ANAESTHESIA HANDBOOK

ICRC

REFERENCE

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ANAESTHESIA HANDBOOK

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A. INTRODUCTION AND STANDARDS

1. INTRODUCTION

The aim of this handbook is to provide guidance for trained anaesthetists working for the ICRC and to offer advice in areas where practice will differ from that in their home country. It is designed to supplement the practical training given in ICRC war-surgery seminars and to support the work of the ICRC in war surgery.

Anaesthetists working in austere environments will generally be expected carry out a far broader range of tasks than at home. For example, they will often need to help with the triage and clinical management of patients in the emergency room and on the ward, as well as preoperatively assess and optimize all patients for surgery. As team members, they need to be prepared to assist in decisions regarding the limits of treatment for patients, given the capacities of the staff, the workload and the available resources. At various times they may also find themselves acting as theatre runners, porters, lab technicians and assistants in sterilization services!

Even in the most austere of conditions it is imperative to realize that anaesthesia is always a significant medical intervention and some basic rules must be adhered to:

- General anaesthesia is the sole responsibility of a practitioner, who is independent of the surgeon.
- The anaesthetist must be a qualified, registered specialist with a current licence to practice, which will be validated in the ICRC recruitment process.
- Minimum standards in respect of preparation, conduct and monitoring of anaesthesia/analgesia must be met.[1]

Limiting factors will be related to the infrastructure, including the availability of equipment, intravenous fluids and essential drugs. For example, blood transfusion services often require the support of local organizations and supplies are therefore frequently rationed. In addition, hospital infrastructure may provide very little shelter from

the natural environment, particularly in the case of very high or low ambient temperatures. The patient population can also present difficulties, which may be summarized as follows:

- Immediate versus delayed presentation. The latter group can be significantly dehydrated with neglected and or infected wounds.
- Cultural and language difficulties, making assessment of past and current medical history difficult, including uncertain "nil by mouth" details.
- Patients with non-trauma pathologies, e.g. obstetrics and paediatrics. Alcohol and drug intoxication may also feature.

Patient history is best assessed using the AMPLE method:

- Allergies
- Medications
- Past medical history
- Last meal/fluids
- Events leading to admission

Safety can be improved by non-technical processes such as the World Health Organization (WHO) checklist.[2]

Wherever possible, deployed teams should take the opportunity to create and rehearse emergency drills and "what if" scenarios.

The subsequent chapters elaborate on every consideration listed here, with the emphasis always on safety and simplicity. Flexibility is a key requirement.

The ICRC follows many of the principles and guidelines established by the World Health Organization. These documents are often updated and revised and ICRC anaesthetists are therefore advised to consult the updated versions prior to deployment.[3]

The ICRC's equipment and drugs kits are rigorously studied and scrutinized on a regular basis and therefore subject to change, particularly in response to the need to adapt them to different mission settings. ICRC anaesthetists should therefore ensure that they have the most recent version of the related documents prior to deployment.

Regardless of the skills that you exercise in your practice at home, it is important to always consider the context in which you are working and to understand that the success and safety of many procedures that are generally taken for granted (e.g. the use of central venous catheters, regional block catheters, post-operative ventilation, etc.) depend on the presence of well-trained ward staff and of a support team, neither of which will be present in the austere environment. It is vital to remember that having the skills to pursue a particular course of action does not necessarily mean that you should do so.

- Anaesthesia always entails a degree of risk.
- Despite the constraints of the austere environment, minimum standards of conduct and monitoring must be followed.
- Patient presentation, history and examination may be varied and difficult.
- Anaesthetic techniques may need to be adapted to the prevailing circumstances.
- Regional anaesthesia should be encouraged but strict adherence to safety principles is required.

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2. World Health Organization, Surgical Safety Checklist, WHO, Geneva, 2015. Available at http://www.who.int/patientsafety/safesurgery/tools_resources/SSSL_Checklist_finalJun08.pdf?ua=1
3. World Health Organization, *WHO guidelines approved by the Guidelines Review Committee.* Available at http://www.who.int/publications/guidelines/en/

2. STANDARDS AND STANDARD EQUIPMENT

2.1 MINIMUM STANDARDS

The World Health Organization (WHO) document Classification and Minimum Standards for Foreign Medical Teams in Sudden Onset Disasters[1] and the publication International Standards for a Safe Practice of Anaesthesia 2010[2] discuss the minimum standards required of medical practitioners and other staff involved in the safe delivery of anaesthesia. The two documents also discuss the levels of care provided at different hospitals.

International Standards for a Safe Practice of Anaesthesia 2010 also reviews the anaesthetic equipment that would be expected to be available within hospitals, depending on the level of service that a hospital provides. It lists highly recommended standards that are regarded as minimum and mandatory for the safe conduct of elective anaesthesia. It recognizes that in some situations these standards may not be met due to limited resources. In such situations any operations should be restricted to emergency surgery in order to save life or limb.

Teams from the ICRC with equipment kits provided by the ICRC should be able to achieve these minimum standards.

The following equipment lists and minimum standards for anaesthesia are adapted from the aforementioned documents, with adaptations made for ICRC work in an area of conflict or disaster:

1. Anaesthetic practitioners must be trained professionals and currently licensed to perform autonomous anaesthetics.
2. Records of each anaesthetic given, including preoperative assessment, must be made and stored with each patient's medical record.
3. Appropriate anaesthetic and resuscitation equipment

should be present for every anaesthetic given (general and regional).
4. The WHO checklist must be used for every surgical case.
5. Preoperative safety checks of all anaesthetic equipment must be carried out prior to any anaesthetic. This may be daily or before each case, depending on the equipment.
6. An assistant must be available to assist the anaesthetist during all anaesthetics.
7. Supplemental oxygen should be available for all surgical cases.
8. Ideal minimum monitoring during every anaesthetic should include oxygen saturations, electrocardiogram, non-invasive blood pressure and end-tidal carbon dioxide monitoring for all those under general anaesthesia.
9. Monitoring alarms, including saturation monitoring and the ventilator disconnection alarm, should always be used and set to appropriate limits.
10. Post operatively patients should be monitored until they have recovered consciousness.

- Despite the difficult environment, teams deployed by the ICRC must meet certain minimum standards as defined by WHO and others.
- Failure to maintain these standards should only be tolerated in extreme emergencies.

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1. Norton, I., *et al., Classification and minimum standards for foreign medical teams in sudden onset disasters*, World Health Organization, Geneva, 2013.
2. Merry, A.F., *et al*., "International standards for a safe practice of anesthesia 2010", *Canadian Journal of Anaesthesia*, November 2010, Vol. 57, pp. 1027-1034.

2.2 STANDARD EQUIPMENT

Pre-op – all	General anaesthesia
• Oxygen (concentrator +/- cylinder) • Saturation monitoring • ECG • End-tidal CO_2 monitoring • BP monitoring • Suction • Anaesthetic machine • Self-inflating bag (Ambu bag) • Stethoscope • Sterile and non-sterile gloves • Tape/marker pen for labelling syringes	• Laryngoscope handles • Laryngoscope blades 1 to 4 +/- straight blades • Endotracheal tubes 3.0 – 8 mm • Guedel airways • IV cannulae 24g to 16g • Tape / Elastoplast / Ties • Bougies • Magill forceps, large and small • Syringes 2 ml – 20 ml +/- 50 ml • Drawing-up needles • Facemasks, neonate to adult • Adult and paediatric oxygen masks/nasal specs • IV giving sets • 3-way taps • Yankaeur suckers + ET suction catheters • HME filters
Extras for regional / spinal anaesthesia	**Drugs**
• US machine • Regional needles • Spinal needles • Syringes for spinal needles • Skin prep	The ICRC constantly reviews the drugs available to ICRC field projects. An up-to-date drug list can be made available on request.
Other kit to consider	
• Nasogastric tubes • Urinary catheters and bags • Chest drain • Pressure bag • IO access • Rescue sheet • Fluid warmer • Peripheral nerve stimulator • Defibrillator • Ayre's T-piece (for paediatrics) • LMAs 2 – 5	

Table 2.1 Standard equipment.

3. HYGIENE AND STERILIZATION

At home in the Western world anaesthetists rarely have to think about cleaning and sterilizing equipment; items are either single use or another member of the theatre team takes care of that aspect of the work. However, in the field it is the anaesthetist's responsibility to ensure that the anaesthetics department is organized properly, the cupboards stocked and the items cleaned and disinfected or sterilized.

The ICRC has produced a publication on this issue, the Sterilization Guidelines.[1] If possible, you should read and be familiar with this document so that you are ready to support the hospital project manager and the head nurse in implementing the guidelines at the hospital.

3.1 KEY TERMS

There are a few key terms of which you should be aware:

Cleaning: the physical removal of contamination without necessarily destroying infectious agents.

Low-level disinfection: the elimination of most pathogens apart from spores, some fungi and viruses.

High-level disinfection: the elimination of all pathogens except spores.

Sterilization: the elimination of all forms of microbial life so that there is a < 1 /1000,000 chance of an infectious organism surviving.

STANDARD ICRC PRECAUTIONS

- All staff must wash their hands between patients.
- Non-sterile gloves must be used when staff have physical contact with patients.

- Staff must change their gloves between patients.
- Instruments or consumables that come into contact with bodily secretions must not be used on more than one patient.
- A separate syringe must be used for each drug and each patient.
- Needles must not be recapped.
- Use the proper sharp disposal systems.
- Treat all patients as if they are a high risk for transmitting infection.

3.2 TECHNIQUES

PRE-DISINFECTION

- All items must be disassembled and then covered with disinfectant (Hexanios 0.5%) for 15 minutes.

CLEANING

- After pre-disinfection, all items must be cleaned before disinfection and sterilization. Brushes should be used for tubing, etc.
- Wash all items thoroughly with Hexanios 0.5%.
- Rinse all items with water.
- Dry the item before its next use or before the disinfection or sterilization process.

DISINFECTION

- Place the item in a Hexanios solution for 15 minutes, then rinse with water.
- Dry the item before its next use.

STERILIZATION

- This process is performed in an autoclave. Please see the ICRC's Sterilization Guidelines[1] for details.

WHICH TECHNIQUE SHOULD BE USED?

The risk of contamination depends on the item and its use. As a general guide, the Spaulding classification is used; it describes three categories of risk.

CRITICAL

- The item enters sterile tissue or the vascular system.
- The item requires sterilization.

SEMI-CRITICAL

- The item will come into contact with mucous membranes and non-intact skin.
- The item requires high-level disinfection or sterilization.

NON-CRITICAL

- The item comes into contact with healthy skin only.
- The item requires cleaning and low-level disinfection.

The AAGBI (Association of Anaesthetists of Great Britain and Northern Ireland) has produced standards for the decontamination of anaesthetic equipment. You should try to meet these standards whenever possible; deviation may be acceptable in life-threatening or limb-threatening situations.

Item	AAGBI standard	Alternative suggestion
Operating theatre	Visible contamination with blood or other bodily materials must be disinfected with sodium hypochlorite (bleach) and then cleaned with detergent and water. The theatre floors should be disinfected at the end of each session.	Minimize traffic in and out of the theatre. Schedule the most heavily contaminated patients at the end of the list.
Anaesthetic machine surfaces	Low-level disinfection of all surfaces daily or immediately if visible contamination.	Wipe down with 0.05% sodium hypochlorite (1 in 10 dilution of bleach).
Ventilator	Daily decontamination is not necessary. Place a heat/moisture exchange (HME) filter on the ventilator expiratory port and change in time with the breathing circuit.	Do the same with an HME filter if possible. If not, try to clean it according to manufacturers' instructions.
Breathing circuits	Change circuits at least weekly if a new HME filter is used for every patient. Change immediately if visible contamination or an infectious case	If no HME filter is used, clean and use either autoclave or high-level disinfection between cases. Discard or change the circuit in contamination or infectious cases, in particular TB.
Catheter mounts	Single use	Clean, then high-level disinfection or boiling.
Monitoring equipment	Clean cables, probes and cuffs with a neutral pH detergent wipe between each case.	Wipe down with 0.05% sodium hypochlorite (1 in 10 dilution of bleach).
Facemasks	Single use or sterilization	Reusable: autoclave or chemical sterilization Single use: clean, then high-level disinfection or boiling.
Guedel airway	Single use	Reject if grossly contaminated. Clean, then autoclave, chemical sterilization or boiling.

Item	AAGBI standard	Alternative suggestion
Laryngeal mask airways (LMAs)	Single use	Reusable: clean, then autoclave. Can reuse up to 40 times. Single use: clean then high-level disinfection or boiling.
Endotracheal tubes	Single use	Most red rubber and silicone tubes should be autoclavable. If not, then clean, high-level disinfection or boiling.
Bougies	High-level disinfect/sterilize gum elastic bougie (GEB) up to five times or single use	Clean, then high-level disinfection or boiling.
Laryngoscope blades	Autoclave or single use	Clean, then autoclave or chemical sterilization or boiling. (N.B. Suddenly immersing hot blades in cold water can cause the fibre optic bundles to crack.)
Laryngoscope handles	Autoclave or single use	Clean, then autoclave, chemical sterilization, high-level disinfection or boiling (take the batteries out first).
Ambuvalves	Single use	Disassemble, clean, then autoclave
Syringes and needles	Single use	If the syringe or needle has come into contact with blood, discard. If the equipment has only come into contact with IV tubing (or the situation is desperate), clean, soak in sodium hypochlorite 0.5% (bleach).

Table 3.1 Standards for the decontamination of anaesthetic equipment. Source: Royal College of Anaesthetists (UK). Reproduced with kind permission.

- Sterilization and decontamination of equipment is another aspect of perioperative care for which the ICRC anaesthetist will have to assume responsibility.
- Wherever possible, recognized guidelines should be rigorously applied.

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1. ICRC, *Sterilization Guidelines*, ICRC, Geneva, 2014.
2. AAGBI, "Infection Control in Anaesthesia", *Anaesthesia*, Vol. 63, No. 9, September 2008, pp. 1027-1036.

B. ADMINISTERING ANAESTHESIA

4. RUNNING A RESUSCITATION TEAM

Irrespective of the location or the composition of the resuscitation or trauma team, human factors and non-technical skills will play an important role in the management of a critically ill casualty. A matrix for non-technical anaesthetics skills has been drawn up and covers the domains of task management, team working, situational awareness and decision making[1]; there is also a matrix for surgeons[2]. This chapter outlines ideal practice. In resource-constrained environments, individuals will need to undertake several of the roles outlined here.

4.1 BEFORE THE PATIENT ARRIVES

The ICRC team needs to understand how they will be summoned to the hospital. Use may be made of walkie-talkies, mobile telephones or even runners if team members do not live far from the hospital. Lists of names, addresses and contact details of team members should be displayed in the emergency room and operating theatre as well as in the ICRC delegation's office.

There may be no formal warning that a casualty is on the way and team members need to be attuned to signals such as explosions and/or gunfire, indicating that casualties may arrive soon. Indeed, a car horn being sounded as the casualty is driven through the hospital gate may be the only warning received.

TEAM BRIEFING[3,4]

- The team leader informs the team why they are called to action. It is important to remember that the team is likely to be multilingual and you will very rarely have an interpreter.

- This will be followed by a description of their "mental model" of the sequence of events. (A "mental model" describes someone's idea of how something works in the real world.)
- Members of the team introduce themselves.
- Roles are allocated.
- If the type of casualty is known, this is a good opportunity to remind everyone of any possible limitations to the level of care being provided (e.g. for severe burns or severe head injuries).

Team leader	• Coordinates the process • Briefs the team • Allocates tasks
Assistant	• Assists the anaesthetist by fetching drugs or equipment, for example
Person in charge of IV access/blood samples	• Secures a peripheral cannula or IO access (if required) • Takes samples for group and save, full blood count
Record-keeper	• Keeps an accurate record of observations and findings
Trauma surgeon	• Carries out surgical procedures as necessary, e.g. chest drain advice on surgical plan

Table 4.1 Team members and their roles.

PREPARING THE RESUSCITATION AREA[5]

- Equipment is checked.
- Drugs are drawn up or made readily available.
- Resuscitation room equipment (as a minimum):
  - Airway equipment: facemask, Guedel airway, bougie, Magill forceps, endotracheal tubes, laryngoscope, surgical airway kit, self-inflating bag or a Mapleson C waters' circuit, suction device, stethoscope
  - Monitoring: ECG, NIBP, Sao2, capnography
  - Vascular access: EZ-IO, cannulas
  - Anaesthetic drugs: ketamine or thiopentone, suxamethonium, midazolam or diazepam, fentanyl or morphine, oxygen
  - Other drugs: tetanus toxoid and immunoglobulin, antibiotics (see Annex 1: ICRC antibiotic protocol)

4.2 WHEN THE PATIENT ARRIVES

The patient should be handed over by the pre-hospital team in a "sterile manner" (minimal additional noise). Unless there is evidence of catastrophic haemorrhage or airway compromise, the team should stand still and listen to the handover. One suitable system for the handover of trauma casualties is "MIST"[6]:

M	Mechanism of injury or insult
I	Injury sustained
S	Signs and symptoms
T	Treatment given

In the ICRC environment the handover may very likely be carried out by a family member or a volunteer ambulance driver – usually without any medical training. It will often require the use of an interpreter, who should be involved in any team preparation at an early stage. The interpreter will probably be another member of the medical team, i.e. a member of the nursing staff.

Once the handover is complete, resuscitation should be carried out in accordance with the airway, breathing, circulation, disability and exposure system. In trauma cases, a primary survey should begin. It is important for the team to know who is leading the resuscitation as this ensures that all activities are coordinated and that *horizontal activity* (the simultaneous occurrence of all components of the primary survey; a shift from traditional teaching) is achieved, allowing a decision to be made on the next steps of treatment. In trauma the paradigm changes to <c>ABC, where <c> represents control of catastrophic haemorrhage.[7] During this time it is important for the team to communicate directly with the team leader and for noise levels to remain low.

When the primary survey or acute A-E assessment and resuscitation has been completed, the team leader should

summarizes what has taken place. This ensures that the team maintains situational awareness. A guide for the duration of this summary is a 10-second summary for 10 minutes of clinical management,[8] although shorter intervals might be required at the start of the trauma call.

Once the initial assessment and resuscitation have been completed and initial treatment commenced, a decision should take place as to the next stage of treatment and location. Depending on the facility, one of the following options will be chosen:

1. Remain in the resuscitation area for a further period of time for treatment, e.g. medical management or blood transfusion, and subsequently make a new decision.
2. Transfer to operating room.
3. Transfer to ward.
4. Transfer to a medical unit with better facilities, if available.

It is important for a decision to be made and communicated to the team.

- Human factors are increasingly recognized as crucial to safe surgery in developed nations.
- This recognition is even more relevant to the ICRC situation – maintaining a team structure requires no special resources and can be a way of offsetting latent failure.

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5. PRACTICAL RESUSCITATION

The key objective is to respect <c>ABC principles to manage the lethal triad of acidosis, coagulopathy and hypothermia. <c>ABC refers to control of massive external haemorrhage <c> followed by airway, breathing and circulation.

Resuscitation is not a "stand alone" procedure but part of a damage control philosophy which dictates early control of haemorrhage and wound contamination. It is contemporaneous with damage control surgery, the objective being to restore physiology, deferring definitive wound repair until later. The particular challenges for the ICRC practitioner in a resource-constrained environment are the restrictions resulting from the following:

1. Non-availability or restricted supplies of blood and blood products.
2. Limited equipment to assist with resuscitation techniques, e.g. pressurized fluid infusions, patient warming, etc.

ICRC patients are often self-selecting, many of them having travelled large distances from the point of injury. However, recent conflicts have demonstrated that catastrophic incidents do occur at the hospital's "front door". Two points are of immediate importance:

1. Delayed patients will often be severely dehydrated and will respond to, and benefit from, intravenous crystalloid infusion prior to anaesthesia and surgery.
2. The immediate injured can receive life-saving intervention by:
    a) Tranexamic acid – 1 gram given IV within 3 hours of injury, followed (if practical) by 1 further gram given over 8 hours.
    b) Control of massive external limb haemorrhage by tourniquet. Traditionally, the ICRC has rejected the application of tourniquets because of the disadvantages. Indeed, tourniquets applied to delayed

injuries or for prolonged periods have led to significant morbidity. However, when faced with an exsanguinating casualty, military experience has clearly demonstrated a survival benefit. It is appropriate to acknowledge that a tourniquet is only necessary when pressure dressings are failing or patently non-applicable at the outset. The staff member applying a tourniquet should have received appropriate training in the technique. Once a tourniquet is applied, the casualty needs to get to medical care quickly as the longer the tourniquet remains in place, the higher the risk of damage to the limb. The time at which the tourniquet is applied must therefore be recorded. Two hours is often stated as the maximum time a tourniquet can be left in place. However, the actual time to limb damage can be much shorter, depending on the extent of the injury and the condition of the limb before the injury.

c) Likewise, faced with the possibility of a pelvic fracture, the application of an improvised pelvic binder will minimize the potential for continued bleeding. N.B. Long bone fractures must be splinted to reduce further blood loss.

5.1 AIRWAY (SEE CHAPTER 8)

In the obtunded patient with a blunt injury above the level of the clavicles, the airway is managed with consideration given to a potential cervical spine injury. Concern over a possible cervical spine injury *must never* detract from the act of establishing an airway by whatever means necessary.

When simple airway manoeuvres, adjuncts and/or endotracheal intubation fail to secure the airway, the ICRC's standard position is surgical cricothyroidotomy with a cuffed tracheostomy tube or appropriately sized/cuffed ET tube.

5.2 BREATHING

In modern trauma anaesthesia or intensive care, considerable resources are applied to managing a casualty's

respiratory status and/or complications. In a typical ICRC environment, the advanced techniques are likely to include needle decompression and subsequent intercostal tube drainage of tension pneumothorax or large simple pneumothoraces. Analgesia for chest injury may include intercostal local anaesthesia blocks.

Prolonged post-operative ventilation will very rarely be an option and this consideration will influence difficult treatment decisions.

5.3 CIRCULATION

The largest adverse factor is the difficulty of organizing and administering a blood transfusion. The rationale of transfusion in an ICRC setting is to sustain the minimally acceptable oxygen carriage – not to restore normal haemoglobin values.

When blood is in limited supply, crystalloid resuscitation must proceed carefully as large volumes of saline can produce acidosis and will dilute critical clotting factors. Use Ringers lactate, which is available in ICRC hospital projects. Less is more – titrate to a radial pulse. This approach (permissive hypotension) is acceptable for a short period (there is evidence to support use for up to an hour) before surgical control of haemorrhage. The exception is head injury, where it is important to maintain normotension and hence cerebral perfusion pressure. Circulatory access may require intraosseous techniques which are described in Chapter 9.

5.4 DISABILITY AND EXPOSURE/ ENVIRONMENT

Even in hot climates hypovolaemic patients will become hypothermic and the lethal triad "initiated". Warm the patient by every means possible – including covering all parts of the patients which are not included in the surgical field and warming intravenous fluids (put the intravenous drip tubing into a bottle of warm water or saline, pre-warm fluid in a bucket of hot water). If there are ways to increase the ambient temperature of a cold operating room, do so.

