuries

The term ‘debridement’, which is often used for these injuries, is not entirely accurate. What the procedure has to be (and also should be called) is wound excision, that is, accurate and careful excision of all devitalised tissue. The steps are simple:
1 Skin
Make a longitudinal excision over both exit and entry wounds. Exceptions: (a) over joints where a curved incision should be made, and (b) if the entry and exit wounds are close together they can be connected.

Do not excise more than a few millimetres of skin and then only severely contaminated parts. Do not excise the borders of the incision.

If it is not clear whether it is a high or low velocity wound, start with a small incision and look. If there is only a minimal amount of necrotic tissue, stop and leave it open (under favourable conditions, with the possibility for post-operative surveillance in the same unit, it can be primarily closed, but in less favourable conditions the safest procedure is to leave it open for delayed primary closure).

If there is a considerable amount of necrotic and devitalised tissue, continue as below.

2 Fascia
High velocity injuries include the potential risk of compartment syndrome (see below). If there is extensive devitalisation, extend the incision in the fascia as far as possible (also subcutaneously) in both directions.

3 Muscles
Excision of muscle is the difficult part of the debridement. Insufficient excision of muscle is the most common cause of infection. On the other hand, the excision should not be too extensive, causing unnecessary disability.

All surgeons dealing with these injuries should be educated and trained in the procedure and be able to identify dead tissue and excise accurately. For a surgeon with good basic training, this is not a difficult procedure.

Signs of devitalised tissue are the well-known '4Cs':
- Colour: devitalised muscle is darker, one of the best signs.
- Consistency: devitalised muscle is looser. This is easily recognised if the muscle is excised with scissors.
- Capillary bleeding: devitalised tissue has no capillary bleeding on the surface.
- Contractibility: devitalised muscles have reduced contraction, but this is also influenced by other factors and is a less reliable sign.

The muscular incision should be done according to the following principles:
- Follow the wound track carefully with a finger (using sharp instruments can create 'false tracks').
- Excise from both entry and exit holes so the whole track can be inspected.
- Make a circular excision stepwise down to the identified borderline between viable and non-viable tissue.
- Open up haematomas: they can hide more devitalised tissue.
- Leave as little foreign material as possible.
4 Bone
Remove fragments without periostial attachments. Leave fragments with periostial attachments. Never do internal fixation in high velocity injuries (injuries with extensive devitalisation that require major debridement).

Whether internal fixation should be done at all in missile injuries is controversial. It can be done under good and well-controlled conditions, by staff with experience and good facilities for post-operative surveillance.

Under primitive conditions or with limited experience, internal fixation should never be done for missile injuries.

Instead, external fixation can be done with simple devices, and there are many simple and cheap ones available today. If you have no access to such instruments, nails drilled through the bone on both sides of the fracture and attached to whatever is available can do quite well.

The fracture should be immobilised in plaster if possible, even if the wound is open, but then the plaster has to be primarily cut to allow inspection, avoid compression, and allow drainage.

5 Vessels
If simple vascular suture is not possible (because of a defect in the vessel), reconstruction may be necessary to preserve the limb. Whether synthetic grafts should be used at all is controversial, and the current opinion is that they should not (high risk of infection). The alternative is to use an autologous graft (such as saphenous vein that can be duplicated to sufficient size), but this is time-consuming. On the other hand, ligation of a popliteal artery in the knee region leads to an amputation rate of nearly 100%, ligation of a femoral artery somewhat less. Again, it is a matter of priority and adjustment.

6 Nerves and tendons
As a general rule, no primary repairs should be done in high-velocity injuries. Identify the injury, mark the separated ends, and repair after, or in connection with, the delayed primary closure.

In low velocity injuries, the same principles apply as for internal fixation: in ideal conditions it is possible; in all other conditions, follow the same principles as for high velocity injuries.

7 Foreign material
All organic material (earth and fragments of clothes) must be thoroughly removed. Extensive irrigation and cleaning of the wound is important.