5.5 RESUSCITATION OUTCOMES

Where possible, aim to monitor blood pressure, pulse rate, temperature and capillary refill. If measuring urine output, the target is 0.5-1 ml/kg/hour. After surgery, careful attention should be paid to the patient's level of consciousness; in the absence of pain or hypoxia, confusion and/or agitation are classic signs of hypovolaemia.

- Resuscitation is one aspect of the damage control philosophy that will often be an inherent part of ICRC surgery.
- In treating the lethal triad, ICRC anaesthetists will need to be prepared to adjust the accepted management of <c>ABC.

References

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6. FASTING RULES

In this environment, assessing fasting time in patients can be difficult, especially in breast-fed babies. Make things very clear to your interpreter – in some cultures, people who are asked when they last ate will not consider a small snack or a bowl of gruel as being "eating"! Standard guidelines are set out below.[1]

6.1 ADULTS

Elective surgery – the "2-6 rule"

- Water and other clear fluids: up to 2 hours before induction of anaesthesia.
- Food (solids, milk and milk-containing drinks): up to 6 hours before induction.
- Consider further interventions for patients at higher risk of regurgitation and aspiration.

Post-operative resumption of oral intake in healthy adults

- Patients should be encouraged to drink when ready, provided that there are no contra-indications.

6.2 CHILDREN

Preoperative fasting in children undergoing elective surgery – the "2-4-6 rule"

- Water and other clear fluids: up to 2 hours before induction of anaesthesia.
- Breast milk: up to 4 hours before induction.
- Formula milk, cow's milk or solids: up to 6 hours before induction.
- Consider further interventions for children at higher risk of regurgitation and aspiration.

Post-operative resumption of oral intake in healthy children:

- Oral fluids can be offered to children when they are fully awake after anaesthesia, provided that there are no contra-indications.

Emergency surgery, trauma, vomiting and bowel obstruction: treat as full stomach and use rapid sequence induction of anaesthesia (RSI) if general anaesthetic is required.

Realistically, most acutely war-injured patients will need an RSI.

- Fasting guidelines require careful management to ensure that they are not misinterpreted in the prevailing cultural context!

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7. ANAESTHESIA IN THE ICRC ENVIRONMENT

7.1 OVERVIEW

Anaesthetists working within the ICRC environment are likely to have to deal with problems and situations that are far removed from those experienced in conventional hospital practice. The following is a set of principles that lay the foundation for more specialized material presented later in this handbook.

Greater flexibility is required of anaesthetists of working in austere conditions. More importantly, they will also need to go back to the basic principles of anaesthesia and decide what is really important and appropriate in each situation.

PREPARATION

The ICRC environment is no place for the ill-prepared. This handbook highlights the fact that anaesthetists must be fully trained, registered specialists with a licence to practice (see Chapters 1 and 2). Moreover, anaesthesia cannot be conducted without a minimum of apparatus, drugs, patient monitoring and recording.

TEAM STRUCTURE

ICRC anaesthetists will need to develop a very close working relationship with their surgical counterparts. In turn, surgeons will need a good working knowledge of basic anaesthetic considerations. This relationship can be optimized by constant adherence to the WHO safety checklist and respect for principles of human factors in general.

CONVENTIONAL CLINICAL STANDARDS VS REALITY

There will be occasions when environmental or logistical considerations will require that "gold standard" clinical care may need to be abbreviated or ignored, e.g. giving a spontaneously breathing anaesthetic for a head injury. While this

may be regarded as an extreme example, other issues occur frequently. In particular, post-operative care must be in line with operative delivery and this imposes restrictions on extensive surgical procedures that would otherwise require post-operative ventilation or other prolonged critical care.

CHOICE OF ANAESTHESIA

For good pharmacological and practical reasons, the ICRC has traditionally regarded ketamine as the general anaesthetic of choice. That philosophy is upheld in this handbook but attention is also drawn to the increasing role of regional anaesthesia in acute trauma. The use of ultrasound for peripheral nerve blocks has extended regional options beyond the conventional concept of "regional means spinal". Like spinals, peripheral nerve blocks have the advantage of "built-in" post-operative analgesia.

Spinal and regional anaesthesia must always be conducted with the same attention to detail and monitoring as for general anaesthesia.

CONCLUSION

ICRC work will often entail difficulties that far exceed those faced by anaesthetists working in a teaching hospital or the equivalent in their own countries. Their clinical expertise has to be combined with a careful appreciation and analysis of the context in which they are working.

- Ketamine has traditionally been the anaesthetic of choice for the ICRC. It is still of central importance but there is increasing appreciation of the potential to expand regional techniques.

Further reading

1. Coupland, R.M., "Epidemiological approach to surgical management of the casualties of war", *British Medical Journal*, Vol. 308, June 1994, pp. 1693-1697.
2. Redmond, A., *et al.* (eds), *ABC of conflict and disaster*, BMJ Books, Blackwell Publishing Ltd., 2006.

3. Giannou, C., and Baldan, M., *War surgery*, Vol. 1, ICRC, Geneva, 2009.

7.2 KETAMINE

The ICRC has designated ketamine as the anaesthetic of choice for major surgery in conditions in which limited resources are available.[1]

ADVANTAGES

- Deemed to be a "safe drug" in comparison to other induction agents, ketamine can be administered intravenously or intramuscularly.
- It causes a state of dissociative anaesthesia in which both amnesia and profound analgesia are delivered.
- Under ketamine, the eyes may remain open, airway reflexes are relatively intact and infrequent purposeful movements, not associated with painful stimulus, may be made.[2]
- Unlike most other induction agents, Ketamine has a unique set of cardiovascular effects, which include an increase in:
  - blood pressure;
  - heart rate; and
  - subsequent cardiac output.

  These effects can be very useful in the haemodynamically compromised patient.[2]
- Swallow, cough, sneeze and gag reflexes remain intact.
- Ketamine is a bronchodilator and can be used as part of the treatment for status asthmaticus.[3]

DISADVANTAGES

Two key disadvantages

- Ketamine can be associated with excessive salivation, which can be particularly problematic in paediatric cases. This effect can be offset by premedication with glycopyrrolate or atropine, or simply by gentle suction at the corner of the mouth.
- It has the propensity to cause vivid dreams and hallucinations[2,4]; to offset these, a benzodiazepine can also be administered.

Other disadvantages

- In the limited-resource environment, some problems may occur that are related to the use of benzodiazepines:
  - Respiratory depression: where recovery facilities are limited, caution should therefore be exercised.
  - Midazolam may be available in ICRC-supported hospitals with deployed war surgery kits. Diazepam may also be available but is extremely painful when given intravenously; it should be well diluted to prevent thrombophlebitis and preferably given after ketamine. Both midazolam and diazepam may be subject to locally controlled drug procedures.
  - It is possible to use ketamine without benzodiazepines but there is then an increased incidence of hypertension, movement and hallucinations.
- Laryngeal mask airways (LMAs) are rarely available in ICRC environments and should not be used with ketamine, as airway reflexes are maintained.
  - Cases in which surgery lasts less than an hour can be managed with ketamine and a spontaneously breathing patient without any airway adjunct, while cases lasting more than an hour should be intubated.
- Ketamine is generally safe to use for people who have essential hypertension. However, ketamine should be avoided for people who are hyperthyroid or taking supplemental thyroxine as, in such cases, ketamine will worsen hypertension.
- Ketamine should be avoided for patients with schizophrenia or other delusional disorders as there is some evidence that it makes these disorders worse.
- Ketamine should be administered carefully in ischaemic heart disease because of the induced hypertension and tachycardia.
- When using ketamine for a caesarean section, it should be borne in mind that it crosses the placenta and that newborns may have residual effects resulting from its use. Prior preparation for potential newborn resuscitation is therefore advised if ketamine is used.

- Traditionally, ketamine was avoided in cases of head injuries owing to fears of increases in intracranial pressure (ICP). However, recent evidence, particularly with regard to traumatic head injury, has shown that, overall, ketamine has benefits in use for head-injured patients. The effect of maintaining blood pressure and therefore cerebral perfusion pressure outweighs any small transient rise in ICP.[5]

PRESENTATION

- Ketamine was initially presented as a racemic mixture. The *R*(-) optical isomer is believed to be responsible for many of the drug's unwanted effects.
- Ketamine in its purely *S*(+) optical isomeric is becoming widely available. The *S*(+) form is more potent and has a faster recovery time than the original form, allowing for lower doses with reduced psychological side effects.[2]
- If *S*(+) ketamine is used, approximately half the dose of the racemic mixture should be used.
- Whenever ketamine is used, it is crucial that the vial be checked for the type of ketamine and the concentration presented (10, 50, 100 mg/ml formulations) and the appropriate dose be calculated.

CONCLUSION

Ketamine has been shown to have several benefits in limited-resource environments. These include ease of administration, maintenance of airway control and provision of both anaesthesia and profound analgesia. Furthermore, in exceptional circumstances the use of ketamine allows the anaesthesia-provider to be freed up for other duties.[1,3,4,6]

- Ketamine is an essential drug as defined by WHO.
- The ICRC regards ketamine as the general anaesthetic of choice.
- Ketamine is unique in providing dose-related profound analgesia and/or general anaesthesia.
- The drug has a high safety profile in both adult and paediatric populations and "emergence" issues are readily managed with benzodiazepines.

KETAMINE REGIMES

Table 7.1 provides examples of recommended regimes for the use of ketamine in disaster-affected areas.

Delivery (based on required duration)	Regime examples
Induction and bolus maintenance for short procedures	Ketamine – either IM or IV – is the anaesthesia of choice for short procedures.[4] **IV ketamine recipes** • Ketamine 1-2 mg/kg IV: produces dissociative anaesthesia; patient maintains own airway.[6,9] • Midazolam 5 mg or diazepam 2-5 mg IV with a small dose of morphine IV, followed by ketamine 80-100 mg IV (1-2 mg/kg) as a slow IV bolus over at least 20 seconds. – Intermittent boluses of ketamine IV, one-quarter of the induction dose, every 15 minutes. – Doses of benzodiazepines or opioids added as necessary in response to increasing vocalization or purposeful movements with surgical stimuli.[7] • Midazolam 0.07mg/kg IV, followed 2 minutes later by ketamine 1 mg/kg IV.[8] **IM ketamine recipes** • Bolus dose of ketamine 4-6 mg/kg IM, depending on depth of anaesthesia required.[1,8] This may be very useful in a mass casualty scenario. • Ketamine 10 mg/kg IM with anaesthesia given over 5-10 minutes for surgery lasting 12–25 minutes.[9] **IV ketamine recipe for sedation in short procedures** • For very short procedures such as changing burns dressings or splinting trapped limbs using 10 mg/ml IV boluses of 10-20 mg (1-2 ml) ketamine.[9]
IV infusions bags	• "The ICRC way": ketamine infusion (0.5 mg/ml ketamine in 1 litre of normal saline) titrated to effect following IV ketamine bolus induction.[4] • Ketamine infusion (500 mg ketamine in 500 ml dextrose or saline). Via a standard 15 drop/ml non-micro chamber, drip initiated at 2 drops/kg/min until an adequate level of anaesthesia is attained (usually takes 2 minutes). Drip rate is then reduced to 1 drop/kg/min. Patients will awaken 10 minutes after the drip is stopped.[1]
Analgesia	• Ketamine doses of less than 1 mg/kg IV.[1] • Ketamine as an IV infusion should be dosed at 60-180 mcg/kg/hr. For an adult, put 50 mg in a 500 ml bag of saline and administer at 40-80 mls/hr. • Ketamine 0.5 mg/kg IM.[8]
IM: intramuscular **IV:** intravenous	

Table 7.1 Ketamine induction and maintenance regimes recommended for use in disaster-affected areas.

References

1. Mellor, A.J., "Anaesthesia in austere environments", *Journal of the Royal Army Medical Corps,* Vol. 151, 2005, pp. 272-276.
2. Pai, A., Heining, M., "Ketamine", *Continuing Education in Anaesthesia, Critical Care & Pain*, Vol. 7, No. 2, April 2007, pp. 59-63.
3. Mahoney, P.F., McFarland, C.C., "Field anaesthesia and military injury", in C.E. Smith (ed.), *Trauma Anesthesia*, Cambridge University Press, Cambridge, 2008, pp. 343-359.
4. Giannou, C., and Baldan, M., *War Surgery,* Vol. 1, ICRC, Geneva, 2009, pp. 305-314.
5. Filanovsky, Y., Miller, P., and Kao, J., "Myth: ketamine should not be used as an induction agent for intubation in patients with head injury", *Canadian Journal of Emergency Medicine,* Vol. 12, 2010, pp. 154-157.
6. Read, D., Ashford, B., "Surgical aspects of Operation Bali Assist: initial wound surgery on the tarmac and in flight", *ANZ Journal of Surgery*, Vol. 74, No. 11, November 2004, pp. 986-991.
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8. Grande, C.M., *et al.*, "Trauma anesthesia for disasters: Anything, anytime, anywhere", *Critical Care Clinics*, Vol. 7, No. 2, May 1991, pp. 339-361.
9. Hopperus Buma, A.P.C.C., *et al.* (eds), *Conflict and Catastrophe Medicine: A Practical Guide*, Springer, London, 2002.

8. AIRWAY MANAGEMENT TECHNIQUES

When limited resources are available, it is important to ensure that basic airway manoeuvres are performed well. When managing an acutely unwell patient with airway compromise, basic manoeuvres to open the airway include the following:

- Head tilt and chin lift (if no concerns about cervical spine injury);
- Jaw thrust;
- Good head position, achieved by combining lower cervical spine flexion, head extension at the atlanto-occipital joint, and positioning the ears anterior to the sternum ("sniffing the morning air").

To maintain a patent airway a number of devices can also be used:

- Oropharyngeal airway (Guedel airway);
- Nasopharyngeal airway;
- Laryngeal mask airway;
- Endotracheal tube, if indicated.

8.1 WHEN IS A SECURE AIRWAY (ENDOTRACHEAL INTUBATION OR A SURGICAL AIRWAY) NEEDED?

It is important to differentiate between "ideal" practice and the realities of a resource-constrained austere environment.

The limits placed on care and likely triage decisions need to be worked through by the team in advance as this will vary from one deployment to another.

There is unlikely to be access to post-operative or intensive care ventilation and even if the machine is available, the personnel who know how to use it may not be there.

Oxygen may not be available 24 hours a day since power is needed for oxygen concentrators. The safety of stored oxygen in a war zone is a major concern. Oxygen stored in cylinders or manifolds can add to the explosive potential of any live ammunition.

Intubation should only be carried out if there is a clear, short-term, reversible problem or the opportunity to transfer the patient to another, better equipped, facility, e.g. respiratory arrest secondary to drugs would be intubated but respiratory arrest secondary to pneumonia or COPD would not. Head injuries may be intubated if they can be transferred to an appropriate centre or burr holes can be made at the receiving facility; otherwise they are managed with simple airways (even if the GCS is less than 8).

Unstable mandible/maxillary fractures or other upper airway compromise may be intubated initially but the patient must then undergo tracheostomy or cricothyroidotomy followed by tracheostomy.

A large flail chest segment would be intubated in a Western hospital but it is likely that in an austere environment, no more than intercostal blocks and CPAP are used. CPAP machines are unlikely to be available in the ICRC setting and anaesthetists are therefore advised to consider alternative methods that would allow a CPAP effect to be achieved.

Oropharyngeal burns would only be intubated in the short term, prior to tracheostomy.

8.2 GENERAL PRINCIPLES FOR IMPROVING AIRWAY MANAGEMENT

- Train your assistants *before* they have to manage a difficult airway. Check what equipment is available, teach them what each item is for and rehearse the process so they know what to pass to you and when. If intubation is likely, rehearse the procedure for RSI, including use of the bougie and the process for managing a failed intubation.

- Undertake appropriate airway assessment and planning if difficulty is predicted. This should not be restricted to assessing only the ease of laryngoscopy and endotracheal intubation. It must also evaluate the ease/difficulty of bag mask ventilation, supraglottic airway ventilation and performing a surgical airway.
- Positioning (see above: Airway management techniques).
- Preoxygenation, for three minutes. Most preoxygenation will be performed through a drawover circuit using an oxygen concentrator. The best concentrators currently have a maximum output of 8 l/min; if vital capacity breathing is used with this system, preoxygenation cannot be performed effectively.
- Maintain oxygenation with mask ventilation if difficult intubation is encountered.
- Plan for anticipated and unanticipated difficult airway, including use of supraglottic airways[1] and front–of-neck surgical access.[2]

8.3 SURGICAL AIRWAYS

The need for a surgical airway should be identified at an *early* stage and performed *quickly*. This may be the primary airway (e.g. with maxillo-facial injuries, wounds to the neck involving the larynx or pharynx or haematoma accumulation) or following failure of endotracheal intubation.

Cricothyroidotomy is preferred to tracheostomy in emergency situations as it is generally quicker and there is less risk of complications such as bleeding.

8.4 ELECTIVE OR SEMI-ELECTIVE AIRWAY MANAGEMENT

There are four basic ventilation techniques that may be used alone or in combination in order to ensure adequate gas exchange:

1. Bag mask ventilation (BMV);
2. Endotracheal tube and positive pressure ventilation;
3. Supraglottic airway devices (laryngeal mask airway) and spontaneous ventilation;
4. Surgical airways.

- Airway management follows established principles but careful consideration must be given to the post-operative course as prolonged ventilation will rarely be an option.
- Surgical cricothyroidotomy is the definitive emergency airway when endotracheal intubation is not possible.

References

1. Giannou, C., and Baldan, M., *War Surgery,* Vol. 1, ICRC, Geneva, 2009.
2. Open Anesthesia (website), *Encyclopedia: Airway Management (Anesthesia Text),* 2015, available at https://www.openanesthesia.org/airway_management_anesthesia_text/#RSI_and_Airway_Safety

9. VASCULAR AND INTRAOSSEOUS ACCESS

9.1 VASCULAR ACCESS

Vascular access is crucial for:

- fluid or blood product resuscitation;
- delivery of medication, which includes anaesthetic drugs for induction and infusions for anaesthesia maintenance;
- fluid maintenance.

ICRC kits include the equipment for peripheral venous cannulation, intraosseous access and venous cut-down.

Central venous access has limited use in austere environments because:

- personnel lack the skills to handle it correctly;
- many drugs which normally need central delivery (e.g. noradrenaline) are not available in the field;
- parenteral feeding is not available on most deployments.

A number of peripheral gauges are included in the kits.

9.2 INTRAOSSEUS ACCESS

Intraosseous (IO) access has become a quick and effective mode of attaining early access for delivery of drugs, fluid and blood product boluses until intravascular (IV) access is successfully achieved. IO should be considered in the trauma or resuscitation scenario if IV access is considered to be too difficult or initial attempts have failed. The standard ICRC kit currently includes the IO drill that is often referred to by its commercial name, "EZ-IO" (EZ-IO® Teleflex).

Figure 9.1 An IO drill (EZ-IO). Source: Teleflex. Reproduced by permission.

An EZ-IO can be sited in the proximal humerus, the proximal tibia, the distal tibia or the distal femur, the first two being the preferred sites. In adults, the proximal humerus is the primary site, whereas in small children or infants, the proximal tibia is preferred, and the distal tibia or distal femur may be considered.

- The EZ-IO needle is 15 gauge and comes in three different needle lengths:
  - 15 mm (pink hub: 3-39 kg weight range)
  - 25 mm (blue hub: 40 kg or over)
  - 45 mm (yellow hub: 40 kg or over and excessive soft tissue).
- The EZ-IO catheter is marked with a black line 5 mm from the hub.
  - If the EZ-IO needle is inserted through the soft tissue and does not reach the bone or the 5 mm needle mark from the hub is not visible above the skin, a longer needle or alternate site should be chosen prior to penetration of the bone cortex.
- Adults
  - A 45 mm needle is recommended for the proximal humerus site in most adults.
  - A 25 mm needle is used for tibial access.

- Once inserted, the IO access may remain in situ for a maximum of 72 hours; best practice is to have it removed once sufficient, stable IV access has been established.
- The aspirated marrow from the IO access can be used for blood tests and group and save sampling.
- To achieve adequate flow through an IO access, the infusion needs to be pressurized. This may be achieved by injecting fluid boluses through a syringe or applying pressure bags to IV infusions.
- Infusions through IO access can be very painful. See Teleflex's recommended anaesthetic regime to address this issue (see Table 9.2 below).

- Fracture in targeted bone
- Excessive tissue or absence of adequate anatomical landmarks
- Infection in the area of the insertion site
- Previous, significant orthopaedic procedure at the site (e.g. prosthetic limb/joint)
- IO access in targeted bone in the past 48 hours

Table 9.1 Contraindications for the EZ-IO intraosseous infusion system

1. Prime EZ-Connect extension set with lidocaine.
2. Note that the priming volume of the EZ-Connect is approximately 1.0 ml.
3. If primed with 1% preservative-free lidocaine, this will be approximately 10 mg. If primed with 2% preservative-free lidocaine, this will be approximately 20 mg.
4. Slowly infuse 40 mg of lidocaine IO over 120 seconds (2 minutes).
5. Allow lidocaine to dwell in IO space 60 seconds (1 minute). Flush the IO catheter with 5 to 10 ml of normal saline.
6. Flush the IO catheter with 5 to 10 ml of normal saline.
7. Slowly administer an additional 20 mg of lidocaine IO over 60 seconds (1 minute).
8. Repeat PRN for pain.
9. Consider systemic pain control for patients not responding to IO lidocaine.

Recommended anaesthetic for infants and children (and those weighing less than 80 kg) responsive to pain

10. 1% and 2% preservative-free and epinephrine-free lidocaine.
11. The usual initial dose is 0.5 mg/kg; not to exceed 40 mg.
12. Prime EZ-Connect extension set with lidocaine.
13. Note that the priming volume of the EZ-Connect is approximately 1.0 ml.
    - If primed with 1% preservative-free lidocaine, this will be approximately 10 mg.
    - If primed with 2% preservative-free lidocaine, this will be approximately 20 mg.
14. Slowly infuse lidocaine IO over 120 seconds (2 minutes).
15. Allow lidocaine to dwell in IO space 60 seconds (1 minute).
16. Flush the IO catheter with 2 to 5 ml of normal saline.
17. Slowly administer subsequent lidocaine (half the initial dose: 0.25 mg/kg) IO over 60 seconds (1 minute).
18. Repeat PRN for pain.
19. Consider systemic pain control for patients not responding to IO lidocaine.

Source: Teleflex. Reproduced by permission.

Table 9.2 Recommended anaesthetic for adult patients responsive to pain 1% and 2% preservative-free and epinephrine-free lidocaine.

Complications are rare:

- Extravasation of fluid is the most common complication with IO infusions.
- Compartment syndrome can result if a large extravazation goes undetected. Surgical intervention may be required.
- Osteomyelitis is a rare but serious infection.

MEDICATIONS THAT CAN BE INFUSED VIA THE INTRAOSSEOUS ROUTE

Most medication or fluid infused via a peripheral IV route can be safely infused through the intraosseous route. As with intravenous drug infusions, incompatible drugs and fluids should be infused sequentially. Figure 9.2 is a list of drugs that can be used safely.

- Adenosine (e.g. Adenocard)
- Albumin
- Alfentanil (e.g. Alfenta)
- Aminophylline
- Amiodarone (e.g. Cordarone)
- Ampicillin
- Anascorp (scorpion antivenin)
- Anesthetic agents
- Antibiotics (multiple)
- Antitoxins (various)
- Atracurium besylate (e.g. Tacrium)
- Atropine
- Azactam (e.g. Aztreonam)
- Blood and blood products
- Calcium chloride
- Calcium gluconate
- Cefepime hydrochloride (e.g. Maxipime)
- Ceftriaxone (e.g. Rocephin)
- Contrast media (e.g. Omnipaque)
- Dexamethasone (e.g. Decadron)
- Dextran
- D5 ½ NS
- Dextrose 10%
- Dextrose 25%
- Dextrose 50%
- Diazepam (e.g. Valium)
- Diazoxide (e.g. Hyperstat)
- Digoxin (e.g. Lanoxin)
- Diltiazem (e.g. Cardizem)
- Diphenhydramine (e.g. Benadryl)
- Dobutamine hydrochloride (e.g. Dubutrex)
- Dopamine
- Ephedrine
- Epinephrine
- Esmolol (e.g. Brevibloc)
- Etomidate
- Fentanyl
- Fluconazole (e.g. Diflucan)
- Flumazenil (e.g. Romazicon)
- Fosphenytoin (e.g. Cerebyx, Prodilantin)
- Furosemide (e.g. Lasix)
- Gentamycin
- Haloperidol (e.g. Haldol)
- Heparin
- Hydroxo-cobalamin (B12)
- Hydropmorphone (e.g. Dilaudid)
- Insulin
- Isoprenaline (e.g. isoproterenol, Isuprel)
- Ketamine
- Labetalol (e.g. Normodyne)
- Levetiracetam (e.g. Keppra)
- Lidocaine (e.g. Xylocaine)
- Linezolid (e.g. Zyvox)
- Lorazepam (e.g. Ativan)
- Magnesium sulphate
- Mannitol
- Methyl-prednisolone (e.g. Solu-Medrol)
- Metoprolol (e.g. Lopressor)
- Midazolam (e.g. Versed)
- Mivacurium (e.g. Mivacron)
- Morphine sulphate
- Nalbuphine (e.g. Nubain)
- Naloxone (e.g. Narcan)
- Neostigmine (e.g. Prostigmin)
- Nitroglycerin
- Nitroprusside (e.g. Nipride)
- Norcuron
- Norepinephrine (Levarterenol, Levophed)
- Normal saline
- Odansetron (e.g. Zolfran)
- Pancuronium (e.g. Pavulon)
- Paracetanol (e.g. acetaminophen)
- Phenobarbital
- Phenylephrine (e.g. Neo-Synephrine)
- Phenytoin (e.g. Dilantin)
- Piperacillin (e.g. Zosyn)
- Plasmanate
- Potassium chloride
- Promethazine (e.g. Phenergan)
- Propofol (e.g. Diprivan)
- Propranolol (e.g. Inderal)
- Remifentanil (e.g. Ultiva)
- Ringer's lactate
- Rocuronium (e.g. Zemuron)
- Sodium bicarbonate
- Standard IV solutions
- Succinylcholine (e.g. Anectine)
- Tenectaplase (e.g. TNKase)
- Thiamine
- Tiopental (e.g. Pentothal)
- Tobramycin sulphate
- Vancomycin
- Vasopressin (e.g. Pitressin, Argipressin)
- Vecuronium

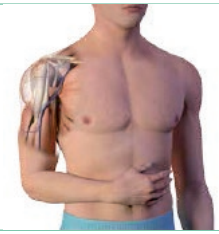
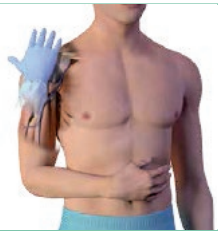
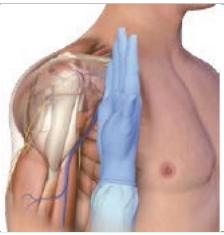
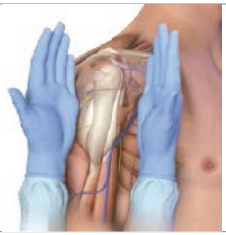
Figure 9.2 Safe drugs for use in anaesthetics. Source: Teleflex at http://www.teleflex.com/en/usa/ezioeducation/index.html

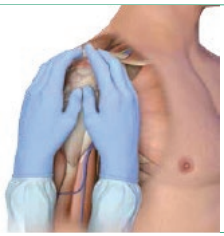
IDENTIFICATION AND INSERTION TECHNIQUES

The following set of diagrams illustrate the anatomical landmarks and insertion techniques, i.e. for the following locations:

- Proximal humerus (Figure 9.3);
- Proximal tibia (Figure 9.4);
- Distal tibia (Figure 9.5);
- Distal femur (Figure 9.6).

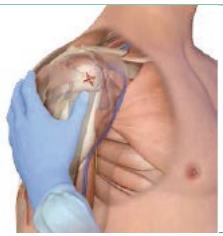
Ez-io proximal humerus identification and insertion technique Identify the proximal humerus:

	
Place the patient's hand over the abdomen (elbow adducted and humerus internally rotated).	Place your palm on the patient's shoulder anteriorly. • The area that feels like a "ball" under your palm is the general target area. • You should be able to feel this ball, even on obese patients, by pushing deeply.
	
Place the ulnar aspect of one hand vertically over the axilla.	Place the ulnar aspect of the opposite hand along the midline of the upper arm laterally.



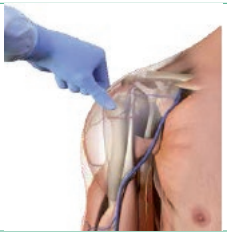
Place your thumbs together over the arm.

- This identifies the vertical line of insertion on the proximal humerus.



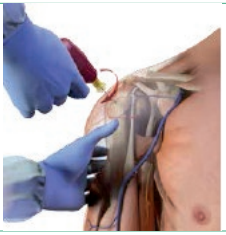
Insertion:

- Prepare the site by using antiseptic solution of your choice (e.g. Chlorhexidine).
- Remove the needle cap.
- Aim the needle tip downwards at a 45-degree angle to the horizontal plane. See Figure 10. The correct angle will result in the needle hub lying perpendicular to the skin.



If necessary, for further confirmation, locate the inter-tubercular groove:

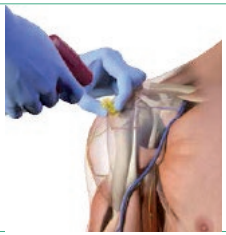
- With your finger on the insertion site, keeping the arm adducted, externally rotate the humerus 90-degrees. You may be able to feel the intertubercular groove.
- Rotate the arm back to the original position for insertion. The insertion site is 1-2 cm lateral to the intertubercular groove.



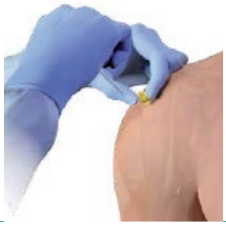
Insertion:

- Prepare the site by using antiseptic solution of your choice (e.g. Chlorhexidine).
- Remove the needle cap.

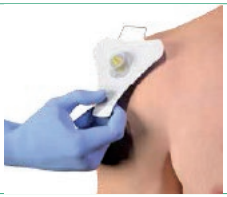
Aim the needle tip downwards at a 45-degree angle to the horizontal plane. See Figure. The correct angle will result in the needle hub lying perpendicular to the skin.



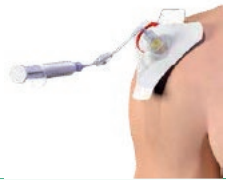
- Hold the hub in place and pull the driver straight off. See Figure.
- Push the needle tip through the skin until the tip rests against the bone.
- The 5mm mark from the hub must be visible above the skin for confirmation of adequate needle length.
- Gently drill into the humerus 2 cm or until the hub reaches the skin in an adult. Stop when you feel the "pop" or "give" in infants and children. Avoid recoil by actively releasing the trigger when you feel the needle set enter the medullary space – do NOT pull back on the driver when releasing the trigger.



- Continue to hold the hub while twisting the stylet off the hub with counterclockwise rotations. See Figure. The needle should feel firmly seated in the bone (1st confirmation of placement.
- Place the stylet in a sharps container.

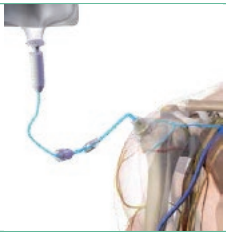


- Place the EZ-Stabilizer dressing over the hub.



- Attach a primed EZ-Connect extension set to the hub, firmly secure by twisting clockwise. See Figure.

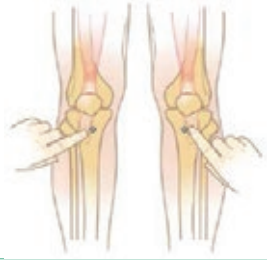
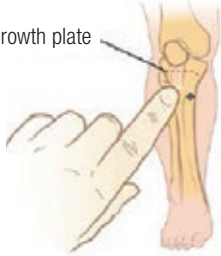
- Aspirate for blood/bone marrow (2nd confirmation of placement). See Figure.



- Flus the IO catheter with normal saline (5-10 ml adults; 2-5 ml for infants and small children).
- Connect fluids if ordered; infusion may need to be pressurized to achieve desired rate.
- Secure the arm in place across the abdomen.

Figure 9.3 Proximal humerus. Source: Teleflex. Reproduced by permission.

Proximal tibia

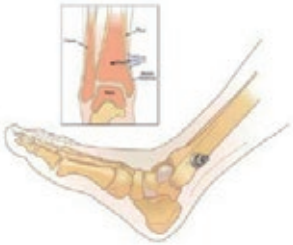
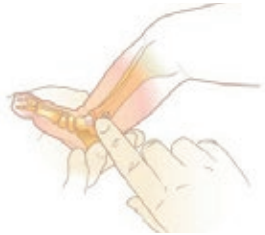
Proximal tibia insertion site identification – Adults	**Proximal tibia insertion site identification – Newborns, infants and small children**
Extend the leg. Insertion site is approximately 3 cm (2 finger widths) below the patella and approximately 2 cm (1 finger width) medial, along the flat aspect of the tibia. See Figure.	Extend the leg. Insertion site is located just below the patella, approximately 1 cm (1 finger width) and slightly medial, approximately 1 cm (1 finger width) along the flat aspect of the tibia. Pinch the tibia between your fingers to identify the centre of the medial and lateral borders. See Figure.
	

EX-IO priximal tibia insertion technique:

- Prepare the site with antiseptic (e.g. chlorhexidine) of your choice.
- Use a clea “no touch” technique.
- Remove the needle set cap.
- Stabilize the extremity.
- Aim the needle set at a 90-degree angle to centre of the bone.
- Push the needle tip through the skin until the tip rests against the bone.
- The 5 mm mark from the hub must be visible above the skin for confirmation of adequate needle set length.
- Gently drill, advancing the needle set approximately 1-2 cm after entry into the medullary space or until the needle set hub is close to the skin.
- Infants and small children: Gently drill, immediately release the trigger when you feel the “pop” or “give” as the needle set enters the medullary space.
- Do not pull/jerk back (recoil) on the driver when releasing the trigger.
- Hold the hub in place and pull the driver straight off needle set.
- Continue to hold the hub while twisting the stylet off the hub with counterclockwise rotations.
- The catheter should feel firmly seated in the bone (1st confirmation of placement)
- Place the stylet in a sharps container.
- Place the EZ-Stabilizer dressing over the hub.
- Attach a primed EZ-Connect extension set to the hub, firmly secure by twisting clockwise.
- Pull the tabs off the EZ-Stabilizer dressing to expose the adhesive, apply to the skin.
- Aspirate for blood/bone marrow. (2nd confirmation of placement)
- Flus the IO catheter with normal saline (5-10 ml adults; 2-5 ml for infants and small children).
- Connect fluids if ordered, infusion may need to be pressurized to achieve desired rate.

Figure 9.4 Proximal tibia. Source: Teleflex. Reproduced by permission.

Distal tibia

Distal tibia insertion site identification – Adults	Distal tibia insertion site identification – Newborns, infants and small children
Insertion site is located approximately 3 cm (2 cm finger widths) proximal to the most prominent aspect of the medial malleolus. Palpate the anterior and posterior borders of the tibia to assure that your insertion site is on the flat centre aspect of the bone. See Figure.	Insertion site is located approximately 1-2 cm (1finger width) proximal to the most prominent aspect of the medial malleolus. Palpate the anterior and posterior borders of the tibia to assure that your insertion site is on the flat centre aspect of the bone. See Figure.
	

EZ-IO distal tibia insertion technique:

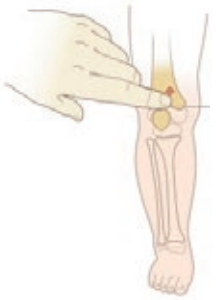
- Prepare the site with antiseptic (e.g. chlorhexidine) of your choice.
- Use a clean "no touch" technique.
- Remove the needle set cap.
- Stabilize the extremity.
- Aim the needle set at a 90-degree angle to centre of the bone.
- Push the needle tip through the skin until the tip rests against the bone.
- The 5 mm mark from the hub must be visible above the skin for confirmation of adequate needle set length.
- Gently drill, advancing the needle set approximately 1-2 cm after entry into the medullary space or until the needle set hub is closed to the skin.
  - Infants and small children: Gently drill, immediately release the trigger when you feel the "pop" or "give" as the needle set enters the medullary space.
  - Do not pull/jerk back (recoil) on the driver when releasing the trigger.
- Hold the hub in place and pull the driver straight off needle set.
- Continue to hold the hub while twisting the stylet off the hub with counterclockwise rotations.
- The catheter should feel firmly seated in the bone. (1st confirmation of placement)
- Place the stylet in a sharps container.
- Place the EZ-Stabilizer dressing over the hub.
- Attach a primed EZ-Connect extension set to the hub, firmly secure by twisting clockwise.
- Pull the tabs off the EZ-Stabilizer dressing to expose the adhesive, apply to the skin.
- Aspirate for blood/bone marrow (2nd confirmation of placement)
- Flush the 10 catheter with normal saline (5-10 ml adults; 2-5 ml for infants and small children).
- Connect fluids if ordered, infusion may need to be pressurized to achieve desired rate.

Figure 9.5 Distal tibia. Source: Teleflex. Reproduced by permission.

Distal femur

Distal femur site identification – Newborns, infants and small children only

Secure the leg out-stretched to ensure the knee does not bend. The insertion site is just proximal to the patella (maximum 1 cm) and approximately 1 cm medial to the midline. See Figure 21. EZ-IO distal femur insertion technique – newborns, infants and small children only:



Ez-io distal femur insertion technique – Newborns, infants and small children only:

- Prepare the site by using antiseptic (e.g. chlorhexidine) of your choice.
- Use a clean, "no touch" technique.
- Remove the needle set cap.
- Aim the needle set at a 90-degree angle to centre of the bone.
- Push the needle tip through the skin until the tip rests against the bone.
- The 5 mm mark from the hub must be visible above the skin for confirmation of adequate needle set length.
- Gently drill, immediately release the trigger when you feel the "pop" or "give" as the needle set enters the medullary space.
- Do not pull/jerk back (recoil) on the driver when releasing the trigger.
- Hold the hub in place and pull the driver straight off needle set.
- Continue to hold the hub while twisting the stylet off the hub with counterclockwise rotations.
- The catheter should feel firmly seated in the bone (1st confirmation of placement).
- Place the stylet in a sharps container.
- Place the EZ-Stabilizer dressing over the hub.
- Attach a primed EZ-Connect extension set to the hub, firmly secure by twisting clockwise.
- Pull the tables off the EZ-Stabilizer dressing to expose the adhesive, apply to the skin.
- Aspirate for blood/bone marrow (2nd confirmation of placement).
- Flush the IO catheter with normal saline (2-5 ml for infants and small children).
- Connect fluids if ordered, infusion may need to be pressurized to achieve desired rate.

Figure 9.6 Distal femur. Source: Teleflex. Reproduced by permission.

- The intraosseous route of fluid and drug administration has extended the options available for circulatory access.
- IO techniques are very relevant to humanitarian situations, especially those involving a significant paediatric workload.

10. FLUID MANAGEMENT

Fluid requirements can be broken down into resuscitation, replacement and maintenance. These call for different types of fluid (depending on availability). Initial patient assessment is important when managing fluid requirements, but can be deceptive in healthy trauma patients.

10.1 ADULTS

RESUSCITATION

Undertake a <c>ABC assessment for hypovolaemia using clinical parameters and injury mechanism to determine fluid resuscitation. If appropriate, 500 ml boluses of a balanced salt solution such as Ringers lactate should be administered. If the patient is deemed to be at risk of major haemorrhage, a damage control resuscitative approach should be taken using blood products (where available).

TRAUMA/MAJOR HAEMORRHAGE[1]

Damage control resuscitation: aim to control bleeding points and base initial resuscitation on a strategy of permissive hypovolaemia (hypotension) involving fluid resuscitation administered to increase blood pressure without reaching normotension.

The aim is for cerebration in awake patients, or a systolic blood pressure of 70-80 mm Hg in penetrating trauma and 90 mm Hg in blunt trauma, using blood product resuscitation if available without depleting the blood supplies.

This period of hypovolaemia (hypotension) should be kept to a minimum, with rapid transfer to the operating theatre for definitive care.

Tranexamic acid administered intravenously within three hours of injury improves mortality in trauma patients who are thought to be bleeding.[2]

REPLACEMENT[3]

Estimate deficits or excesses (see below). Add to or subtract from routine maintenance, adjusting for all other sources of fluid and electrolytes (oral, enteral and drug prescriptions).

To replace upper GI losses leading to hypochloraemia, use 0.9% NaCl. Otherwise use balanced solutions such as Ringers lactate for replacement.

Assessment for existing or ongoing abnormal fluid or electrolyte losses
Check for:

- dehydration
- fluid overload
- hyperkalaemia/ hypokalaemia (if possible)

Check for ongoing losses and estimate amounts:

- vomiting and NG tube loss
- biliary drainage loss
- diarrhoea/excess colostomy loss
- ongoing blood loss, e.g. melaena
- sweating/fever/dehydration
- pancreatic/fistula/stoma loss
- urinary loss, e.g. post acute kidney injury polyuria

In redistribution and other complex cases, check for:

- gross oedema
- severe sepsis
- renal, liver and/or cardiac impairment
- post-operative fluid retention and redistribution

[CAUTION should be observed in malnourished patients owing to the risk of refeeding syndrome.]

MAINTENANCE

Adults: Ringers lactate will be available in the ICRC setting.

Normal daily fluid and electrolyte requirements: (NICE/ GIFTASUP)[3,4]

- 25-30 ml/kg/day water
- 1 mmol/kg/day sodium, potassium, chloride
- 50-100 g/day glucose (e.g. glucose 5% contains 5 g/100ml)
- Calories: minimum 400 calories (i.e. 100g dextrose)

Encourage oral fluids and stop IV fluids when no longer needed.

Nasogastric fluids or enteral feeding is preferable when maintenance needs are for more than three days.

Avoid dextrose-containing solutions in head injuries.

10.2 CHILDREN[5]

RESUSCITATION

The same principles of fluid resuscitation for trauma apply for children as for adults.

Initially assess the possibility of using the <c>ABC approach and use physiological parameters including heart rate, capillary refill time and mental state to determine if the patient is hypovolaemic. If a fluid bolus is required, use 10 ml/kg fluid boluses of 0.9% NaCl, other isotonic crystalloids or blood if available and reassess the patient after each bolus.

Damage control resuscitation: aim to control bleeding as soon as possible. In uncontrolled bleeding do not aim for normalization of blood pressure until surgical control is achieved as this may disrupt any clot that has formed and could increase bleeding. Use 10ml/kg fluid boluses and reassess the patient after each bolus, repeating as necessary.[6]

Tranexamic acid (15mg/kg) should be used in children with bleeding caused by trauma and given within three hours of the injury.[7]

Paediatric trauma patients are at risk of hypoglycaemia and a blood sugar should always be checked. If the patient is

hypoglycaemic, give a bolus of 2ml/kg of 10% glucose[6] and repeat the measurement to ensure a response.

MAINTENANCE

Post operatively all children should be encouraged to take fluid orally if possible or given oral fluids via NG where this can be achieved.

If this is not possible, for IV daily maintenance use 0.45% saline with 5% glucose. Using the 4:2:1 ml/kg formula based on the child's weight will calculate IV fluid rates in ml/hr:

- 4 ml/kg/hr for the first 10 kg
- 2 ml/kg/hr for the next 10 kg
- 1 ml/kg/hr for the remaining kgs

EXAMPLES

8 kg child: 8 x 4 = 32 ml/hr

14 kg child: 10 x 4 = 40 **plus** 4 x 2 = 8
40 + 8 = 48 ml/hr

35 kg child: 10 x 4 = 40 **plus** 10 x 2 = 20 **plus** 15 x 1 = 15
40 + 20 + 15 = 75 ml/hr

Make sure that you do not use the 0.18%NaCl/4% glucose solution for children – it may result in dangerous hyponatraemia.

K+ levels should be checked in children on IV fluids and levels corrected appropriately.

If the child has significant insensible fluid losses, e.g. from drains or diarrhoea, the volume of these losses should be measured and this volume given as fluid replacement in addition to their daily maintenance volume. This additional fluid may be Ringer's lactate or in cases where sodium may be lost, 0.9% saline. The sodium levels in these children should be monitored closely.

- The requirement for intravenous fluids must be balanced against the patient's presentation and actual volume / electrolyte deficit.
- Dehydrated patients should always receive intravenous fluids before surgery.
- Avoid dextrose-containing solutions in head injury and do not use 0.18% dextrose saline for children.

References

General fluid management

1. Harris, T., Thomas, G.R., and Brohi, K., "Early fluid resuscitation in severe trauma", *BMJ*, Vol. 345, September 2012.
2. CRASH-2 collaborators, "Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial", *The Lancet*, Vol. 376, July 2010, pp. 23-32.
3. Sansom, L.T., and Duggleby, L., "Intravenous fluid prescribing: Improving prescribing practices and documentation in line with NICE CG174 guidance", *BMJ Quality Improvement Reports*, Vol. 3, No. 1, 2014.
4. Powell-Tuck, J., *et al.*, British Consensus Guidelines on Intravenous Fluid Therapy for Adult Surgical Patients, GIFTASUP, revised March 2011.

Paediatric fluid management

5. AAGBI, *APA consensus guideline on perioperative fluid management in children*, September 2007, available at: http://www.apagbi.org.uk/sites/default/files/Perioperative_Fluid_Management_2007.pdf
6. Advanced Life Support Group, *Advanced Paediatric Life Support*, 5th ed., Wiley, UK, 2011.
7. Beno, S., *et al.*, "Tranexamic acid in pediatric trauma: why not?", *Critical Care*, Vol. 18, No. 4, July 2014.