On the other hand, it is not necessary to remove all inorganic material (metallic fragments). Remove everything that is possible to reach easily from the wound, but do not extend the operation by trying to remove all the fragments.
8 Leaving the wound open

In high velocity injuries, the wound should be left open, even after complete excision. Good drainage is necessary and this is the most effective.

*The wound should not be packed.* Cover with loose dressings.

If the excision has been complete, there is no need to change the dressing daily. Let it stay in place until time for delayed primary closure (see below). If the excision was incomplete, there will be fever and secretion; take the patient to the operating theatre and complete the débridement.

Recent data support the idea that low velocity injuries can be primarily closed under ideal conditions. As already mentioned, when conditions are not ideal (severe contamination, delayed treatment, limited experience and reduced possibilities for post-operative surveillance) leave the wound open. The disadvantages of this are limited.

There are few (if any) exceptions to the rule of leaving the wound open. In the face or hands, the cosmetic result of primary closure might be better, but a wound closed for the wrong indications in this region may also be a disaster for the patient.

9 Delayed primary closure

'Delayed primary closure' means closing within the normal phase of healing, that is, within 5-10 days. If proper excision has been done, this can be done without further excision.

If the primary excision has not been sufficient and devitalised or contaminated tissue is still present, complete the excision. If the additional excision is extensive, the wound should be left open for a further period before delayed primary closure. Closure should be done without tension. If it is not possible to close the wound without tension, apply skin grafts (or, if possible, reconstruct with flaps).

10 Amputation - when and how?

If the injury is extensive, primary amputation might in some cases be a better option. Trying too hard to save limbs can lead to complications, and even risk loss of life.

Primary amputation should at least be taken into consideration in severe musculoskeletal injuries with loss of substance combined with loss of nerve function, making the chance of restored function of the limb small.

These are extremely difficult decisions, particularly in young patients, and should, whenever possible, be done by two independent physicians who share the responsibility.

If amputation is done, it can be in the form of débridement (excision of all devitalised tissue), preserving vital tissue, and leaving the wound open (possibly with single adaptation sutures) for later cosmetic and functional adjustment of the
stump at the time of delayed primary closure. Traction applied to the skin can prevent retraction of soft tissues over the bone.

6.3 Compartment syndrome

The so-called 'compartment syndrome' is a complex entity in which products from injured tissues cause swelling inside the fascia leading to increased pressure, impairment of peripheral circulation, and further death of tissue and systemic effects of trauma, including renal, pulmonary and circulatory insufficiency mediated over a complex system of pathways. The characteristic feature is the renal insufficiency caused by the release of myoglobin from devitalised muscle. This was previously thought to be the only systemic effect on this syndrome but, in fact, it is only a part of it.

None of these complex mechanisms will be dealt with in this chapter. There is, however, one important thing that can save limbs and lives when resources are extremely limited: To identify and eliminate the main generator of the syndrome, the subfascial oedema.

This requires neither advanced diagnostic methods nor advanced surgical technique. What is required is the eye and the hand of the physician. If a limb has been exposed to extensive injury, either severe blunt injury or compression over a long period (for example, in trapped patients), but also penetrating injuries, this implies the need to observe peripheral circulation and subfascial tension carefully.

Advanced methods for assessing intra-compartmental pressure are of limited value and too much reliance on such methods has cost limbs. The best instrument is still the hand of the trained physician.

If there is any suspicion of intra-compartment swelling (subfascial tension) do a fasciotomy - better one too many than one too few.

The fascia should be opened widely, which can be done partly subcutaneously from a longitudinal skin incision. Remember that lower limbs have four separate compartments and, if they are all involved, they must all be opened.

In reports from earthquakes, where the risk for compartment syndrome in trapped patients is great, significant differences in outcome between active and less active approaches have been clearly shown. Diagnostic observance and early aggressive treatment are extremely important.
Adapted surgical technologies under extreme outdoor field and/or disaster constraints in developing countries

by BERND DOMRES

7.1 Introduction

Natural as well as man-made hazards often occur in tropical regions and developing countries. We may even say that the normal conditions of life in those countries correspond to the definition of disaster itself, when considering the misrelationship between the necessary demands and available resources.

International support for the developing countries by organizations such as ICRC, WHO, United Nations and other UN organisations as well as by NGOs is therefore indispensable. All these organisations, who are on site either permanently or in case of hazards, keep to established standards in order to guarantee a certain quality of structure, performance, outcome and ethics. By their logistics of procuring, storage, transport and supply of material, it is actually much easier to cope with the most serious problems than even a few years before. From the point of view of these standards, the following techniques and methods may appear obsolete and being only of historical interest. They should, however, be remembered in extreme situations as 'the very last solution', that is, when all other systems and procedures of medical support have failed or, in other words, in places 'where there is no doctor and where there is no chance of logistical support at all'.

What does 'appropriate technology' mean? First of all, regarding the disaster conditions and/or an outdoor field situation, we have to start with the simplest and most primitive technical means at our disposal. There are patients who have to be treated immediately, as the next hospital within reach may be far away, which means that we should use locally available materials and well-known techniques of manufacturing. As technical and material resources for the treatment of patients in the Third World are normally not of the same quality and standards as those in developed countries, we are, from the legal point of view, allowed to relax the level of standards we are used to; indeed, in most cases, we simply have no other choice.

The following 'appropriate technologies' have been selected as basic examples after a number of disaster missions in order to demonstrate how to make use of primitive resources under extreme conditions. These exceptional situations should not be considered as a rule for implementing such techniques. The first example is about the treatment of fractures. Our method of mounting wooden fixators was developed in 1980, when we had to treat Cambodian wounded people in a field hospital of the ICRC. Since that time ICRC has drastically changed its policy insisting on the necessity to improve logistical support at any cost (instead of relying on such heroic procedures) and has issued strict guidelines limiting the use of external fixators to specific situations where other immobilisation procedures cannot

The second example, a primitive form of autotransfusion, will often be the only way of compensating large blood losses in seriously wounded patients, if no other substitutes are at hand. One should always take into consideration the serious potential complications inherent to this procedure, which should be considered when no other alternative is possible.

As in tropical countries about 20% of the black population suffers from the hereditary sickle cell disease, which may lead to lethal complications during surgical operations, we will shortly describe as a third example for 'appropriate technologies' the standard sickling test, which has to be performed before any surgical operation.

The impact of malaria and other infectious diseases being of similar importance in those countries, we will describe as a fourth example, the so-called method of the 'thick drop' as an indispensable device to prove plasmodia.

Finally, the coconut drip will be presented as one of the most primitive, but nonetheless efficient 'technologies' to supply the patient with substances that are, for instance after a shock situation, of vital necessity.

### 7.2 Wooden fixators

#### 7.2.1 Manufacturing and mounting of a wooden fixator (Type I)

Before discussing this technique we wish to emphasise what has been written in the introduction regarding the limitation of use of such heroic techniques. In developing countries, under disaster conditions or in war situations, for reasons of finance or logistics, external fixators may be largely unavailable, or available only in limited number. From this shortage, our idea to utilise locally available materials and construct a wooden fixator by ourselves has been developed.

Wood is available nearly everywhere. For our wooden external fixator we take locally available round timber from 0.6 to 0.8 inches (1.5 to 2 cm) thick, which by saw, plane and carving knife is manufactured into pieces of different lengths (11.8 inches/30 cm for the tibia or the lower leg; 15.7 inches/40 cm for the upper leg or femor). For the inlet of the 'Steinmann-pins', we gimlet two borings of 0.2 inches (5 mm) in diameter laterally, which have to be placed proximally and distally at a distance of 1.57 inches (4 cm). Subsequently, the pieces are sterilised and are kept in plastic bags.