Further reading

World Federation Of Societies of Anaesthesiologists, *Update in Anaesthesia*, *Special Edition: Paediatric Anaesthesia and Critical Care*, WFSA, 2015, available at http://www.wfsahq.org/resources/update-in-anaesthesia.

The fluid management for children discussed in this chapter refers to management of an injured child. The fluid management of sepsis is beyond the scope of this chapter. However, the FEAST trial has challenged the current concept of fluid management in severe infection in Africa and is referenced below for those who may be treating children in that situation:

Maitland, K., *et al.*, "Mortality after Fluid Bolus in African Children with Severe Infection", *New England Journal of Medicine*, Vol. 364, June 2011, pp. 2483-95.

11. BLOOD TRANSFUSIONS

Supplies of blood in the field are usually extremely limited. All efforts must therefore be made to minimize blood loss:

Prehospital and emergency room

- Reduce and splint fractures
- Use tourniquets
- Compress bleeding points
- Prevent hypothermia
- Hypotensive resuscitation
- Give tranexamic acid

Intraoperative measures

- Tourniquets and positioning
- Prevent hypothermia
- Hypotensive anaesthesia
- Meticulous haemostasis

Post-operative measures

- Iron supplementation

11.1 PREPARING FOR TRANSFUSION

WHO TO TRANSFUSE?

The baseline haemoglobin of the local population is often lower than in the populations of developed countries as a result of a mixture of malaria, intestinal parasites and malnutrition. The decision to transfuse should always be a clinical one based on the relative risks and benefits of a unit of blood in your institution. However there are some broad guidelines for transfusion thresholds.

For otherwise healthy individuals with chronic anaemia WHO suggests a transfusion threshold of 5 g/dl unless there are signs of decompensation. In perioperative patients where further bleeding is expected, or for the critically ill, a transfusion threshold of 7 g/dl is suggested.[1]

Be aware that in major trauma the initial haemoglobin may well be normal as there has not yet been time for haemodilution. Indeed, some patients who have been transferred in very hot conditions may well be very dehydrated and a falsely high haemoglobin may be measured.

Besides major trauma, the other two groups of patients who frequently have major blood loss in theatre are women undergoing caesarean sections and large burn debridements. Blood should always be crossmatched preoperatively in these cases.

Be very alert for insidious severe anaemia in ward patients who have returned to the theatre for multiple debridements of relatively small infected soft tissue injuries and who have open wounds. They can develop unrecognized severe anaemia over a couple of weeks and suffer sudden decompensation either on the ward or under anaesthesia. Always check haemoglobin on these patients both before and after the operation. This can be done formally if you have laboratory facilities or by using capillary blood and a HemoCue machine).

HAEMOGLOBIN MEASUREMENT

This is performed with a HemoCue machine. Always check which HemoCue machine you are using **(see Figure 11.1)** and make sure that you use the appropriate cuvettes for the machine that you have.

Figure 11.1 HemoCue machine. Source: Royal College of Anaesthetists, UK. Reproduced by permission.

BLOOD TRANSFUSION AND MONITORING

Blood must be given using a blood transfusion set. This contains a filter which is not present in the standard IV fluid-giving set. Before giving the unit of blood, a final check must be carried out as in Figure 11.2 using a rapid test card. This is very important since the tracking of blood products is not as reliable in the field. Figure 11.2 shows that the patient is A+ and is being given an O+ unit.

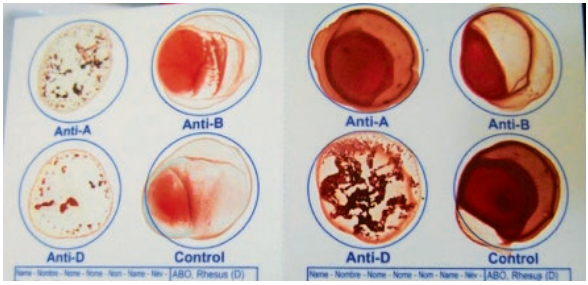


Figure 11.2 Rapid test card. Source: Royal College of Anaesthetists, UK. Reproduced by permission.

Patients should have their heart rate, blood pressure and temperature measured every 5 minutes for the first 15 minutes and then every 30 minutes until the transfusion is finished. Transfusion complications are managed in

accordance with standard protocols but limitations may be imposed by available resources.

11.2 SOURCES OF BLOOD AND TESTING

Whole blood is the most common form (rather than packed cells) in the ICRC setting. The ICRC field hospital blood bank should seek to use solar powered blood bank/vaccine refrigerators as available.

SOURCES OF BLOOD

External blood banks

External blood banks are run either by the local government or by other NGOs. Their advantage is that collection, storage and testing of the blood is done for you if a verbal or formal pre-agreement is in place.

The disadvantages are that it is difficult to find out what quality control processes are in place for crossmatch and infection testing. Often only packed cells are supplied without the possibility of conducting any other component therapy. In addition, these banks are usually open only during "office hours", in which case, a supply of O negative blood would ideally also be stored at the field hospital.

Field hospital blood bank

Where external blood banks are not available, it may be possible to set up a blood bank at the field hospital.[2] It is important to make sure that it is legal for you to do so as some countries have very strict regulations in this respect. Discussions with local and religious leaders may be required. Acquiring blood donors – even for family members – can be difficult in some countries, depending on the prevailing culture and religion. Coordination with local leaders can help to improve donation rates.

The advantage of a field hospital blood bank is that a supply of whole blood is available at all hours. The disadvantages are that all testing has to be done by field hospital staff, which requires training and time. In addition, it is necessary

to have a secure enough power supply to ensure that the blood bank refrigerator can maintain its temperature at all times.

"Walking" blood banks

An alternative to keeping a supply of blood at the field hospital is to have a supply of donors who have been pretested for infection and blood group. This resolves storage problems but is only possible where there are good communication systems that allow the donors to be called to the hospital as and when required.

Family donation

This is probably the most common method. Family and friends of the injured person are asked to donate blood and are tested for infection and compatibility. The disadvantages of this approach are that in some cultures people may be extremely reluctant to donate, they may not be compatible or, in areas with high infectious disease rates, there may be problems with HIV and hepatitis.

Cell salvage

Salvage of red cells is possible from a haemothorax. The pleural space contains its own anticoagulant and is otherwise a clean space from which to salvage cells. The circuit shown in Figure 11.3 can be used. The equipment required is a chest drain with drainage bottle or bag system and connecting tubing, a standard blood collection bag (as used in blood donation) and a clamp. The tube connecting the drain to the drainage bottle is clamped. The needle of the blood collection bag is pushed into the connecting tubing above the clamp, which enables the blood collection bag to fill. Once the bag is full, the needle is removed and the small hole in the connecting tubing covered with a piece of tape (alternatively a further blood bag can be connected).

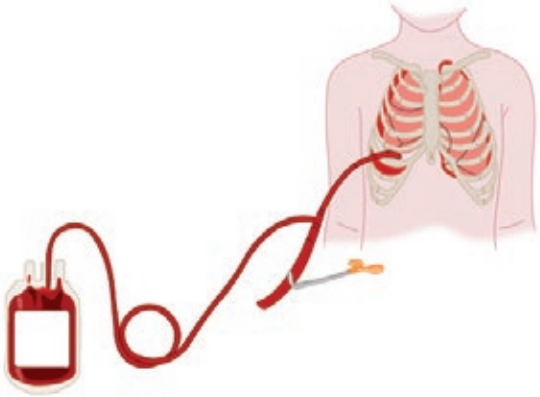


Figure 11.3 Haemothorax. Source: Royal College of Anaesthetists, UK. Reproduced by permission.

The ICRC often combines a limited field hospital blood bank with a "walking" blood bank and family donations.

TESTING THE BLOOD

It is possible to test for a wide range of infectious diseases including HIV, hepatitis B, hepatitis C, malaria and syphilis. Furthermore, many of these tests produce a quick result that is readily available to clinicians in the field. Blood is also tested for antibodies prior to transfusion. In the field it is only possible to test for ABO and rhesus antibodies. It is more complicated to test for other antibodies such as Kell, Kidd and Duffy, which, although less common, can still cause significant transfusion reactions. For this reason it is important for the patient's serum to be tested against the donor blood (a crossmatch) to reduce the risk of one of these uncommon transfusion reactions occurring.

OTHER BLOOD COMPONENTS

Blood component therapy is not usually available in the field. Fresh whole blood (collected within the preceding four hours and not refrigerated) contains, in addition to red cells, active clotting factors and platelets. It is also warm and not acidotic. This makes it the unit of choice in major haemorrhage, DIC and other coagulopathy.

Once blood has been refrigerated, the platelets aggregate and their activity is lost. Blood continues to have active clotting factors for the first 72 hours after refrigeration. After that time their activity rapidly falls off. Blood that has been stored for less than 72 hours is therefore the next preferred option in major haemorrhage and patients at risk of coagulopathy.

Whole blood can be stored for up to 28 days and is suitable for replacing red cells only. Whole blood can be stored for up to 35 days when using CPDA 1 anticoagulant and for up to 42 days when using SAGM. Packed cells are sometimes preferable in patients who are otherwise at risk of fluid overload, e.g. children (especially those who are malnourished or have severe malaria). Unfortunately, packed cells are often unavailable.

- Restrictions on blood and blood products is one of the greatest challenges faced by an ICRC surgical team.
- Fresh whole blood is extremely useful.
- Consider obtaining units of blood for patients who may need it at a later date. In practice, permissive anaemia may have to be tolerated while "local" efforts are made to organize and deploy a limited supply of blood.

References

1. World Health Organization, *The Clinical Use of Blood in Medicine, Obstetrics, Paediatrics, Surgery & Anaesthesia, Trauma & Burns,* WHO, Geneva, available at http://www.who.int/bloodsafety/clinical_use.
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3. World Health Organization Blood Transfusion Safety, *The Clinical Use of Blood Handbook*, WHO, Geneva, 2015, available at: *http://www.who.int/bloodsafety/clinical_use/en/Handbook_EN.pdf*

12. DRAWOVER ANAESTHESIA[1]

The following favourable characteristics of drawover anaesthesia, particularly with modern systems, are important for an ICRC mission:

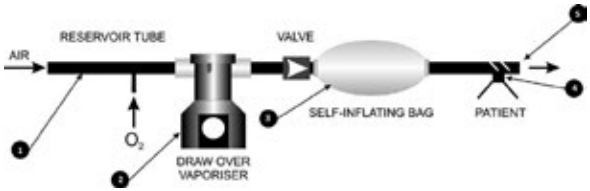
- It can be used without supplementary oxygen;
- It does not require an electricity supply;
- It is modular, compact and easy to transport;
- It is very robust;
- It is simple to operate after appropriate training;
- It can be used in extremes of temperature and air pressure;
- It can use a variety of volatile agents;
- It can be used on adults and children;
- It is easy to service and maintain
- It is economical

12.1 PRINCIPLES

- Compressed gases are often unavailable in limited-resource environments.
- In the absence of compressed gases, conventional continuous flow machines cannot function.
- In drawover systems the carrier gas is air, with oxygen supplementation if available, prior to the gas entering the vaporizer.
- The agent concentration is achieved by controlling the proportion of gas flow passing through the vaporizing chamber.
- Volatile gas is drawn through by a pressure drop generated either by:
  - the patient's inspiration (spontaneous ventilation);
  - a self-inflating bag (manual assisted ventilation);
  - a ventilator (IPPV).

1 This chapter was written with the kind support of Diamedica (UK) Ltd.

- The system can be operated in drawover mode when the patient's respiratory effort exceeds the flow rate of the carrier gas flow. The Diamedica DPA system will shift to continuous flow mode if the flow rate of the carrier gas is increased above the patient's minute volume.
- Inhalation induction is possible with the system:
  - A close-fitting mask with a tight seal is required so that room air is not entrained. If room air is entrained rather than the gas flow, the inspired concentration of anaesthetic agent will be reduced and inhalational induction becomes impossible.



Key
1. Reservoir
2. Vaporizer
3. Self-inflating bag
4. Non-rebreathing valve
5. Scavenging tube

Figure 12.1 Components of a basic drawover system. Source: Diamedica (UK) Ltd. Reproduced by permission.

12.2 PARTS

A basic drawover system comprises the following five parts:

1. Reservoir
2. Vaporizer
3. Self-inflating bag
4. Non-rebreathing valve
5. Scavenging tube

RESERVOIR

- In its simplest form the reservoir is a piece of corrugated tubing.
- If a sidearm for supplementary oxygen is present, it can be from
  - an oxygen concentrator; or
  - an oxygen cylinder, if available.
- When the patient exhales, the reservoir fills with the carrier gas, e.g. an oxygen and air mix, primed ready for the next breath.

- Depending on the patient's minute volume,1 l/min O_2 will produce an FiO_2 of 30-40%; 5 l/min will produce an FiO_2 of 60-80%.

VAPORIZER

- Unlike conventional vaporizers, a drawover vaporizer must have minimal resistance to allow spontaneous ventilation.
- The same vaporizer may be used for halothane or isoflurane since they have nearly the same saturated vapour pressure. Halothane is provided in the ICRC kits. You need to make sure that you know which agent is in the vaporizer.
- Never allow the vaporizer to tip or fall over when filled as agent can spill directly into the circuit, resulting in an overdose.

SELF-INFLATING BAG

- For controlled or assisted ventilation.

NON-REBREATHING VALVE

- A unidirectional (one-way) valve must be present to ensure that the anaesthetic mix is fully directed towards the patient.
- The unidirectional valve ensures that no rebreathing occurs and that the cleanliness of the system is maintained. However, a bacterial filter is still recommended if available.

SCAVENGING TUBE

- In order to scavenge exhaled gases, a tube can be attached to the expiratory limb from the non-rebreathing valve.

The ICRC currently uses the Diamedica system, which is presented in Chapter 24.

- Drawover anaesthesia has advantages for ICRC and other limited-resource environments.
- The system will facilitate spontaneous or controlled ventilation and is not dependent on an oxygen supply.
- Safe use requires familiarization with the equipment and close attention to vaporizer contents.

13. ULTRASOUND-GUIDED REGIONAL ANAESTHESIA

13.1 GENERIC PRINCIPLES

- Regional blocks are a valuable addition to aid with anaesthesia for surgery as well as a useful tool in a multimodal analgesic regime.
- In limited-resource environments the techniques are safe and require minimal equipment and drugs.
- Regional techniques offer a number of important advantages:
  - Very effective analgesia;
  - Increased patient cooperation;
  - Physiological advantages with attenuation of the sympathetic nervous system-driven stress response;
  - The necessity for general anaesthesia and the associated risks can be avoided;
  - Opiate sparing – in an environment where opiate availability may be limited, especially in the post-operative period. The ICRC strives to ensure that opiates are available in supported hospital structures but it is important to note that difficulties may be encountered with the importation, supply and use of opiates as a result of regulations enforced by local authorities;
  - Potential prevention of chronic pain syndromes.
- The following contraindications and risks are relative and contextual. Their relevance in individual cases should be discussed by the surgical team and anaesthetist:
  - Coagulopathy;
  - Blocking nerves which may have already been damaged as part of the injury;
  - Risk of masking the features of acute compartment syndrome;
  - Allergy to local anaesthesia.
- The following general preparations should be carried out before undertaking any regional block:

- Patient consent and explanation, especially with regard to the length of the block and the "sensations" that occur during the onset and offset of the block;
- Preparation of and access to resuscitation equipment;
- Non-invasive monitoring to include ECG, BP and pulse oximetry;
- "Stop before you block", i.e. check that the proposed anatomical block site matches the proposed surgical procedure. The subsequent patient position will vary according to the specific block.

- Ultrasound machine preparation
  - Select the most suitable position for the ultrasound machine, which should be in the operator's line of vision. The ultrasound machine is often placed opposite to the operator and thus on the opposite side of the patient.
  - Set the most appropriate depth for the block, e.g. axillary block 3-6 cm.
- Equipment preparation
  - Regional needles, e.g. short bevelled, 40 mm or 75 mm-long stimulating 22-G block needle, depending on the block. Other lengths tend not to be available in the field;
  - Local anaesthetic for skin infiltration in a 5 ml syringe with 1% lidocaine;
  - Local anaesthetic for the block itself, e.g. 20-30 ml of 0.5% bupivacaine.
- Any neurological changes associated with local anaesthetic (LA) toxicity must be monitored attentively during the block and in the hours immediately afterwards. See Chapter 21 for further details on symptomology, resuscitation and acute management.
- A nerve stimulator can be used, but directly visualizing the nerves and the needle-tip with ultrasound guidance, and a careful injecting technique is thought to potentially decrease the risk of nerve damage and intravascular injection (never inject against resistance, always ensure gentle negative aspiration before injecting, visualize the nerve, needle tip and LA deposition and spread).

- A portable ultrasound device is suitable for regional anaesthetic techniques.
- There is increasing evidence that that ultrasound-guided blocks increase success rates while decreasing the potential for complications.
- As with all regional anaesthesia, attention to detail is important.
- In the ICRC environment single-shot techniques are appropriate but post-operative nerve catheters are rarely suitable because of safety constraints.

Further reading

1. The New York School of Regional Anesthesia (NYSORA), *Ultrasound-Guided Techniques,* website, available at http://www.nysora.com/techniques/ultrasound-guided-techniques/index.1.html.

13.2 ULTRASOUND MACHINE

The ICRC now works with the FUJIFULM SonoSite, Inc. M-Turbo portable ultrasound (US) machine. Figure 13.1 shows the machine and its key functions.

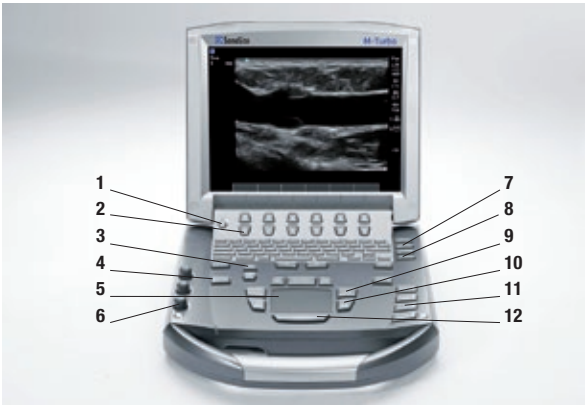


Figure 13.1 The FUJIFILM SonoSite, Inc. M-Turbo US machine, the US machine used by the ICRC. Source: With compliments of FUJIFILM SonoSite, Inc.

Key

1. On/off button
2. Function control buttons
3. Depth buttons
4. Zoom (2x)
5. Track pad/ball
6. Gain button
7. Review stored images
8. Patient information
9. Save video clips
10. Save image
11. Colour doppler
12. Freeze image

The ultrasound machine has a high frequency (6-13 MHz) linear array probe, which is the most suitable for the regional blocks discussed in Chapter 25, which include:

- Axillary brachial plexus block;
- Femoral nerve block;
- Popliteal nerve block.

14. PAIN MANAGEMENT

14.1 INTRODUCTION

Pain has multiple negative effects on a casualty, whose pain "experience" will not necessarily be related to the degree of physical insult sustained.

Pain is treated by the three Ps: **psychology** (humanitarian), **physical** methods (surgical fixation, physiotherapy) and **pharmacology** (drugs). The best outcomes are achieved by a balance of these approaches. There is good evidence that effective management of acute pain reduces the development of persistent pain syndromes.

The key principles for treating acute pain are as follows:

- Pain needs to be assessed (scored) and treated and the response to analgesia assessed and re-scored.
- Treating pain is a proactive process – anticipated surgical pain is easier to manage than established pain. Analgesia should be regular but once the acute situation has passed, dosing should be switched to an "as required" basis prior to cessation.
- Optimum results are achieved using a multimodal approach combing different drugs and/or regional analgesic techniques to modulate the pain pathways at different anatomical and pharmacological levels.
- The classic approach of a step-wise escalation of pain therapy as described by the WHO pain ladder derives from treating cancer pain. Acute pain is best treated using the "reverse WHO" concept, i.e. utilizing a combination therapy as per step 3 of the WHO ladder and then de-escalating therapy as acute pain is controlled.

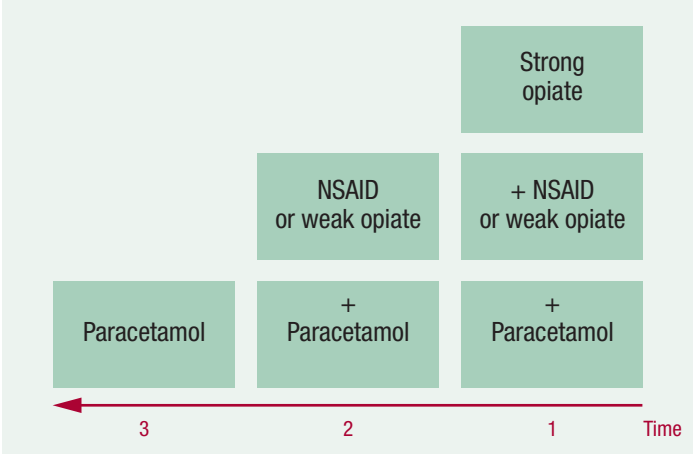


Figure 14.1 The reverse WHO pain ladder.

- Regional analgesia provided by peripheral nerve blocks or spinal anaesthesia can be very successful in the acute post-operative period and may be considered as an adjunct at every level of the WHO pain ladder.
- Severe trauma (in particular, amputation) is often associated with nerve damage, which requires specific prospective anti-neuropathic medication.
- Historically the "gold standard" of analgesia is morphine. Opioids may only be administered by trained personnel in patient-monitored environments so that oversedation or respiratory depression can be detected and treated. **Naloxone** must be available in any area in which opioids are used.
- IV opioid administration should be confined to the operating theatre or recovery area.
- Acute analgesic failure in the recovery area can be treated using bolus ketamine (0.1 – 0.3 mg/kg IV) as discussed in Chapter 7.

SCORING PAIN

Pain needs to be reported by the patient using a simple scale, bearing in mind that communication may be problematic, e.g. children or language issues. Various scales can be used but a pragmatic verbal scale for adults is:

0	No pain
1	Mild
2	Moderate
3	Severe

Good analgesia should maintain scores of 0 -1 with an occasional 2.

Persistent scores of 2-3 require reappraisal.

Pain should be scored at least as frequently as other patient observations.

OPIOID SEDATION / OVERDOSE

Sedation precedes respiratory depression. A simple system is suggested for us in ICRC settings:

0	None: patient awake and alert
1	Mild: occasionally drowsy, but easy to rouse
2	Moderate: frequently drowsy, but easy to rouse
3	Severe: drowsy and difficult to rouse
S	Sleep: normal sleep and easy to rouse

Unresponsive patients (sedation score: 3) with a respiratory rate of < 8bpm should be given Naloxone.

- Adults: one ampoule (= 0.4 mg), dilute to 8 ml (= 0.05 mg/ml) and inject IV 1 ml incrementally until the patient responds.
- The contents of one ampoule (0.4 mg) may be repeated up to a maximum of 4 mg.
- After treatment the patient must be observed closely as the effects of Naloxone are short-lived. Naloxone as an infusion (1-5 µg/kg/hour) is an alternative.
- Children under 12 years of age: dose = 100 µg/kg (diluted and incrementally dosed) repeated up to a maximum of 2 mg.

- Acute pain requires proactive multimodal treatment utilizing a "reverse WHO" approach.
- Neuropathic pain requires additional drugs.
- Good pain relief is not only a humanitarian consideration. It may also limit persistent pain syndromes and is vital for physiotherapy and successful rehabilitation.

14.2 PAIN MEDICATION

Appropriate analgesic dosing for adults and children is indicated in the following tables.

Drug	Route / dose	Comment
Paracetamol	1 g qds PO/IV IV 15 mg/kg	Max. 4 g/day reduced to 2 g/day if body weight < 50 kg
Ibuprofen	200-400 mg tds PO	As with all NSAIDs, caution is required with asthma, renal impairment, history of peptic ulcer disease, pre-eclampsia. Avoid if any haemorrhage concerns. Use for 1-3 perioperative days.
Diclofenac	75 mg bd IV / PR or 50 mg tds PO Max. 150 mg per day	Can be given IM but not recommended. Serious side effects include kidney problems and even kidney failure, which are often very difficult to treat in ICRC settings.
Tramadol	50-100 mg 4-6 hourly PO/IV Max. 600 mg per day	IV loading dose of 50 -200 mg Useful in neuropathic injury.
Pethidine	50-150 mg 3-4 hourly IM/PO 10-20 mg IV increments, titrate to effect	
Morphine	SC/IM 5-15 mg 4 hourly PO 10-20 mg bd as sustained release or 10-20 mg 2-4 hourly as quick acting IV 1-2 mg increments, titrate to effect	IV route confined to OT and recovery.
Gabapentin (Note: Gabapentin is not currently provided in ICRC kits and is therefore unlikely to be available in the field.)	Usually introduced as 300 mg PO od, increasing daily to 300 mg tds. On rare occasions starting dose is 300 mg tds. Max. 3.6 g per day.	Use for neuropathic pain and prospectively with amputation surgery.

Table 14.1 Analgesic dosing for adults.

Drug	Route / dose	Comment
Paracetamol	Oral / suppository / IV Loading dose: 15 mg/kg Maintenance: 15 mg/kg qds Max. dose: 90 mg/kg/day	Children > 50 kg: use adult dose
Ibuprofen	> 5 kg body weight max. of 30 mg/kg/day in 3-4 divided doses	Caution in cases of asthma and renal Impairment. Prescribe for max. 72 hours.
Diclofenac	> 12 kg 1 mg/kg tds Max. daily dose: 100 mg	Caution in cases of asthma and renal Impairment. Prescribe for max. 72 hours.
Pethidine	Child > 12 years IM 1 mg/kg 4 hourly IV 0.25 – 0.5 mg/kg increments Titrate to effect	
Tramadol	Child > 12 years only: 50-100 mg 6 hourly	ICRC and other humanitarian organizations will use tramadol in younger children – particularly if there are import restrictions or other barriers to opiate use.
Morphine	Subcutaneous / IM 0.05 – 0.1 mg/kg 4 hourly IV 0.05 mg/kg increments Titrate to effect	
Gabapentin (Note: Gabapentin is not currently provided in ICRC kits and is therefore unlikely to be available in the field.)	Initially 10 mg/kg od, then increase to 10 mg/kg bd and then to 10 mg/kg tds. If tolerated, this increase can be made daily. However, if side effects develop, the increase of doses should take place over one to two weeks. Following the increase, this would give a 30 mg/kg total dose.	Not normally recommended in children but is used in conflict zones characterized by significant paediatric amputee casualties.

Table 14.2 Analgesic dosing for children.

C. SPECIAL CONSIDERATIONS AND EMERGENCIES

15. BURN MANAGEMENT

The management of burns requires access to extensive resources, including large amounts of equipment, drugs and multidisciplinary personnel. These measures are very difficult to access and implement in resource-constrained environments. See Annex 2 for further information.

When faced with a major burn, it is important for the limits of what treatment is possible in your context to have been discussed in advance and to be clear to the team. Options for severe burns requiring prolonged intensive support may include palliation or transfer, depending on the geographical and cultural context.

15.1 SOME CRUCIAL ELEMENTS

- **Acute aggressive resuscitation**: IV crystalloid fluid, calculated with a modified Parkland formula (see under "Circulation" below)
- **Early surgical debridement** and life-critical interventions such as escharotomies
- **Ongoing and repeated surgical intervention**
- **Potential major blood loss** requiring massive blood transfusion, particularly during debridement of burns >15% body surface area (BSA)
- **Analgesia:** pain can be severe or chronic and associated with complex neuropathic features, requiring early multi-modal treatment
- **Preventive measures:**
  - Tetanus prophylaxis
  - **Infection**: increased risk of infection due to both reduced natural barriers and the SIRS response to the burn injury
  - **Venous thromboembolism**: caused by immobility and the SIRS response
  - **Hypothermia**
  - **Hypermetabolic state**: burns injuries result in a hyper-catabolic state and an increased calorie requirement
- Management of **inhalation injury**:

- Associated with a high mortality 27.6%[1]
- Noxious gases: carbon monoxide (CO) or cyanide poisoning. The diagnosis for CO poisoning is usually made with arterial blood sampling using a CO-oximeter, although this is unlikely to be a resource available in the ICRC environment. However, for both these states clinical suspicion based on the mechanism of the burn is crucial, e.g. prolonged exposure in a confined area, along with symptoms such as low GCS, headache and seizures should provide suspicion for diagnosis. This is particularly important in limited-resource environments. For example, oxygen is a precious commodity, which may only be driven by oxygen concentrators, but remains the primary management tool for CO poisoning. Furthermore, hyperbaric treatment is not possible.
- Upper airway heat injury: direct heat injury causes swelling to the pharynx, epiglottis and glottis. Signs and symptoms include stridor, change in voice and soft tissue swelling.
- Lower airway injury: this does not occur as a result of direct heat as this has often been dissipated before breaching the glottis. The exposure of the lower airway mucosa to toxic, noxious elements causes damage to the epithelium, releasing inflammatory triggers with mucus hypersecretion, production of carbonaceous sputum and airway obstruction.

15.2 <C>ABCDE

Patients with burns should be treated as any other trauma casualty, i.e. catastrophic haemorrhage, airway, breathing, circulation, disability and exposure. The burn injury may be severe but should not divert attention from other major life-critical injuries such as a major compressible bleed or tension pneumothorax.

15.3 BURN DETAILS

The following must be ascertained:

- Mechanism of the burn: thermal, blast, explosion, chemical, electrical.

- If the burn is thermal, whether it occurred in a confined, contained area, as this adds to the risk of inhalational injury.
- Extent of burn, depth, body surface area.

15.4 AIRWAY AND BREATHING

A low GCS < 8, hypoxia and hypercapnia are standard reasons for intubation and ventilation. In addition, if there is any evidence of an airway thermal injury, early intubation is mandatory. Intubation with an uncut large ETT (> 8.0 mm) is the standard recommendation. An uncut tube is important because as the facial and airway swelling develops, intubation can become difficult or even impossible. All potential or actual thermal airway injuries should be treated with the patient in a semi-recumbent position in order to help reduce airway swelling. Consider adrenaline nebulizers.

Induction for intubation can be with suxamethonium up to 24 hours from the burn. The risk of life-critical hyperkalaemia from extra-junctional acetylcholine receptors prevents the use of suxamethonium from this 24-hour mark to up to one year.

Circumferential burns around the chest may restrict ventilation and hence emergency escharotomies may be required.

15.5 CIRCULATION

Fluid resuscitation is a crucial part of management in the first few hours. Venous access may be a problem, in which case the femoral site, which is usually unaffected by the burn, can be used although there is a risk of infection, particularly in case of prolonged use. Central access or intraosseous access may well be required at least for the initial resuscitation efforts. Fluid in the form of crystalloids should be infused and they should ideally be warmed. There is no reason not to establish IV access through a burnt area.

The Parkland formula (4 ml/kg/hr x % body surface area) can be used to calculate the fluid requirement for the first 24 hours from the time of the burn.[2,3] The ICRC endorses a modified Parkland formula for fluid calculation:

2 ml/kg/hr x % BSA (body surface area)

The BSA can be calculated using the "rule of nines." This may be more useful in austere environments, where a Lund-Browder chart may not be available.

The Parkland formula is one of the many formulae for burns resuscitation. All these formulae are merely guides, particularly on starting resuscitation. The amount of fluid will need to be altered depending on how the patient responds. This will change considerably in the first 24-48 hours as the patient responds to the burn injury. Monitor the urine output. If this increases above 1-2 ml/kg, reduce the amount of fluid and reassess.

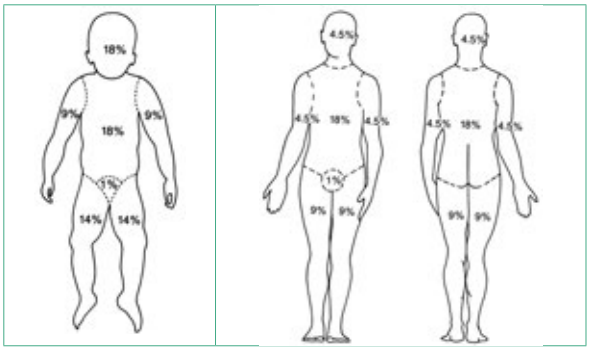


Figure 15.1 The percentages associated with the "rule of nines." Source: Giannou, C., and Baldan, M., *War Surgery,* Vol. 1, ICRC, Geneva, 2009.

A major burn is defined as having a BSA of >15% or 10% if associated with an inhalational injury. This type of burn would require fluid resuscitation with the modified Parkland formula. The calculated total fluid is divided in half. The first half is given over 8 hours from the time of the burn and the second half is given over the remaining 16 hours.

15.6 SURGICAL INTERVENTIONS

Surgery is generally performed early to wash and debride dead tissue and accurately assess the extent of the burn. This strategy aims to reduce wound infection. Other early surgical interventions can include escharotomies for areas where a circumferential burn produces a tourniquet effect. This can cause a compartment syndrome, necessitating early surgical intervention to release this critical danger. Skin substitutes will not be available in the humanitarian environment and unless there is sufficient unburnt tissue, the options for skin harvest are limited. This needs to be borne in mind when deciding on the limits of treatment.

Surgical intervention is crucial and may be repeated and frequent. It is necessary to prevent or minimize acute problems such as sepsis and long-term sequlae such as debilitating contractures.

15.7 ADDITIONAL CONSIDERATIONS FOR ANAESTHESIA IN BURN VICTIMS

Anaesthesia for burn victims can be very challenging, particularly if there is limited access to blood products, advanced monitoring and post-operative critical care.

Restricted monitoring may mean that oximetry and non-invasive BP monitoring are the only options. Cardiovascular instability is very frequently faced, particularly as a result of ongoing SIRS, which can be compounded further by intra-operative acute blood loss. Repeated debridements in these patients can lead to progressive severe anaemia that can be very well tolerated until the point of decompensation. Always check a HemoCue both before and after repeated surgeries, including small procedures/dressing changes.

The choice of drugs in limited-resource environments should include ketamine, a benzodiazepine and if necessary a non-depolarizing muscle relaxant. The use of opioids and early consideration of multimodal analgesia should be based on what is available. Neuropathic pain medication

may be restricted to amitriptyline. In addition to opioids and the standard analgesic ladder, regional techniques and local anaesthetics should be used wherever possible. Graft sites are often the most painful and femoral nerve blocks when harvesting split skin grafts from the thigh are particularly useful. Otherwise, spinal anaesthesia is ideal for lower limb work. Eextensive burns will, however, restrict the use of regional techniques. Small debridements and dressing changes can usually be safely performed with ketamine IV anaesthesia alone. For more severe burns and longer procedures, intubation is recommended as these patients often develop severe ileus and are at high risk of aspiration.

15.8 ADDITIONAL CONSIDERATIONS FOR THE CRITICAL CARE OF BURN VICTIMS.

In conventional practice, the critical care of burn patients involves many important considerations which cannot be addressed in limited-resource environments. However, simple procedures, if done well, can significantly improve the prognosis for burn patients and do not require complex equipment.

NUTRITION

Early enteral feeding via NG is crucial. It is critical to promote and maintain enteral feeding as there is no possibility of TPN. Conventional feeds are made as a high protein, calorific base to help prevent catabolism of viable tissue and muscle and to prevent immune failure and infection. While standard enteral feeds may not be available, therapeutic milks and feeds often are. Milk and egg mixes also work well. It is important to enlist the help of family members with feeding as it takes time and is often neglected on busy, understaffed wards. The hypermetabolic state can exist up to 1.5 years after the injury, with a peak at any time up to two weeks. Besides helping with the catabolic state, early enteral feeding reduces the incidence of ileus and helps to preserve gut integrity and reduce stress ulceration – all of which are major problems in burn patients.

WARMING

It is important to try and prevent heat loss to reduce coagulopathy, infection and energy requirements. If possible, ensure that the ambient temperature of the room is warm. IV fluids can always be warmed by placing them in a bottle of hot water. Try warm packs under the axilla and viable parts of the body that are not burnt.

INFECTION CONTROL

The risk of infection is very high in patients with burns. Wound infection and subsequent sepsis is the major cause of mortality in burn victims, but prophylactic antibiotics are not recommended. The antibiotic prophylaxis in case of surgery is outlined in Annex 1 on the ICRC's antibiotic protocol. Frequent dressing changes and surgical debridement along with meticulous patient handling can help to provide realistic preventative measures in the austere environment. Ensure that the patient is nursed in a "clean area" of the ward, isolated from other infected cases that are commonly found in this environment. Maintain strict handwashing procedures. Do not forget tetanus prophylaxis.

- Major burns are catastrophic injuries whose management requires intensive and prolonged medical and nursing care.
- Standards attainable in specialist burns units are not possible in the ICRC situation and difficult treatment decisions may have to be made when faced with a severe burns injury.
- Anaesthesia and perioperative care of smaller burns will focus on managing analgesia, nutrition and infection care.

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3. Baxter, C., "Fluid resuscitation, burn percentage, and physiologic age", *The Journal of Trauma,* Vol. 19, November 1979, pp. 864-865.
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16. CRUSH INJURIES

After entrapment in rubble there is a high risk of crush injury to limb/s. Sudden release may result in:

- *Reperfusion syndrome*: acute hypovolaemia and metabolic abnormalities from release of damaged cell contents. This condition may cause lethal cardiac arrhythmias and hypotension; and/or
- *Myoglobinuria*: causes renal failure if untreated.

The same picture may occur after prolonged tourniquet use in the field or after revascularization of a limb.

16.1 CLINICAL PRESENTATION

HYPOTENSION

Compartment syndrome

Massive third spacing occurs in the crushed area over a 48-hour period. This may require fasciotomy.

Rhabdomyolysis (also a risk in severe deep burns and electrical burns)

Rhabdomyolysis releases myoglobin, potassium, phosphorous, and creatinine into the circulation. It is indicated by chocolate urine and myoglobin on urine dipstick. This may lead to renal failure.

Release of electrolytes from ischaemic muscles causes metabolic abnormalities.

METABOLIC ABNORMALITIES

Arrhythmias and cardiac arrest

Secondary to hypocalcemia, hyperkalaemia and metabolic acidosis from lactic acid.

16.2 MANAGEMENT

HYPOTENSION

IV fluids up to 1.5 l/hour to produce urine output of 1-2 ml/kg (insert catheter)

MYOGLOBINUREA

Induce an alkaline diuresis for 48hrs:

- Add 20 ml 8.4% sodium bicarbonate to each litre of normal saline.
- Aim for a urine output of 1-2 ml/kg/hr and urine pH of 6.5.
- Early consideration of IV mannitol (0.25 g/kg of 20% solution over 10 to 30 minutes) may avoid the need for an alkaline diuresis. Note that mannitol is unlikely to be available in ICRC settings.
- Haemodialysis may be required. Depending on the context, there may be specialist centres available for referral. However, it is important to be aware that many centres are established to deal with chronic renal failure and not with acute renal failure.

HYPERKALAEMIA/HYPOCALCAEMIA

- Calcium gluconate 10% 10 ml
- Insulin 10 IU in 50 ml 50% dextrose over 20 minutes
- Salbutamol nebulizer
- Monitor for arrhythmias and treat accordingly.

SECONDARY COMPLICATIONS

Treat open wounds with antibiotics, tetanus toxoid and debridement.

Further reading

1. Hayward-Karlsson, J., *et al.*, *Hospitals for War-Wounded*, ICRC, Geneva, 2005, available at https://www.icrc.org/eng/assets/files/other/icrc_002_0714.pdf.
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17. PAEDIATRIC ANAESTHESIA

Paediatric anaesthesia is always a large part of the workload in austere environments and may not be an area familiar to all anaesthetists. The vast majority of cases can be handled under spontaneously breathing ketamine anaesthesia. For the rare instances in which volatile general anaesthesia is required, the ICRC provides a full range of paediatric equipment.

17.1 PREOPERATIVE ASSESSMENT

There are some essential differences between a paediatric population and adults:

MALNUTRITION

Malnutrition is often evident and is the result of pre-existing food insecurity, acute post-disaster food shortages or illness (malaria, measles, diarrhoea). There are a number of implications for anaesthesia:

- Chronic anaemia
- Cardiomyopathy, arrhythmia and easy fluid overload
- Increased duration of muscle relaxants
- Poor wound healing
- Immune compromise leading to high rates of preoperative and post-operative infection, e.g. pneumonia

The "normal" age-based paediatric formulae (e.g. Weight = (Age + 4) x 2) do not work.

It is essential to perform a nutritional assessment and not to carry out surgery on anyone with malnutrition unless it is an absolute emergency.

PARASITES

In many areas, infection with intestinal parasites is endemic. This leads to chronic anaemia and can be the cause of admission with a high parasite load causing intestinal

obstruction. Consider treating any child admitted with albendazole 400 mg PO once only.

MALARIA

Malaria in children can be very severe. Be very cautious of taking any children with malaria to the operating theatre. They can decompensate rapidly with severe anaemia and pulmonary oedema. In addition, they often develop hypoglycaemia, for which they must be monitored. In endemic areas a rapid check for malaria must be made of any child with a fever.

POOR GROWTH

Because of poor nutrition and repeated bouts of infection during their childhood, these children are, by Western standards, usually small for their age. Even in the absence of malnutrition, our normal (Western) paediatric formulae are not very helpful for estimating weight and endotracheal tube size. Any child admitted to the operating theatre must be weighed. To estimate ETT size, little finger size is a better guide than age-based formulae. A range of tube sizes must always be available.

17.2 PAEDIATRIC EQUIPMENT

It is useful to have a paediatric box set up so that everything is to hand in an emergency.

DIAMEDICA DPA 03

The DPA 03 has a smaller self-inflating bag for use in paediatrics and a smaller dead space coaxial circuit. The proximal positioning of the patient valve in the DPA 03 ensures that there is minimal weight at the patient end of the circuit. If an Ayres T-piece is preferred, the DPA circuit can be removed and the T-piece added using the adaptor supplied. At the lower flows generated by small children, the reservoir bag automatically fills and pressurizes to the limit of the 7.5 cm H_2O pop-off valve (provided that 5 l/min of oxygen is supplied). This pressurized bag turns the system into continuous flow mode. When performing a gas

induction, it is very important for the face mask seal to be tight as air rather than an anaesthetic gas mix will otherwise be entrained, making it almost impossible to perform induction; CO induction with a small amount of IM ketamine is very helpful in this situation.

AIRWAY

The ICRC supplies a full range of sizes of ETTs, face masks and Guedel airways.

PRECORDIAL STETHOSCOPE

In the absence of conventional monitoring, a precordial stethoscope can be very useful when dealing with babies and small children, allowing rapid detection of differences in breathing, heart rate, heart rhythm and, with experience, even cardiac output. Dedicated precordial stethoscopes only have one earpiece so the rest of the room can be heard at the same time. Standard stethoscopes can be used but must be taped in place and listened to intermittently. Alternatively, a standard nursing stethoscope can be cannibalized to make a single-tube earpiece. For airway information, tape it at the suprasternal notch. For heart and breath sounds, tape it at the apex of the heart.

VASCULAR ACCESS

The ICRC has paediatric size cannulae and paediatric intraosseous needles (see Section 2.2).

PATIENT WARMING

Keep the operating theatre (OT) warm; do not use air conditioning if it is available. Keep the child well covered and make a hat from Tubigrip or Gamgee for use during surgery. Ensure that all fluids are warmed by placing them in a bucket of hot water. In recovery, the use of a survival blanket and, if possible, theatre lights can help to actively warm the child if other devices are not available.

THE UNCOOPERATIVE CHILD

The vast majority of children in austere environments

are incredibly stoical. However, in the case of trauma and burns, recurrent visits to the operating theatre are often required and everything possible should be done to make these visits as atraumatic as possible. For IV access, topical local anaesthetic cream could be used if available, but it is not routinely supplied by the ICRC. Parents can accompany children to the theatre as far as recovery, where a small sedative dose of ketamine either IV (0.5 mg/kg) or IM (2-4 mg/kg) with the child sitting on the parent's lap provides very good conditions for transfer to the theatre and induction. Distraction also works well; it can therefore be a good idea to take some picture books/magazines with you, cartoons on an iPhone® or iPad®, an inflated glove with a face on it, etc.

17.3 POST-OPERATIVE MANAGEMENT

PAIN

Children can be very stoical; in combination with the language barrier, this can make pain assessment difficult. Be proactive by using local anaesthetic and nerve blocks wherever possible. To minimize acute pain, apply the WHO pain ladder and encourage the presence of supportive parents.

PAINFUL DRESSING CHANGES

The first dressings will be applied in the OT; subsequent dressings may be applied on the ward (with appropriate analgesia) or in the OT, depending on the severity of the case and the need for debridement. In ICRC environments, ketamine is often used when dressings are changed, using the dosages for regular pain management. Ketamine should be administered and monitored by the anaesthetist. Alternatively, morphine can be used as detailed below.

Pain management for bedside dressing changes

Morphine 0.2-0.5 mg/kg SC 60 minutes before dressing change in children >1 year

- ½ dose <1 year
- ¼ dose <3 months

Observe RR every 15 minutes following dressing change.

If analgesia is insufficient, move the child to the theatre.

Naloxone and airway management equipment should be available.

NUTRITION

Even in children who are not malnourished on admission, development of nutritional deficiency in hospital is common. All attempts must be made to reduce starvation times to the minimum possible. Children should be regularly reviewed post-operatively for their nutritional status. Those with major trauma and burns will benefit from systematic nutritional supplementation. Other children should be regularly reassessed and nutritional support implemented if required. If appetite is poor, nasogastric feeding may be required.