The mounting of the conventional wooden fixator may be inferred from the following working steps:
1 First gimlet two channels for the 'Steinmann-pins' into the bone on both sides. 'Kirschner-wires' are suitable as spot help device.
2 Bring in the 'Steinmann-pins.'
3 Set up and fix the previously bored round timber. The different functions of a fixator, such as neutralisation, distraction or compression of the fractured area, may be realised through the wooden fixator by appropriate mounting techniques. For instance, if you want to compress, you have to choose the distance between the two proximally and the two distally bored channels in the bone approximately 0.2 to 0.4 inches (0.5 to 1 cm) wider, as is the distance of the borings of the round timber. You may also employ further mounting techniques such as a clip fixator or a three-dimensional construction spanning the knee-joint.

Advantages of this technique in comparison with metal fixators are:
- short time of mounting
- low weight and no heat conduction
- x-ray transparency
- low cost (2 - 4% of the cost of a metal fixator)
- independence of logistics of procurement

The disadvantages of such a wooden fixator are:
- correct mounting demands use of an experienced and trained surgeon
- secondary correction of position demands new mounting

Because we found that this latter drawback arose in clinical practice in the field, that is, after mounting secondarily, follow-up reposition, application of compression and dynamisation of the fracture zone could not be effected, the original construction has been technically improved² (Figs 1 and 2).
7.2.2 Manufacturing of a wooden fixator of the second generation (Type II)

1. In a first step, saw two round or square timber pieces 12 inches (30 cm) in length and one inch (2.5 cm) in thickness.

2. In a second step, gimlet proximally into each of both pieces three bore-holes (0.2 inches/5 mm in diameter) at a distance of 1.6 inches (4 cm) from the end of the piece and the following borings.

3. In the next step, insert with a gimlet and a file in the distal areas of both pieces instead of the three borings a deft of 0.2 inches (4.5 mm) breadth and 2.75 inches (7 cm) length. The deft should be at a distance of 1.6 inches (4 cm) from the distal end of the piece.

4. In a last step of preparing the external supports, bore with a gimlet (1.8 inches/1.5 mm in diameter) from distally into each of the pieces a hole to the cleft and cut a screw-thread. Drive into each of the threads a wing screw from the end of the piece to the beginning of the cleft.

5. Finally, prepare two short pieces of wood of approximately 4 inches (10 cm) length (thickness as the main pieces 1 inch/2.5 cm). Gimlet into each of these pieces three bore-holes (0.2 inches/5 mm in diameter) at a distance of approximately 1 inch (2.5 cm).

The wing screws (0.2 inches/5 mm in diameter) should have a minimum length of 2 inches (5 cm). The 'Steinmann-pins' should be 0.18 inches (4.5 mm) in diameter.
7.2.3 Mounting of a wooden fixator of the second generation

1 The repositioning should be made as exact as possible after careful debridement of the wound. During the mounting of the fixator, the resulting reposition should now be secured by a reposition punch.

2 In a next step, make two or three borings (0.2 inches/5 mm in diameter) into the proximal part of the tibia from laterally to medially at a distance of 1.4 inches (3.5 cm). Then insert the ‘Steinmann-pins’ (0.18 inches/4.5 mm in diameter) through these borings. ‘Steinmann-pins’ with a thread part in the medium third are preferred, as they guarantee a better adhesion in the bone.

3 Proceed similarly in the distal area. The distance between the two borings here should be 0.8 inches (2 cm). Insert here the three ‘Steinmann-pins’ (0.18 inches/4.5 mm in diameter) as well.

4 In the next step, put the two round or square timber pieces of 12 inches (30 cm) length, which have bore-holes in the proximal part and a cleft in the distal part, upon the ‘Steinmann-pins’ on both sides. Now the fixators are attached to the ‘Steinmann-pins’ in the proximal area. In the distal area the ‘Steinmann-pins’ have to be inserted into the clefts of the two fixators.