Nutritional support for children in austere environments

- Empirically treat all children with albendazole, if not received in the previous 6 months.
- Give infants small feeds frequently.
- Encourage breast-feeding in <1-year-olds, every 2-3 hours.
- Ensure oral intake as soon as surgically allowed.
- If the child is anaemic, with Hb <10 g/dl, prescribe folic acid.
- If the child has diarrhoea, give oral rehydration solution (ORS) and reintroduce feeds as soon as possible. Check that the child continues on a normal diet and add ready-to-use therapeutic food (RUTF), such as BP-100 biscuits or Plumpy'Nut® (PPN):
  - Child <8 kg: give 2 PPN per day.
  - Child >8 kg: give 3 PPN per day.
- If in any doubt, consult a nutritionist. A nutritionist is often available for consultation in the field setting or at headquarters level.

- Paediatric anaesthesia will be a feature of conflict and disaster areas.
- While both stoical and resilient, the children encountered will frequently be suffering from chronic disease and malnutrition.
- Guidelines employed for paediatric anaesthesia in developed countries will often be inappropriate in the ICRC setting.

References

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17.4 NEONATAL RESUSCITATION

During a caesarean section in the field the anaesthetist is frequently needed to help with neonatal resuscitation. Have a box set up with the appropriate equipment. Ensure that a colleague monitors the mother while you are occupied with the baby. Remember that your colleague is unlikely to be another anaesthetist but will more likely be a member of the nursing team.

EQUIPMENT FOR THE NEONATAL RESUSCITATION TROLLEY

- Towels
- Paediatric Ambu bag with a neonatal face mask
- As small a gauge cannulae as available (24G cannulae are available in ICRC kits)
- Small soft suction catheter
- Scissors and clamp (for cord clamping)
- Stopwatch if possible

A well baby: blue, good tone, cries within a few seconds of birth, HR 120-150, establishes good respiration quickly.

Less well baby: blue, poor tone, HR <100, slow to breathe >90-120 seconds.

Sick baby: pale, floppy, HR very slow (<60), not breathing.

The vast majority of babies will respond to being dried and warmed.

Up to 10% of newborn babies will need some initial basic respiratory support but will usually respond very quickly to simple airway measures.

QUESTIONS TO CONSIDER IN THE SICK BABY

Is meconium present?

If meconium is present and *causing obstruction* then gently suction the mouth, the nose and then the oropharynx. **Deep suction should always be avoided** as it can cause fatal bradycardia. Do not suction routinely if there is no evidence of obstruction.

Is the baby septic?

Risk factors for newborn sepsis include prolonged rupture of membranes, maternal sepsis, prolonged maternal labour and preterm labour. In any unwell newborn child, sepsis should be considered a possibility.

If in doubt give antibiotics (benzylpenicillin 25 mg/kg 12 hourly and gentamicin 3-5 mg/kg 24 hourly; ampicillin 50-100 mg/kg 12 hourly can be used as an alternative to benzylpenicillin). If Gram -ve bacteria are suspected, give cefotaxime 50 mg/kg 24 hourly. Antibiotic therapy usually lasts 7 days.

Check blood glucose and treat as required (recommended: use 10% glucose 2.5 ml/kg in order to provide sufficient glucose without volume overload).

Has the mother taken any drugs?

Use of traditional medicines, some of which have respiratory depressant properties, during labour is common. If a history of medication during labour is obtained and the baby's respiration is depressed, consider Naloxone 0.1 mg/kg IV or IM. Having given Naloxone, observe for a minimum of 2 hours.

How far should I take the resuscitation?

Most newborn babies respond to having their airways opened and some initial help with breathing. If this does not meet with a good response and there are no other reversible causes, continue ventilating.

Respiratory arrest only: continue for up to 20 minutes; if there is then no response, stop.

Cardiorespiratory arrest: think carefully before commencing chest compressions – is special neonatal care available? If there has been no response after 10 minutes of effective resuscitation, resuscitation should be abandoned.

Notes

Ensure that the baby's head is in a neutral position (towel roll under the shoulders).

Resuscitation should be with air, not oxygen.

If adrenaline is given, the dose is 10-30 mcg/kg IV – but consider the circumstances carefully before commencing advanced life support.

17.5 POST-RESUSCITATION CARE

Keep the baby warm.

RESPIRATORY SUPPORT

If the baby is grunting, nasal CPAP using 1 l/min from an oxygen concentrator through nasal specs can be very effective. CPAP machines are unlikely to be available in ICRC settings and anaesthetists are therefore advised to consider alternative methods to achieve a CPAP effect.

FEEDING

Encourage feeding as soon as possible and monitor blood glucose. If unable to feed, consider nasogastric feeding of breast milk.

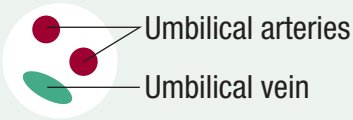

Figure 17.1 Basic anatomy of the umbilical cord.

- The ICRC anaesthetist may be expected to adopt the role of neonatologist.
- Most neonatal problems will often respond to simple measures. If these fail, careful decisions must be made in respect of further cardio-respiratory resuscitation.

Further reading

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18. OBSTETRICS

Regardless of the type of deployment – post-disaster or conflict – babies continue to be born and obstetrics always form part of the workload. Many anaesthetists may not carry out obstetric anaesthesia in their regular work. Even for those who practise obstetric anaesthesia regularly, there are some different considerations and limitations in the field.

18.1 PREOPERATIVE ASSESSMENT

The general health of the mother in some parts of the world may be less than optimal and account will need to be taken of malnutrition and high rates of malaria, TB and HIV. It is common for there to be very little antenatal care or none at all, and conditions such as placenta praevia and pre-eclampsia may therefore be undiagnosed. Access difficulties may often lead to mothers arriving very late for caesarean section; it is not uncommon for patients to have been in obstructed labour for several days.

Besides your usual preoperative assessment, you will need to consider the following:

- General maternal state: chronic anaemia, TB, HIV, malnutrition, malaria, congenital heart disease and valvular abnormalities
- Unrecognized antenatal problems: placenta praevia, pre-eclampsia and grande multiparous pregnancy
- Complications caused by prolonged labour: exhaustion and dehydration, sepsis, uterine rupture, intrauterine death with sepsis and DIC

18.2 PREOPERATIVE MANAGEMENT FOR EMERGENCY CAESAREAN SECTION

1. Oxygen
2. Left lateral position
3. Large bore IV access – check Hb, obtain blood if possible
4. IV fluids – Ringer's lactate or sodium chloride – caution with IV fluids if preeclamptic /eclamptic

5. Omeprazole IV
6. Antibiotics if evidence of sepsis

18.3 CHOICE OF ANAESTHETIC TECHNIQUE

Spinal anaesthesia is usually the safest option, except in cases of major haemorrhage and coagulopathy or maternal respiratory distress.

SPINAL ANAESTHESIA FOR CAESAREAN SECTION

Pre-delivery

1. Full monitoring
2. Position either lateral or sitting
3. Aseptic technique
4. 25G pencil point spinal needle – an introducer is often not provided; a 16G needle works well
5. Heavy bupivacaine 0.5% 1.5-2.3 ml, depending on patient size
6. Once the spinal is inserted, position the patient on her back with a 15 degree left lateral tilt – either by turning the table or placing a wedge – to reduce aortocaval compression
7. Check the blood pressure every 2 minutes in the early stages of the block
8. Treat hypotension aggressively with vasopressors – nausea and vomiting is an early sign of hypotension
9. Assess the block height – you are aiming for a block to nipple height. It is rare for ethyl chloride to be available in the field but you will usually have access to some ice or cold packs as most field hospitals will have a refrigerator. Other clear signs are inability to lift the legs and warm dry feet with dilated vessels. Assessment can be very difficult even with a translator present. Have the surgeon check with forceps before using the scalpel
10. Give Cefazolin 1 g IV

After delivery

11. Administer Oxytocin 5 units slowly – causes vasodilation and reflex tachycardia. Make sure that a twin is not present before administering it!
12. An oxytocin infusion may be asked for. Put 30 units in a 500 ml bag of saline and give over 4 hours. Pumps are not usually available; use the drops per minute method. Be aware that oxytocin infusion may have also been administered prior to the decision to proceed with a caesarean section
13. Motor power and sensation should be fully returned by 6 hours; the patient should remain in bed until that time

In case of pain during a caesarean section:

- Ketamine 5-10 mg bolus IV is very effective
- Local anaesthetic supplementation by surgeon

Differences from practice in non-austere environments

Spinal opiates

Generally these are avoided as monitoring on the ward may be suboptimal.

Lower volume spinals

We often use anaesthetic volumes of 2-3 ml. In the field high blocks and hypotension can be difficult to manage and a total spinal is very difficult to give. It is therefore usually safer to use lower volumes with the risk of some intraoperative pain – which is easily and safely treated with ketamine and/or local infiltration.

GENERAL ANAESTHESIA FOR CAESAREAN SECTIONS

Pre-delivery

1. Full monitoring
2. Left lateral tilt
3. Pre-oxygenation
4. Have all intubation equipment, including bougie, close to hand

5. Ensure that an assistant is present who understands how to apply cricoid pressure and how to use a bougie
6. **Rapid sequence induction** (As anaesthetists are aware, this is one of the very few occasions where rapid induction is a must)
7. Maintenance with oxygen and volatile or, if the patient is shocked, with ketamine
8. Cefazolin 1 g IV prior to surgery

Post-delivery

1. Oxytocin as for spinal anaesthesia
2. Give opiates, unless you have used ketamine, in which case opiates are usually unnecessary
3. TAP block by the surgeon or anaesthetist for post-operative analgesia
4. Extubate a patient when awake, either on the side or in a sitting position

Differences from practice in non-austere environments

Assistance

A skilled assistant is rarely available. Make sure that you have identified someone in your team who can help with cricoid pressure and difficult intubations and teach them what you need.

Ketamine for caesarean section

In the shocked patient, using ketamine for induction and maintenance is a very effective technique. Owing to the risk of aspiration, it is usually best for a fully trained anaesthetist to intubate and ventilate patients having a general anaesthetic for caesarean section.

If a general anaesthetic is necessary but you are worried about a difficult airway, a ketamine anaesthetic with spontaneous ventilation and oxygen via a Hudson face mask may be a safer option. Keep the patient with her head slightly raised in order to reduce the risk of regurgitation. Ketamine crosses the placenta, so be aware of the

possibility of neonatal respiratory depression. To reduce the dose of ketamine required, it is good if the surgeon can infiltrate with local anaesthetic. For many anaesthetic officers in the developing world, this is the standard technique for caesarean section. The dose of ketamine for caesarean section is 1 mg/kg as higher doses cause neonatal depression. It is worthwhile discussing the anticipated absence of muscle relaxation with the surgeon and hence the need for surgeons to adjust their technique, e.g. make a larger incision.

OBSTETRIC EMERGENCIES

An obstetrician is rarely available in the field. The medical management of obstetric patients will therefore often fall to the anaesthetist. There may also be an ICRC mobile midwife working within the hospital facility who will be able to support you.

Pre-eclampsia

Recognition

Pre-eclampsia is defined as a triad of hypertension (>140/90), proteinuria and peripheral oedema.

Severe pre-eclampsia is hypertension of >140/90 with 2+ protein and/or other symptoms, e.g. headache, epigastric pain, visual disturbance, jitteriness, breathlessness, reduced urine output.

Eclampsia is pre-eclampsia with seizures.

HELLP syndrome is hypertension, elevated liver enzymes and low platelets; in the field we are usually unable to measure platelets and liver enzymes and the condition is classified as severe pre-eclampsia.

Management of severe pre-eclampsia

The treatment is delivery of the placenta after stabilization of the mother.

The management aims are to control the hypertension and to prevent seizures. These patients are at risk of pulmonary oedema, making careful fluid management essential.

- **IV access**
- **Blood pressure management: aim for 130-140/90-100**
  Give hydralazine 5 mg over 3 minutes
  - Repeat after 30 minutes if not sufficient
  - Maximum dose: 20 mg

  OR give labetalol 10 mg IV
  - Keep increasing the dose by 10 mg every 10 minutes until a satisfactory effect is obtained

Hydralazine is available in ICRC kits but labetalol is currently not available.

- **Seizure prevention**
  Magnesium loading dose: $MgSO_4$ 4 g slow IV injection (10-15 minutes). The 50% magnesium solution should always be diluted to a maximum of 20% for IV injection.
  Magnesium maintenance dose:
  - Pump available: 1 g/hr for 24 hours after last convulsion or delivery
  - No pump: 5 g IM (2.5 mg to each buttock with 1 ml 2% lignocaine) 4 hourly for 24 hours
  - **Do not give further magnesium if knee jerk absent or respiratory depression occurs**
  - Treatment for respiratory depression: calcium gluconate 1 g IV (10 ml of 10%) over 10 minutes; restart Mg at half previous rate once the depression is resolved
- **Fluid management**
  - Urinary catheter aiming at 0.5 ml/kg/hr max
  - Fluid input/output chart
  - Restrict intake to 1 ml/kg/hr
  - Furosemide may be required
- **Management of convulsions**
  Most eclamptic fits are self-limiting. Put the patient in the left lateral position and maintain the airway giving oxygen.
  If magnesium has not yet been started, give it.
  If convulsions recur after magnesium, give a further 2 g

by slow IV injection after 15 minutes.
If convulsions still continue or if magnesium is not available, give diazepam 10 mg IV slowly with appropriate airway maintenance.
Whilst eclamptic fits would be the most common diagnosis and can occur even in the absence of hypertension in endemic areas, always consider cerebral malaria and meningitis.

- **Delivery**
  The mother should be stabilized prior to delivery
  If a caesarean section is required, the technique of choice is a spinal anaesthetic unless there is clear evidence of coagulopathy, in which case GA is preferable.
  - *GA in pre-eclampsia*
    - Intubation may be difficult due to soft tissue oedema
    - Hypertensive responses to laryngoscopy and extubation must be attenuated: MgSO4 if not already loaded
    - Fentanyl / labetalol. Avoid ketamine if possible
- **Post-delivery**
  The mother will need to be closely monitored for 24 hours owing to the ongoing risk of convulsions and fluid overload.
  - *Analgesia*
    - Paracetamol
    - Morphine
    - TAP blocks
    - Avoid NSAID owing to risk of renal failure
  - *Fluids*
    - Restrict to 1 ml/kg/hr and start oral intake immediately; when tolerated, stop infusion
  - *Magnesium*
    - Continue for 24 hours from the last convulsion
- **Management of severe pre-eclampsia and (insipient) heart failure**
  - The mother with severe pre-eclampsia may also be in heart failure
  - Signs and symptoms:
    - Respiratory distress caused by pulmonary oedema

- Orthopnoea
- Hypoxia
- Bibasal crepitation over the lungs
- Tachycardia
- Gallop rhythm

- Management:
  - Oxygen
  - Keep the mother in a comfortable position; usually sitting
  - Urinary catheter if not already in place
  - Decrease the afterload: Furosemide 20mg IV. This condition is a good indication for an epidural if possible but beware of coagulopathy associated with HELLP syndrome
  - IV digoxin
  - Continue treatment until orthopnoea, bibasal crepitations and gallop rhythm have subsided. This may take 3- 4 hours
  - The obstetrician/surgeon may want to operate immediately; good communication is necessary to explain that the risks to the mother (and baby) are extremely high
  - For surgery, extend the epidural if necessary or perform a careful spinal
  - Post-operative care as for other cases of severe pre-eclampsia

Obstetric haemorrhage

Obstetric haemorrhage is the leading cause of maternal death worldwide.

APH: placenta praevia and abruption

PPH: The four Ts:

- Tone: atony: grand multip, prolonged obstructed labour, older mothers
- Tissue: retained products
- Trauma: genital tract lacerations
- Thrombin: coagulopathy

Obstetric haemorrhage is difficult to manage because of the lack of blood products and often very late presentation.

Management

APH

- IV access and blood for crossmatch and Hb
- Rapid IV fluid bolus to restore BP (warmed fluids)
- Left lateral
- High flow of oxygen
- Coagulopathy
  - Keep warm
  - Treat blood loss aggressively to prevent onset of coagulopathy
  - Fresh whole blood if possible
  - Consider tranexamic acid (1 g slow IV injection) *post delivery*
- Resuscitate while transferring to the theatre
- If shocked: intubated GA with ketamine induction and maintenance

PPH

As above PLUS …

- Tone:
  - Oxytocin 5 iu slow IV bolus plus 30-40 units in 500 ml over 4 hours
  - Ergometrine 0.5 mg IM (not in asthmatics or pre-eclamptics)
  - Misoprostol 1000 mcg rectally
  - Bimanual compression of uterus
  - Early decision to perform a hysterectomy in case of lack of blood products
  - If the patient is already in theatre, it is possible to continue under spinal anaesthesia but conversion to GA may be necessary

Obstetric sepsis

Recognition

Suspect obstetric sepsis if some or all of the features listed below are present:

- Fever >38° C
- Increased RR, HR (mother and foetus)
- Low BP
- Altered mental state
- Onset of preterm labour
- Risk factors:
  - HIV and malnutrition
  - Diabetes
  - PROM (prolonged rupture of membranes)
  - Long labour
  - Retained products

Non-obstetric causes may also be present:

- Malaria
- Pneumonia
- Typhoid
- Appendicitis/cholecystitis
- Pyelonephritis
- Hepatitis

Management

- IV access and fluid bolus
- Paracetamol to reduce temperature
- Begin antibiotics and or antimalarials immediately if shock is present
- Ampicillin 2 g IV 6 hourly
- Gentamicin 5 mg/kg IV daily
- Metronidazole 500 mg IV 8 hourly
- Continue antibiotics until there are no signs of sepsis for 48 hours
- Treat the cause: abscess drainage/evacuation of products/ appendicectomy, etc.
- If the baby is delivered, ensure it is also treated for sepsis

Non-obstetric surgery for obstetric patients

The most common reasons for non-obstetric surgery are trauma and intra-abdominal sepsis (appendicitis and cholecystitis).

The main points to note are as follows:

- After 16/40 the mother is at risk of aspiration
- After 20/40 aortocaval compression may be apparent and the mother should have a 15 degree left tilt
- Regional techniques are preferable as there is some evidence of increased rates of miscarriage and preterm labour with low birth weight after GA
- Maternal systemic vascular resistance should be maintained during anaesthesia as placental blood flow is dependent on it
- NSAIDs should be avoided as they may cause foetal abnormalities

- Conflict zones are no barrier to background obstetric activity.
- Obstetric pathology will often be present and severe.
- The anaesthetist may well have to assume the role of perinatal physician for both mother and baby.

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19. HEAD INJURY/ NEUROSURGERY

Head injury can be classified as either primary or secondary. Primary injury occurs directly, as a result of a penetrating or blunt injury, or indirectly as a result of the brain moving within the skull vault, sustaining a variety of different injury patterns. Secondary injury occurs as a result of the physiological and pathological changes in response to injury, which can exacerbate the primary injury by producing ischaemia in the at risk watershed areas around the primary injury extending the area damaged.[1]

Patients with a head injury may require anaesthesia to facilitate surgery directly related to the head injury or for other injuries. The anaesthetist's targets are to provide good operative conditions and adequate anaesthesia while minimizing any further secondary injury. The most important causes of secondary injury are listed in Table 19.1[2].

Parameter	Targets / notes
Hypotension	Systolic BP >120 mmHg / MAP >90 mmHg
Reduced Cerebral Perfusion Pressure (CPP)	CPP = 50 – 70 mmHg
Hypoxaemia	PaO_2 >100 mHg (13 Kpa) / SaO_2 >95%
Pyrexia	Normothermia -1^0 C rise produces 10% rise in Cerebral metabolic rate (CMR)
Hyperglycaemia/ hypoglycaemia	BM 5-10 mmol/l
Seizures	Increase CMR

Table 19.1 Causes of secondary head injury.

Cerebral perfusion pressure (CPP) is dependent on the mean arterial pressure (MAP), the intracranial pressure (ICP) and the central venous pressure (CVP).

CPP = MAP – ICP – CVP

Although it is unlikely that you will be able to measure ICP, it can be assumed that it will be raised in a patient with a head injury (ICP > 20-25 mmHg would be considered a treatment threshold in a monitored setting) and we know that cerebral blood flow (CBF) and hence ICP are affected by PaO_2, $PaCO_2$ and MAP; cerebral autoregulation will be disrupted in a head injury and becomes pressure dependent. It would therefore be pragmatic to attempt to maintain a MAP greater than 90 mmHg, PaO_2 > 100 mmHg (13 Kpa), normal $PaCO_2$ (30-35 mmHg) and to use manoeuvres to minimize increases in CVP (tilt head upwards, loosen neck collars and ties, etc.).

The anaesthetic technique used should therefore attempt to rapidly induce anaesthesia, secure the airway and control ventilation while limiting haemodynamic instability. Ketamine is the ICRC's anaesthetic agent of choice for major surgery, and standard practice includes craniotomy under ketamine anaesthesia. Ketamine has traditionally been thought to be contraindicated in cases of brain injury but the evidence base for this position is weak and many authors argue that any adverse effects of the drug on cerebral physiology are attenuated or reversed by controlled ventilation and the haemodynamic stability that it offers.[3]

The perioperative period can be divided into three distinct phases; although the physiological goals remain the same, there are specific considerations for each phase.

19.1 PREOPERATIVE

The first priority is to ensure that the patient is adequately resuscitated to maintain an appropriate blood pressure to perfuse the brain.[4] This resuscitation should be with fluids and blood products, as available, in order to optimize oxygen delivery to the brain. There is often a conflict between the concept of hypotensive resuscitation and achieving adequate cerebral perfusion pressure, which may require compromise. Life-threatening extracranial injuries, particularly non-compressible haemorrhage, will require treatment before any intracranial injuries. If the

patient's level of consciousness is compromised, and especially if the GCS is </= 8, the patient should be intubated early to enable adequate oxygenation, ventilation and airway protection.

MANNITOL

If there are signs of raised intracranial pressure such as pupillary abnormalities or other lateralizing, focal neurological signs, intravenous mannitol (0.5 g/kg) may be used as a temporary measure. Mannitol can cause hypotension in under-resuscitated patients and will cause diuresis; a urinary catheter should therefore be inserted and the blood pressure monitored closely. The ICRC does not provide mannitol in all contexts as its benefit is only temporary. The availability of mannitol will therefore be dependent on the availability of appropriate referral structures.

19.2 INTRAOPERATIVE

Following appropriate resuscitation, anaesthesia should be induced with ketamine (1-2 mg/kg, depending on the clinical condition of the patient) and muscle relaxation achieved with suxamethonium using a rapid sequence induction (RSI) technique. While securing the airway, consider the possibility of a cervical spine injury and attempt to minimize unnecessary neck movement but remember that the priority is securing the airway and that the risks of exacerbating a cervical injury with careful laryngoscopy are low.

Anaesthesia can be maintained with ketamine or a volatile anaesthetic technique and supplemented with a long-acting neuromuscular blocking drug. Ventilation should be controlled manually or mechanically in order to control end-tidal CO_2: end-tidal CO_2 should ideally be monitored.

Fluid balance should be monitored and a urinary catheter inserted. Urine output (> 0.5 ml/kg/hr) is a good indication of adequate resuscitation. Mannitol, if administered, may cause diuresis.

Although there is no evidence that seizure prophylaxis prevents late onset seizures, it is often given as unrecognized seizures while anaesthetized will cause a rise in the cerebral metabolic rate and may increase intracranial pressure (ICP). A loading dose of intravenous phenytoin (20 mg/kg) should be given slowly with blood pressure and ECG monitoring, as it can cause hypotension and arrhythmias.

Careful attention to perioperative targets will optimize the patient's outcome.[5]

Parameter	Targets
Mean arterial blood pressure (MAP)	>/= 90 mmHg
PaO_2 / SaO_2	>/= 13 KPa (100 mmHg) / >95%
End-tidal CO_2	4-4.5 KPa (30-35 mmHg)
Temperature	Normothermia
Blood glucose	5-10 mmol/l

Table 19.2 Perioperative targets.

19.3 POST-OPERATIVE

Post-operatively goals remain the prevention of secondary brain injury by maintaining the intraoperative targets into the immediate post-operative period and by providing good nursing care. If the GCS remains low (</= 8), it may be wise to consider an early tracheostomy to ensure airway protection.[6]

Fluid balance and nutrition are important considerations to optimize recovery; careful input and output monitoring are required and enteral nutrition through a nasogastric tube and prophylaxis for stress ulceration may be necessary. If analgesia is required, avoid NSAIDs and use regular paracetamol and opioids as needed. Seizures should be treated if they occur but there is no evidence that anti-seizure prophylaxis prevents the occurrence of late onset epilepsy. The CRASH study[7] confirmed that

there is no place for the use of steroids in the treatment of head injury.

19.4 SUMMARY

Anaesthesia for head-injured patients is based on good quality anaesthesia with controlled ventilation and haemodynamic control, maintaining the specific targets to reduce secondary brain injury. Attention to detail needs to be maintained into the post-operative period and include good nursing care to optimize recovery and rehabilitation.

- Successful anaesthesia for head injuries relies on careful attention to physiology in order to minimize secondary insult.
- Despite the best care, the limitations of post operative ventilation and critical care will have an impact on the outcome of severe head injury.

References

1. Chesnut, R.M., *et al.*, "The role of secondary brain injury in determining outcome from severe head injury", *The Journal of Trauma*, Vol. 34, No. 2, February 1993, pp. 216-222.
2. Brain Trauma Foundation, *Guidelines for the Management of Severe Traumatic Brain Injury*, 3rd edition, 2007.
3. Morris, C., *et al.*, "Anaesthesia in haemodynamically compromised emergency patients: does ketamine represent the best choice of induction agent?", *Anaesthesia*, Vol. 64, No. 5, May 2009, pp. 532-539.
4. Chesnut, R.M., *et al.*, "A Trial of Intracranial-Pressure Monitoring in Traumatic Brain Injury", *New England Journal of Medicine*, Vol 367, December 2012, pp. 2471-2481.
5. Maas, A.I., *et al.*, "EBIC-guidelines for management of severe head injury in adults", *Acta Neurochirurgica*, Vol. 139, No. 4, April 1997, pp. 286-294.
6. Pai, A., and Heining, M., "Ketamine", *Continuing Education in Anaesthesia, Critical Care & Pain*, Vol. 7, No. 2, 2007, pp. 59-63.

7. CRASH trial collaborators, "Final results of MRC CRASH, a randomised placebo-controlled trial of intravenous corticosteroid in adults with head injury – outcomes at 6 months", *The Lancet*, Vol. 365, No. 9475, June 2005, pp. 1957-1959.

20. ANAPHYLAXIS

This guidance is based on the AAGBI (Association of Anaesthetists of Great Britain and Ireland) guidelines and Resuscitation Council (UK) algorithms. Reported anaphylaxis rates vary widely from 1 in 3,000 to 1 in 20,000 people. Although rare, this is a severe, potentially life-threatening allergic reaction; early recognition and management are important. In anaesthesia, the agents most commonly leading to anaphylaxis include neuromuscular blocking agents, antibiotics, thiopentone and latex but this list is not exhaustive. Follow-up for allergy testing will depend on the existence of an intact local health system.

20.1 ASSESSMENT AND MANAGEMENT

- ABC approach (airway, breathing and circulation)
- Remove all potential causative agents and maintain anaesthesia, if necessary.
- **CALL FOR HELP** and note the time.
- Maintain the airway and administer 100% oxygen. Intubate and ventilate if necessary.
- If appropriate, start cardiopulmonary resuscitation immediately according to the Advanced Life Support Guidelines (Resuscitation Council (UK)).
- Prior to intubation/ventilation the anaesthetist must consider the availability of aftercare.

GIVE ADRENALINE

Adrenaline IM: doses of 1:1000 adrenaline (repeat after 5 minutes if no better)

- Adult 500 mg IM (0.5 ml)
- Child more than 12 years: 500 mg IM (0.5 ml)
- Child 6-12 years: 300 mg IM (0.3 ml)
- Child less than 6 years: 150 mg IM (0.15 ml)

Adrenaline IV

- Adult dose: 50 mg (0.5 ml of 1:10,000 solution)
- Child's dose: 1.0 mg/kg (0.1 ml/kg of 1:100,000 solution)

- Several doses may be required if there is severe hypotension or bronchospasm. If several doses of adrenaline are required, consider starting an intravenous infusion.
- Give crystalloid boluses (Large volumes may be required.)
- Adult: 500–1000 ml
- Child: 20 ml/kg

Transfer the patient to an appropriate critical care area, if available. Otherwise keep the patient in the theatre or recovery area, intubated and if necessary hand-ventilated until there is no risk to the airway. This is important since there is a clearly defined cause that is probably very reversible.

20.2 SECONDARY MANAGEMENT

Give chlorphenamine IV

- Adult: 10 mg
- Child 6-12 years: 5 mg
- Child 6 months – 6 years: 2.5 mg
- Child < 6 months: 250 µg/kg

Give hydrocortisone i.v.

- Adult: 200 mg
- Child 6-12 years: 100 mg
- Child 6 months – 6 years: 50 mg
- Child < 6 months: 25 mg

Persistent bronchospasm

- Treat using salbutamol infusion.
- Consider giving IV magnesium sulphate.

- Severe anaphylaxis can be immediately life threatening but is reversible with prompt recognition and treatment.

References

1. AAGBI, *Management of a Patient with Suspected Anaphylaxis During Anaesthesia SAFETY DRILL*, 2009, available at http://www.aagbi.org/sites/default/files/ana_laminate_2009.pdf.
2. Resuscitation Council (UK), *Emergency treatment of anaphylactic reactions: Guidelines for healthcare providers*, available at https://www.resus.org.uk/anaphylaxis/emergency-treatment-of-anaphylactic-reactions/.

21. LOCAL ANAESTHETIC SYSTEMIC TOXICITY (LAST)

Local anaesthetic systemic toxicity (LAST) can occur after administration of an excessive dose, with rapid absorption, or because of an accidental intravenous injection. Management can be challenging and prolonged resuscitation may be required, especially in the case of cardiac toxicity. Management is especially difficult in ICRC settings, with prevention being particularly important. Careful calculation of local anaesthetic (LA) doses is crucial, as is the practice of always aspirating before injecting LA.

LAST usually manifests as central nervous system (CNS) toxicity (tinnitus, confusion and, ultimately, seizures) or cardiovascular toxicity (hypotension, dysrhythmias and cardiac arrest). As the CNS is more susceptible, these symptoms tend to develop at lower concentrations.

21.1 RECOGNITION

SIGNS OF SEVERE TOXICITY (DELAYED ONSET IS POSSIBLE)

- Sudden alteration in mental status, severe agitation or loss of consciousness, with or without tonic-clonic convulsions
- Cardiovascular collapse

IMMEDIATE MANAGEMENT

- Stop injecting the LA.
- Get HELP.
- Maintain the airway and, if necessary intubate.
- 100% oxygen ensuring adequate lung ventilation. (Hyperventilation may help by increasing plasma pH in the presence of metabolic acidosis.)
- Control seizures: give a benzodiazepine or thiopental in small incremental doses.

IN CIRCULATORY ARREST

- Start cardiopulmonary resuscitation (CPR) using ALS protocols.
- Manage arrhythmias, these may be refractory to treatment.
- Give IV lipid emulsion (see below).
- Continue CPR throughout treatment with lipid emulsion.
- Recovery from LA-induced cardiac arrest may take >1 hour.
- Lignocaine should NOT be used as an anti-arrhythmic therapy.
- Arrange safe transfer to an appropriate clinical area.

WITHOUT CIRCULATORY ARREST

- Use conventional therapies to treat:
  - Hypotension
  - Bradycardia
  - Tachyarrhythmia
- Consider use of lipid emulsion.

LIPID EMULSION REGIMEN

Immediately

- Initial IV bolus of 20% lipid emulsion 1.5 ml/kg over 1 minute.
- Start an IV infusion of 20% lipid emulsion at 15 ml/kg/hr.

After 5 minutes

Give a maximum of two repeat boluses (same dose) if:

- cardiovascular stability has not been restored or there is circulatory deterioration.

Leave 5 minutes between boluses. A maximum of three boluses can be given.

Continue infusion at same rate, but double the rate to 30 ml/kg/hr at any time after 5 minutes, if cardiovascular stability has not been restored or a previously adequate circulation deteriorates.

Continue infusion until stable or the maximum dose of lipid emulsion has been given.

Do not exceed a maximum cumulative dose of 12 ml/kg.
The ICRC "resuscitation set" includes lipid emulsion for this indication only; it should therefore be available in the field. (Please note that the ICRC does not provide lipid emulsion for enteral nutrition.)

- Treatment of severe LAST can be prolonged and difficult.
- Prevention is better than cure.

References

1. AAGBI, *Management of Severe Local Anaesthetic Toxicity*, AAGBI Safety Guideline, available at http://www.aagbi.org/sites/default/files/la_toxicity_2010_0.pdf.

22. MALIGNANT HYPERTHERMIA

Malignant hyperthermia (MH) is a rare pharmacogenetic autosomal dominant muscle disorder of the sarcoplasmic reticulum. It is induced by exposure to suxamethonium and all volatile anaesthetic agents and is characterized by hypermetabolism, muscle rigidity and hyperpyrexia.

Without standard monitoring in a limited-resource environment, recognition will be difficult. It is important to remain clinically vigilant; treatment with dantrolene (if available) can be life-saving. Post-exposure investigations to confirm the diagnosis as normally performed in a robust health-care system will rarely be feasible in a limited-resource environment.

Owing to the reasons stated above, the rare nature of MH and its high cost, dantrolene is not currently available in ICRC structures.

22.1 RECOGNITION

- Onset may be within minutes of induction or insidious.
- Unexplained increase in ETCO2 *and*
- Unexplained tachycardia *and*
- Unexplained increase in oxygen requirement
- Temperature changes are a late sign.
- Previous uneventful anaesthesia does not rule out MH.

22.2 IMMEDIATE MANAGEMENT

- STOP all trigger agents.
- CALL FOR HELP. Allocate specific tasks.
- Remove the breathing system and change to an Ambu bag and hyperventilate with 100% O_2 at the highest flow possible.
- Maintain anaesthesia with intravenous ketamine.
- ABANDON or FINISH surgery as soon as possible.

- Muscle relaxation with non-depolarizing neuromuscular blocking drug.

22.3 MONITORING AND TREATMENT

- Give dantrolene (2.5 mg/kg immediate IV bolus).
- Repeat 1 mg/kg boluses as required to a maximum of 10 mg/kg.
- Initiate active cooling, trying to avoid vasoconstriction. Cool blocks may be available, otherwise wet cloths draped on the patient with a standard room fan blowing is quite effective. Bladder irrigation with refrigerated cold water.
- Tepid sponging.
- NG tube with cold fluid washout.
- Cold to the axillary areas.

TREAT

- **Hyperkalaemia**: if ECG available, large peaked t waves initially, followed by widening of QRS and bradycardia
  - Calcium chloride, glucose/insulin, $NaHCO_3$
- **Arrhythmias:** magnesium/amiodarone/metoprolol

AVOID

- Calcium channel blockers – interaction with dantrolene

CONTINUOUS MONITORING (IF AVAILABLE)

- Core and peripheral temperature
- $EtCO_2$
- SpO_2
- ECG
- Blood pressure monitoring (intra-arterial or non-invasive)

PATIENTS AT RISK OF

- Metabolic acidosis: hyperventilate, $NaHCO_3$
- Myoglobinaemia: Hydration is the key:
  - 20 ml/kg crystalloid bolus followed by twice the maintenance dose, aiming for a urine output of 2-3 ml/kg/hr

- Consider a forced alkaline diuresis: mannitol dose 0.25-0.5 g/kg bd; $NaHCO_3$ dose 2-5 mmol/kg over 4-8 hours (equivalent to 2-5 ml /kg when using an 8.4% $NaHCO_3$ solution).

22.4 FOLLOW-UP

- Continue monitoring and repeat dantrolene as necessary.
- Monitor for clinical signs of acute kidney injury and compartment syndrome.
- Consider alternative diagnoses (e.g. sepsis, phaeochromocytoma, thyroid storm, myopathy).

- Malignant hyperpyrexia is a rare complication of exposure to anaesthesia – the established syndrome will carry a high mortality.
- Opportunities to confirm the diagnosis in the ICRC setting are unlikely.

References

1. AAGBI, *Malignant Hyperthermia Crisis,* AAGBI Safety Guideline, 2011, available at http://www.aagbi.org/sites/default/files/MH%20guideline%20for%20web%20v2.pdf.

D. EQUIPMENT GUIDANCE AND REGIONAL BLOCKS

23. ADMINISTERING OXYGEN

The two possible oxygen sources in the field are oxygen cylinders and oxygen concentrators. Oxygen may not be available 24 hours a day since power is needed for oxygen concentrators. The safety of stored oxygen in a war zone is a major concern and is an obstacle to storing oxygen at a hospital as well as to sourcing oxygen cylinders. Oxygen stored in cylinders or manifolds can add to the explosive potential if it comes into contact with live ammunition.

23.1 OXYGEN CYLINDERS

Oxygen cylinders deliver oxygen at 4 bar. They are convenient as they are portable, do not require a power source and can deliver high-flow oxygen. However, in the field they have a number of disadvantages:

- They may be unavailable.
- They are difficult to transport because of their weight and the associated fire/explosive hazard.
- Facilities for refilling may be lacking or very expensive.
- Poor maintenance of cylinders can make them dangerous.
- Poor maintenance of the pressure gauge can produce faulty readings and unexpected oxygen failure.
- Inconsistent colour coding of cylinders can make it difficult to be sure what gas is being given.
- Purity of the oxygen is unknown.
- Unsafe unless they are tethered to the wall or placed on solid metallic stands.

In practice in the field, a few small oxygen cylinders are often available as a temporary back-up in case of power failure. Otherwise, oxygen concentrators are used.

23.2 OXYGEN CONCENTRATORS

Oxygen concentrators work by compressing air and passing it over zeolite, which adsorbs the nitrogen. The best concentrators produce a maximum flow rate of

oxygen of around 8 l/min at low pressure, with an inspired oxygen concentration of around 90%. They are a cheap source of oxygen, require little maintenance and are safe since even in the event of a complete breakdown they will still provide a minimum of 21% oxygen. However, they do require a power source.

23.3 OPERATION

Concentrators can be run from the mains or a generator supply. A voltage stabilizer should be used between the concentrator and the electricity supply as voltage fluctuations are very common both with generators and local power supplies and these can significantly affect the performance and life of the concentrator.

Each oxygen concentrator is fitted with a low FiO2 alarm consisting of a high-pitched sound and a light. When the concentrator is switched on, this alarm will sound as a test, after which the alarm light and sound should switch off automatically.

A concentrator has two output flowmeters, both of which are marked up to 10 l/min. (N.B. The maximum output is approximately 8 l/min of oxygen *in total*.) If both flowmeters are set at up to 10 l/min each, the performance of the concentrator and the oxygen concentration will rapidly decline; there will be an output of >8 l/min of gas but the difference of 2 l/min will be mainly compressed air.

A bottle of water can be added to one of the outputs for humidification. However, this cold water humidification is not very effective, can be a source of infection and is often a site for leaks from the circuit. For these reasons, the bottle is not normally used. Moreover, it should not be used in conjunction with halothane.

When the concentrator is not in use, it should be switched off in order to conserve generator fuel and to prevent the build-up of oxygen if working in tents.

23.4 MAINTENANCE

Concentrators require minimal maintenance. On the back of the concentrator there is a small foam filter which fills with dust. This filter needs to be removed every few days and run under water to clean it. It is then shaken dry and placed back on the concentrator. Filters should be replaced immediately after washing since they are easily mislaid and without the filter, the concentrator can cease to function as a result of a build-up of dust. The filters provided with the concentrator machine should not be replaced by "make-shift" or "home-made" filters, i.e. pillow sponge.

In addition, concentrators have internal filters, which should not be cleaned by the operator. No attempt should be made to interfere with the zeolite canisters.

Figure 23.1 Foam concentrator filter.

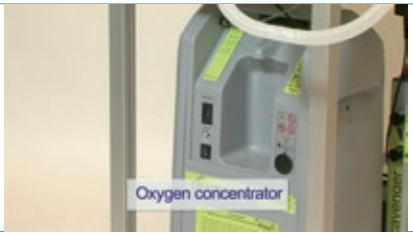
24. DIAMEDICA EQUIPMENT

24.1 GLOSTAVENT® ANAESTHETIC MACHINE

Low-resistance breathing circuit
Vaporizer
Ventilator
Oxygen concentrator
Uninterruptible power supply

Low-resistance vaporizer and breathing system

Gas-driven ventilator



Oxygen concentrator

Uninterruptable power supply

24.2 VAPORIZER AND BREATHING SYSTEM

Drawover vaporizer

Vaporizer control lever

For use with Halothane/Isoflurane or alternatively Sevoflurane

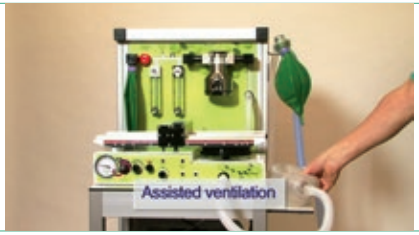
Note: A separate vaporizer is required for Sevoflurane.

Room air entrainment and supplementary oxygen

Patient valve

Oxygen flush

Expired gases and scavenger



Assisted ventilation

Mechanical ventilation

Ventilator controls

Ventilator controls

Patient pressure controlled by moving weights

For paediatric patients the weights are split ...

... and a smaller paediatric bellows fitted

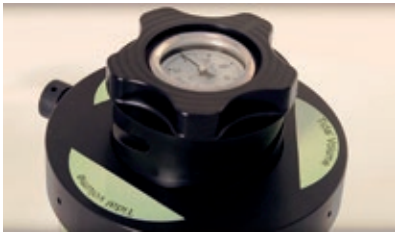
24.3 OXYGEN CONCENTRATOR

The Oxygen Concentrator provides both oxygen and air through the flowmeters on the control panel.

The uninterruptable power supply (UPS)

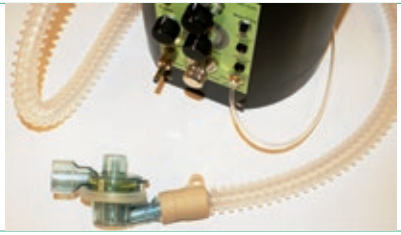
24.4 HELIX VENTILATOR

The Diamedica Helix Ventilator

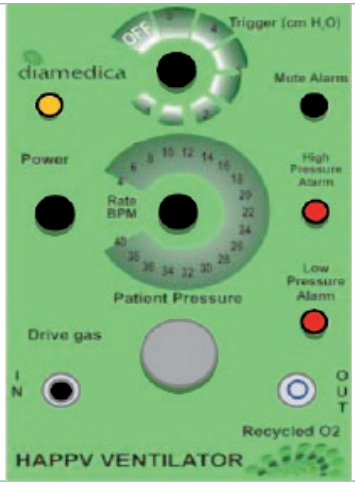


Patient pressure gauge location – top

Patient circuit block position – left side



Patient non-rebreathing valve



Ventilator control panel

Down the right-hand side:

- Alarm mute (top)
- High pressure warning light: this is illuminated if the airway pressure exceeds 50 cm H2O (middle).
- Low pressure warning light (bottom): this is illuminated if the airway pressure fails to reach 5 cm H2O during IPPV. After 20 seconds this is accompanied by an audible warning.

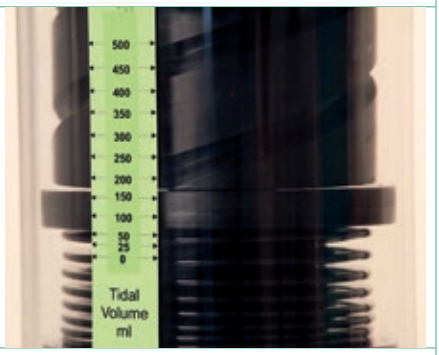
At the bottom of the panel: the drive gas connections and return (recycled O2)

Ventilator control panel Controls

This contains the following features from left to right:

- On/off power switch with illuminated "power on" indicator above.
- Trigger level control (top).
- Respiratory rate control (centre).
- Patient pressure control (bottom).

Tidal volume control with twist screw



Tidal volume scale

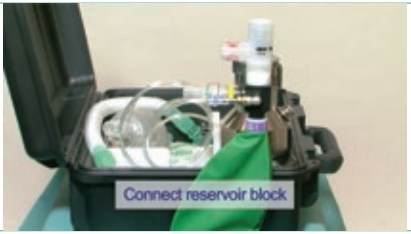
Ventilator connected to DPA 02 portable anaesthesia machine

24.5 PORTABLE ANAESTHETIC MACHINE (DPA 01™)

DPA 01 Diamedica Portable Anaesthetic Machine
Remove patient circuit

Secure vaporizer

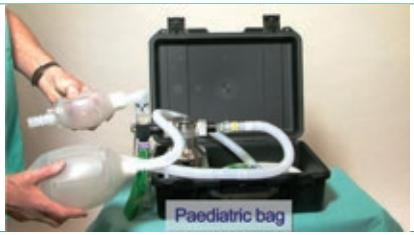
Secure vaporizer



Connect reservoir block

Connect patient circuit

Test the circuit

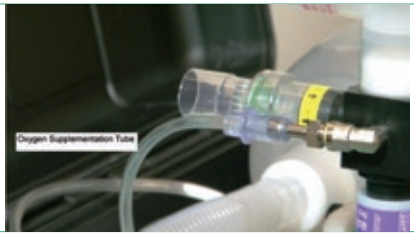


Paediatric bag

Scavenging tube

Filling the vaporizer

Vaporizer control



Oxygen supplementation tube

Oxygen regulator adjustment

25. REGIONAL BLOCKS

25.1 AXILLARY BRACHIAL PLEXUS BLOCK

Indications: analgesia or surgical anaesthesia for elbow, forearm and hand

Preparation of patient, equipment, drugs for resuscitation and the block as described in Section 13.1 on the generic principles of regional anaesthesia

Specific preparation: 22G block needle 50 mm in length loaded with a 20 ml syringe of 0.5% bupivacaine

Patient position: supine, with head turned away from the side being blocked, the elbow flexed at 90 degrees and arm abducted

Transducer position: place transducer transversely, just distal to the pectoralis major insertion (Figure 25.1).