5 Now attach in the distal area on both sides the short wooden pieces of 4 inches (10 cm) length to the ‘Steinmann-pins,’ which now reach through the cleft of the main support. Then control the reposition, which now may still be corrected in longitudinal direction as well as ‘ad axim.’ A rotatory movement, however, is no longer possible.

6 As a last step of the mounting, drive the wing screws on both sides from distally into the main supports. The wing screws now reach proximally into the cleft and there meet the distal ‘Steinman-pin.’

7 By fastening the wing screws the ‘pins’ are under pressure, and the distal fragment is moved under compression towards the proximal fragment. If the

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**Figure 3**

Wooden Fixator (Type II) - The illustration shows how secondary reduction can be performed even after mounting.
Primitive Autotransfusion in the theater of a field hospital for Cambodian refugees.
reposition has been successful, the fracture area may be compressed. The reposed fracture and the whole construction achieves a considerable stability by this compression. (Fig. 3)

7.3 **Appropriate technologies in exceptional circumstances**

7.3.1 *Primitive autotransfusion*

If in the outdoor field or in war situations we have to dealing with patients suffering from large blood losses, for instance after hepatic or lienal ruptures, ruptures of vessels or after extrauterine gravidity and tubal rupture, we may, in order to compensate the losses, make use of the so-called primitive autotransfusion as a further example of 'appropriate technologies' under extreme conditions. As mentioned in the introduction, this technique should be considered only when no other possibility exists to compensate the blood loss. The method is quite simple.\(^5\) (Fig. 4 and 6)

Take an infusion set, a sterile funnel, open-weave gauze as filter and a scoop. The most primitive procedure is to scoop the blood from sterile areas such as the thorax or the abdominal cavity, pour it back into the funnel which has been attached to the infusion set and from there reinfuse it immediately. You may also suck up the collected blood into a sterile bottle, if possible via blood filter, and reinfuse it from there by a pressure-pump. In order to avoid clotting add heparin or sodium citrate. After the autotransfusion the sodium citrate has again to be compensated by calcium citrate.

This primitive form of autotransfusion is indicated when the patient suffers from mass bleedings and when clotting factors have only unessentially been activated. You will have the most effective results in the first phase of the bleeding, i.e. as long as the blood is not contaminated with detritus. This is a major limitation. No contaminated blood should be used. This means that most abdominal penetrating injuries are contraindicated. In the case of massive leaching bleedings, primitive forms of autotransfusion should be avoided, as tissue thrombokinase becomes so strong that, after the reinfusion of the patient's own blood, consumption coagulopathy will jeopardise the patient's condition seriously. If the equipment is at hand, an infusion of washed red cells is indicated here.

7.3.2 *The sickling test*

Our third example of 'appropriate technologies' - the standard sickling test - is an indispensable device in tropical countries, where nearly 20% of the black and the mulatto population is suffering from the hereditary sickle cell disease. Patients who are sickle cell positive are, as we know, resistant to malaria. Sickle cell positive patients normally do not survive beyond 20 years of age. In order to avoid lethal complications, resulting from organ infarctions or angiostenosis by sickle cell
thromboses in those patients, sickle cell anemia has to be proved before any surgical operation according to the following method 4.

Take a clean microscope slide and place a drop of blood in the centre. Take 2% sodium metabisulphite that has been freshly prepared that day from dry stored powder and add two drops of it to the blood. Stir with a corner of a slide and apply a coverslip. Wait for 20 min and then rack down the condenser. Sickled cells are said to be most easily seen along the edge of the coverslip. The test is both simple and rapid. Sickle cells have long sharp points sticking out of them. It is advised to set up controls until one is thoroughly familiar with the method.

**7.3.3 Method of the thick drop**

Malaria, caused by various types of plasmodia is one of the most widely spread infectious diseases, either endemically or epidemically in the tropical and subtropical regions of East and West Africa, Middle and South America, India and South-East Asia. From about 250 million infected patients all over the world, nearly 3 million are dying every year. In order to prove plasmodia we recommend the following so-called method of the 'thick drop' 3.

Take a grease-free microscope slide and make a film of the size of a postage stamp in the middle of it. The film has to be of such a thickness that printed matter or the hands of a watch may just be seen through it. (Often the film is not made thick enough). Let it dry but pay attention to the extent of dryness, because its degree of desiccation is critical. The best method is to place it for a night in an incubator, but again, be careful, because the five minutes on top of a microscope lamp are critical and may damage the result. If too wet, it washes off; if too dry, it flakes off.

Use three wide-mouthed screw capped jars that can be closed after use. In the first jar place the blue stain A, in the second one dilute Leishman buffer, and in the third one pour the red stain B. Now wave the film gently to and fro for 1 to 2 seconds in A. Drain it momentarily on the edge of the jar, repeat the process in the buffer, then in stain B, and finally back in the buffer once more. Leave it to dry in a rack, scan it under low power and, having found a good area, search this under oil - an area with several leucocytes per high power field is about right. If the right field is found, malaria parasites or trypanosomes will be observed staining blue and purple against a clear orange background, which is thick enough to show obvious cracks under the oil emersion objective.

The staining times are very short indeed, the film being held in the buffer only until the blue stain ceases to run. Before being examined it must be dry and a domestic hair dryer will be very useful. Be careful to distinguish platelets from the young trophozoites of *P. falciparum*: the chromatin dot and the ring of cytoplasm serve to distinguish them.

The stains last several weeks if kept in closed jars, but they have to be renewed when they discolor.
7.3.4 The coconut drip

Our last example of ‘appropriate technologies’ in outdoor field situations will help effectively, when there is a total lack of different other infusion solutions - see introduction\(^6\). Take a green coconut, which is sterile, and connect it at one of the three holes with an infusion set. Then simply infuse the nut milk into the body of the patient.

The coconut contains

- electrolytes and water (care: high concentration of potassium)
- carbohydrates
- fatty acids
- amino acids
- vitamins
- indispensable ‘trace’ elements (care: rich in K\(^+\))

that is to say, different substrates which are not only sterile, but which also occur in a concentration that they are well tolerated by the patients.

The coconut drip is indicated in shock therapy, in order to supply the patient with lost energy substances or in order to treat dysentery, cholera, malnutrition etc. (Fig. 5). Complications can result from the fact that the liquid is rich in potassium and is of colloid nature.

7.4 Conclusion

After a large number of surgical missions under war and disaster conditions and from our working under extreme outdoor field conditions in several developing countries, we have gathered our experiences and tried to discover and develop ‘appropriate surgical technologies’ in order to cope with the basic medical problems on site. As there is mostly a shortage of technical and material resources in those countries, we have tried to make use of locally available means and techniques of manufacturing. The construction of our first wooden external fixator in 1980 is for instance one result of our attempt to use materials available on site, and thus to compensate for the great shortage of technical equipment. Primitive autotransfusion as a second example of ‘appropriate technologies’, if applied correctly, is in any case better than no therapy at all and can be used as the last possible technique when there is no other alternative. The sickling test, the method of the ‘thick drop’ and the coconut drip are further examples of appropriate technologies that may have to be used under primitive conditions but, according to our experiences, they represent last resort methods for treating patients in the Third World or under disaster conditions. And still, if there is nothing to hand, we have to adapt to the rule, that ‘the humanitarian imperative comes first’: primum non nocere is the rule in medical activities. Therefore we recommend the use of these heroic techniques only when no other possibility exists and when the fact of
doing nothing will certainly be accompanied by the death of the patient. No one not accustomed to these technologies should start to implement them as an 'heroic attempt'. Medical ethics should always be considered first.

Figure 5

Coconut connected to an infusion set - It contains essential substrates and electrolytes in a sterile medium, ready for infusion.
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