Key ultrasound (US) landmarks

- Identify the **pulsating axillary artery (AA)** and the compressible axillary vein (AV) (Figures 25.2 and 25.3).
- Identify the heads of the triceps muscle, which is replaced by the **key landmark of the conjoint tendon** of teres major and latissimus dorsi muscles. It is a key landmark as the radial nerve is almost always found above the conjoint tendon.
- The nerves appear around the axillary artery with mixed echogenicity in the following positions:
  - Median nerve (MN) sits around the 9-12 o'clock position.
  - Ulnar nerve (UN) sits around the 12-4 o'clock position.
  - Radial nerve (RN) sits around the 4-7 o'clock position (just above the conjoint tendon).

- The musculocutaneous nerve (MN) is not directly next to the AA but appears as a hyperechoic flattened structure within the body of the coracobracialis muscle. Dynamic scanning in a proximal to distal direction will give the appearance of the nerve "peeling away" from the AA. Blocking the MN is necessary to offset tourniquet associated pain during surgery.

Key goal of block

The deposition of local anesthetic to circumferentially surround the four key nerves listed above.

N.B. This technique requires comprehensive blocking of four nerves, which can be technically challenging if utilized as the sole means of surgical anaesthesia.

Block technique

- Once the AA and the nerve of interest have been identified, approach the nerve with an in-plane technique.
- Inject up to 5-6 ml of LA around each nerve, looking for circumferential spread around the nerve.
- A total of 20-25 ml of local anesthetic will be used.

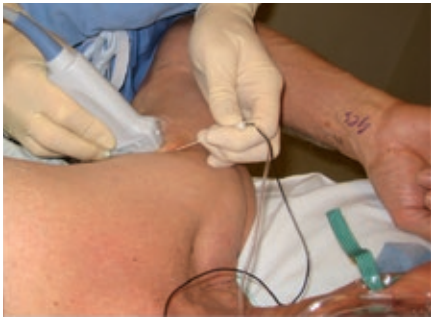


Figure 25.1 Position of the patient and ultrasound probe with needling using an in-plane technique. Source: With compliments of FUJIFILM SonoSite, Inc.

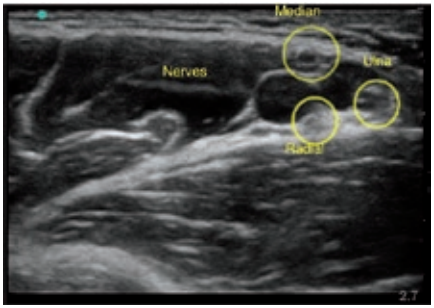


Figure 25.2 US image with the MN, UN and RN surrounding the AA. Source: With compliments of FUJIFILM SonoSite, Inc.

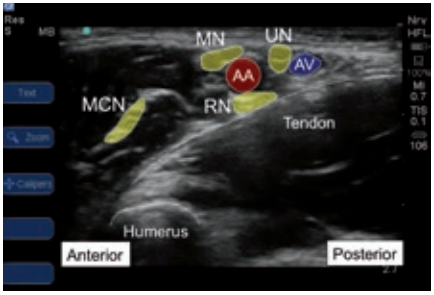


Figure 25.3 US image with the AA, AV, nerves and conjoint tendon highlighted. Source: With compliments of FUJIFILM SonoSite, Inc.

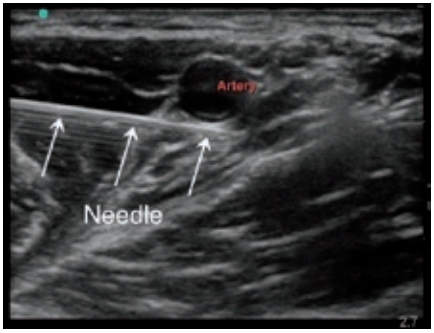


Figure 25.4 The needle shaft and tip seen under the AA. Source: With compliments of FUJIFILM SonoSite, Inc.

25.2 FEMORAL NERVE BLOCK

Indications: analgesia or surgical anaesthesia for anterior thigh, shaft of femur, hip or knee

Preparation of patient, equipment, drugs for resuscitation and the block as described in Section 13.1 on the generic principles of regional anaesthesia

Specific preparation: 22G block needle 50 mm or 80 mm in length loaded with a 20 ml syringe of 0.5% bupivacaine

Patient position: supine with the leg in a neutral position (Figure 25.5). The groin revealing the inguinal crease on the side to be blocked should be exposed.

Transducer position: place transducer transversely just below the inguinal crease (Figure 25.5).

Key ultrasound (US) landmarks (Figures 25.6 and 25.7)

- Identify the **pulsating femoral artery (FA)** and compressible femoral vein (FV).
- The femoral nerve (FN) is lateral to the FA, deep to the fascia iliacus but just above the iliacus muscle.
- The FN can be difficult to visualize but will often appear as a flattened hyperechoic triangular structure immediately adjacent to the artery.

Key goal of block

The deposition of local anesthetic to circumferentially surround the femoral nerve.

Block technique

- Once the FA and FV have been identified, approach the FN using an in-plane technique.
- Target the line of the needle trajectory to arrive lateral to the femoral nerve and under the fascia iliacus.
- Inject 15-20 ml of LA as 1-2 ml aliquots, observing circumferential spread around the FN.
- A total of 20 ml of local anesthetic will be used.

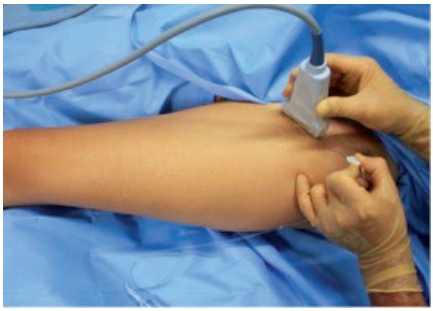


Figure 25.5 Position of the patient and US probe with needling using an in-plane technique. Source: With compliments of FUJIFILM SonoSite, Inc.

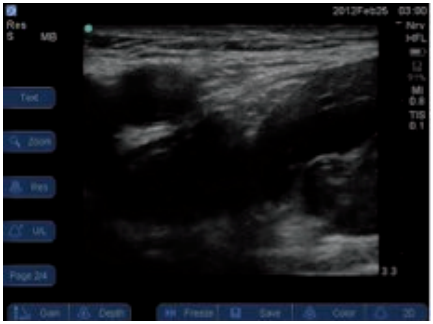


Figure 25.6 US image FA, FV and the hyperechoic FN. Source: With compliments of FUJIFILM SonoSite, Inc.

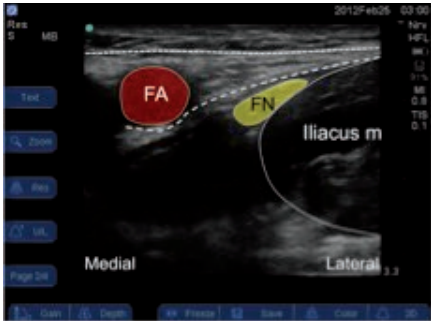


Figure 25.7 US image with the SA, SV, fascia iliacus, iliacus muscle and FN. Source: With compliments of FUJIFILM SonoSite, Inc.

25.3 POPLITEAL SCIATIC NERVE BLOCK

Indications: analgesia or surgical anaesthesia for foot and ankle injury or surgery

Preparation of patient, equipment, drugs for resuscitation and the block as described in Section 13.1 on the generic principles of regional anaesthesia

Specific preparation: 22G block needle 50 mm in length loaded with a 20 ml syringe of 0.5% bupivacaine and an additional 10 ml syringe of 0.5% bupivacaine

Patient position: prone or oblique position (for posterior approach), supine (for lateral approach) (Figure 25.8)

Transducer position: place transducer transversely above the popliteal fossa grove in the midline between the hamstring muscle tendons (Figure 25.8).

Key US landmarks (Figures 25.9 and 25.10)

- Identify the **pulsating popliteal artery (PA)**.
- The sciatic nerve (SN) will appear as a hyperechoic structure above and lateral to the PA.
- Dynamic scanning distally towards the popliteal fossa will show the SN dividing into the tibial nerve (TN) and common peroneal nerve (CPN), scanning back up proximally will identify an optimal site to block where the SN exists as one nerve in an epineural sheath. This is normally 5 cm above the popliteal crease.

Key goal of block

The deposition of local anesthetic to circumferentially surround the SN within the epineural sheath OR if the SN has divided, around the CPN and TN separately.

Block technique

- Once the PA and the SN have been identified, approach the SN using an in-plane technique.

- Target the line of the needle trajectory to arrive just inside the epineural sheath.
- Inject 2-5 ml aliquots, observing for hydro-separation of the CPN and TN in the epineural sheath with circumferential spread around these structures.
- A total of 20-30 ml of local anesthetic will be used.

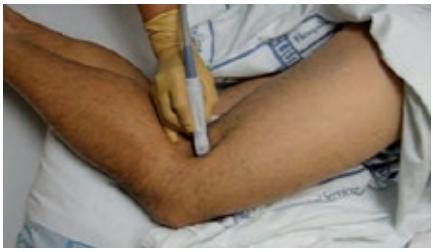


Figure 25.8 Position of the patient in the oblique position and US probe, which will reveal images for a posterior approach, similar to a prone position posterior approach. Source: With compliments of FUJIFILM SonoSite, Inc.

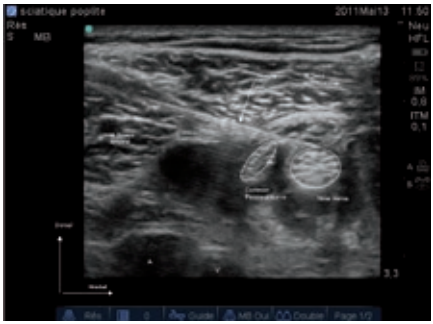


Figure 25.9 Ultrasound image showing the tibial nerve (TN) and the common peroneal nerve (CPN) as well as the biceps femoris and the semimembranosus muscles. The shaft of a needle is demonstrated. Source: With compliments of FUJIFILM SonoSite, Inc.

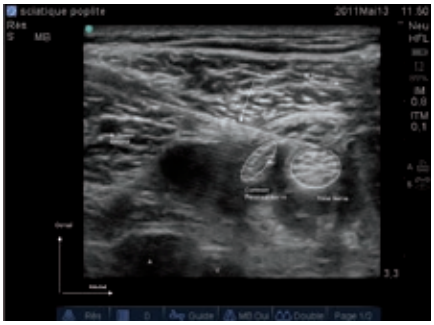


Figure 25.10 The position of the US probe and needle to reveal the US image above. Source: With compliments of FUJIFILM SonoSite, Inc.

25.4 INFRACLAVICULAR BRACHIAL PLEXUS BLOCK

Indications: analgesia or surgical anaesthesia for arm, elbow, forearm and hand injury or surgery

Preparation of patient, equipment, drugs for resuscitation and the block as described in Section 13.1 on the generic principles of regional anaesthesia

Specific preparation: 22G block needle 50 mm or 80 mm in length loaded with a 20 ml syringe of 0.5% bupivacaine and an additional 10 ml syringe of 0.5% bupivacaine

Patient position: supine, with head turned away from the side being blocked. The arm can be by the side or elbow flexed at 90 degrees and arm abducted.

Transducer position: place transducer transversely, alongside the carocoid process below the clavicle. Alternatively, just below the acromio-clavicular joint (Figure 25.11).

Key US landmarks (Figures 25.12, 25.13 and 25.14)

Identify the **pulsating subclavian artery (SA)**.

The plexus and the SA may be deeper than anticipated, so increasing the depth on the US machine will aid to visualize these structures.

At this level the brachial plexus exists as hypoechoic cords lateral, medial and posterior to the SA.

Key goal of block

The deposition of local anesthetic to circumferentially surround the SA, which will spread to surround the three aforementioned cords.

Block technique (Figure 25.15)

- Once the SA and the cords have been identified, approach the SA using an in-plane technique.
- Target the line of the needle trajectory to arrive with the needle tip at 6 o'clock just posterior to the SA.
- Inject 20-30 ml of LA as 5 ml aliquots observing circumferential spread around the SA and cords.
- A total of 30 ml of local anesthetic will be used.

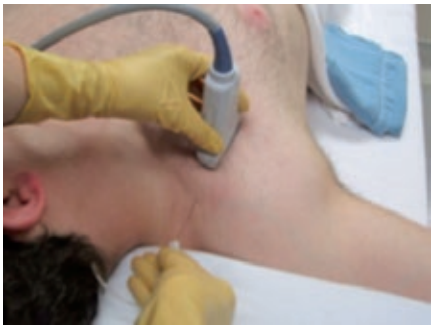


Figure 25.11 Position of the patient and US probe with needling using an in-plane technique. Source: With compliments of FUJIFILM SonoSite, Inc.

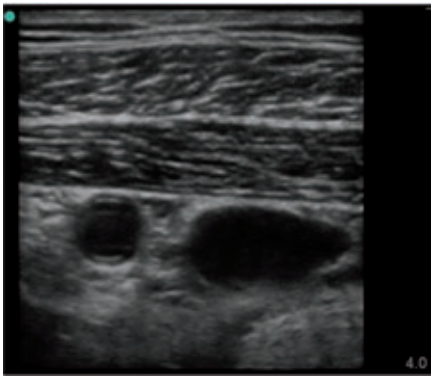


Figure 25.12 US image showing the SA, SV and the hypoechoic lateral, medial and posterior cords. Source: With compliments of FUJIFILM SonoSite, Inc.

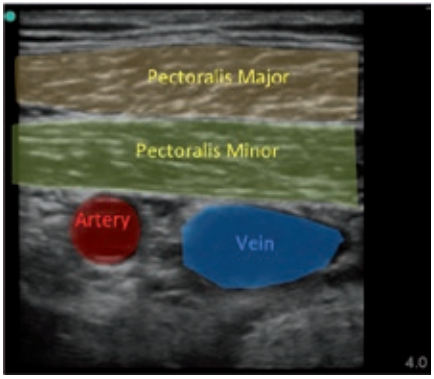


Figure 25.13 US image with the SA, SV pectoralis major and minor. Source: With compliments of FUJIFILM SonoSite, Inc.

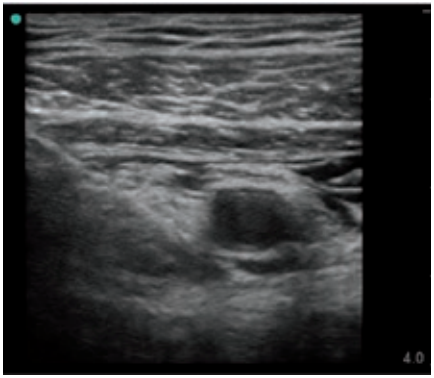


Figure 25.14 The needle shaft and tip are seen approaching the desired 6 o'clock position posterior to the SA. Source: With compliments of FUJIFILM SonoSite, Inc.

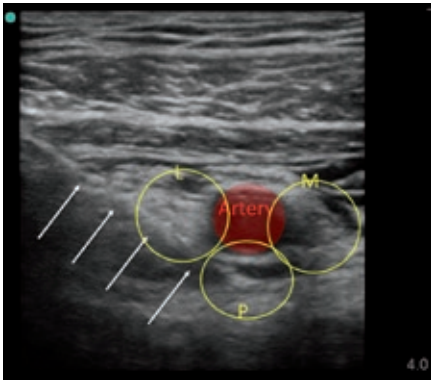


Figure 25.15 The needle shaft and tip are seen approaching the desired 6 o'clock position posterior to the SA, with the hypoechoic lateral, medial and posterior cords. Source: With compliments of FUJIFILM SonoSite, Inc.

E. MEDICAL CONSIDERATIONS

26. TROPICAL DISEASES

As an anaesthetist working with the ICRC, you will encounter tropical diseases as a comorbidity complicating your anaesthetic management and as a reason for surgery. This chapter outlines some of the main anaesthetic considerations in connection with the more common tropical diseases. It is not exhaustive and you are advised to find out at briefing or from the Global Burden of Disease website (www.healthdata.org/gbd) which diseases are endemic to the area in which you will be working.

26.1 MALARIA

Malaria is extremely common and may vary in severity from fever alone to severe complicated malaria.

- In the elective setting, malaria should always be treated before embarking on surgery.
- In the emergency setting, surgery should be delayed if at all possible. The risks are much higher in patients suffering from severe complicated malaria.

Malaria in children and pregnant women tends to be more severe.

ANAESTHETIC CONSIDERATIONS

Fever: You should have a high index of suspicion for malaria in any endemic area as it is a very common cause of perioperative fever. Rapid checks are quick and easy to carry out.

Anaemia: It may be acute and severe, leading to rapid decompensation. Use packed cells to correct if possible because of the risk of pulmonary oedema.

Pulmonary oedema: Increased risk of fluid overload. Resuscitation fluids should be given more cautiously.

Renal impairment: Pre-renal and acute tubular necrosis and nephrotic syndrome may be seen. Monitor fluid balance closely. (Black water fever is massive haemolysis and haemoblobinurea in response to quinine treatment.)

Cerebral oedema and symptoms of raised ICP secondary to vascular occlusion by parasites: Patients may have fits. Be careful with fluid resuscitation, consider an anaesthetic technique that will allow ETCO2 to be well controlled, and ensure free venous drainage from the head – tube ties, head up, etc

Hypoglycaemia: Regularly check BM; glucose may be required.

Liver impairment: Jaundice (due to liver dysfunction as well as red cell haemolysis). Drug handling may be impaired. Avoid halothane if possible because of its potential hepatotoxic effects.

Abdominal pain: it may mimic the acute abdomen.

Splenomegaly is common and may be a cause of pain; increased risk of splenic rupture. It may also cause anaemia and thrombocytopaenia.

Coagulopathy: You are unlikely to be able to carry out a clotting screen but do consider the risk of a coagulopathy when weighing up the risks of using a neuraxial technique.

Co-infection: Patients may have a functional splenectomy and are more at risk of bacterial infections.

Quinine: potentiates non-depolarizing neuromuscular blockade.

26.2 TUBERCULOSIS

Tuberculosis can mimic virtually any condition and can affect any part of the body. It may be the reason why the patient is taken to the operating theatre: lung resection, lymph node biopsy, drainage of tubercular abscesses, bowel obstruction. There are a number of implications for the anaesthetist.

Malnutrition, chronic anaemia and cachexia are common, with consequences for poor healing and increased post-operative infection.

Lungs: Function may be impaired; there may be an effusion or a pneumothorax.

Spine: There may be deformity and/or an abscess. Careful examination is needed prior to neuraxial techniques.

Pericardium: effusion and constrictive pericarditis, more common in patients who also have HIV

CNS: abscesses – ETCO2 control

Co-infection with HIV is common.

Anti-TB therapy: may cause liver damage and alter drug handling, generally inducing cytochrome P450 system and increasing the rate of metabolism. Halothane hepatitis is thought to be more common.

Infection control: Theatre staff should wear protective face masks (HEPA or N95). An HME filter is sufficient to protect the circuit, preferably one at the patient end and one at the machine end. If possible, the circuit should be cleaned after the case and the case should be dealt with last on the list.

26.3 HIV

General state is usually poor: Malnutrition, anaemia and concomitant infection with TB are common.

Lungs: PCP and cryptococcal infections are commonly found with severe effects on lung function.

Kaposi's sarcoma: can be found in the oropharynx and periglottic area and may lead to difficult intubation.

Retroviral treatment potentiates neuromuscular blockers and decreases the metabolism of benzodiazepines and pethidine. Care must be taken with dosing.

Avoid blood transfusion unless absolutely necessary as the CD4 count decreases faster after transfusion owing to the immunosuppressant effect of blood transfusion.

26.4 TYPHOID

Patients with typhoid may present for surgery with an acute abdomen secondary to bowel perforation. They are usually extremely septic with severe dehydration secondary to diarrhoea. They may have the classic rose spots. They have a relative bradycardia, which can be more pronounced under anaesthesia and may require treatment with atropine. Patients may have a myocarditis.

In surgery there are usually multiple perforations and the surgery is prolonged and difficult.

Consider the possibility of typhoid in any severely septic patient presenting with bowel perforations. Take appropriate infection control measures.

26.5 WORMS

Intestinal worms are extremely common. They may be a cause of malnutrition and anaemia. It is common practice to treat any child with malnutrition and anaemia for presumed intestinal parasites.

Worms may cause intestinal obstruction requiring surgery and are quite commonly seen intraoperatively for unrelated bowel procedures. Any that are seen should be removed and any anastomosis should be over-sewn an extra time as worms can escape through the anastomosis, causing leaks.

26.6 HYDATID DISEASE

As an anaesthetist, you may be involved in the management of people with hydatid disease, either in surgery for resection of hydatid cysts or in the emergency room for management of anaphylaxis. Anaphylaxis occurs if the contents of a hydatid cyst escape into the circulation – either during surgery or because of cyst rupture. Usual anaphylaxis management is needed. There is no evidence that pre-treatment with antihistamines helps.

- Tropical disease is common in ICRC situations. It is important both as the reason for surgery and as a potential negative influence on anaesthesia and perioperative care.

References

1. Brent, A., Davidson, R., and Seale, A., *Oxford Handbook of Tropical Medicine*, 4th edition, Oxford University Press, Oxford, 2014.

27. TETANUS

Tetanus is a toxin-mediated disease from clostridium tetani introduced into wounds. High fatality rate of 10-80% even with modern ITU. Incubation period: 3-21 days; the shorter the incubation period, the more severe the disease. Outbreaks of tetanus are well documented after earthquakes, tsunamis and in field hospitals with poor sterilization practices.

27.1 CLINICAL FEATURES

Muscle rigidity and painful muscle spasms, often begins in the jaw (lockjaw) and face, with the characteristic *risus sardonicus*. Spasms are triggered by sensory stimuli, become more generalized and death is usually due to respiratory failure in the absence of ventilatory support. Autonomic instability may also occur, producing hypertension, hypotension and tachy and brady arrhythmias.

27.2 DIAGNOSIS

Diagnosis is clinical; there are no laboratory tests.

27.3 TREATMENT

General measures: Keep the patient in a quiet, dimly lit location and reduce stimuli as much as possible. Extensive cleaning and debridement of all wounds is crucial. Ketamine anaesthesia should be avoided if possible as it can often cause restlessness and hallucinations, which can precipitate spasms. Regional anaesthesia via central neuroaxial blocks or peripheral nerve blocks provide important alternative anaesthetic strategies.

Immunotherapy: The ICRC's war surgery manual contains guidance on the management of all war wounds, whatever their immunization status. This includes giving:

- human tetanus immunoglobulin (immunoglobulin against toxin) 500 IU IM (adults) or 250 IU (children under 15 years of age) – also known as human anti-tetanus serum;

- tetanus toxoid vaccine (inactivated tetanus toxin) 0.5 ml IM, to be repeated at four weeks and again at six months.[2]

The manual offers further advice on the treatment doses of immunotherapy in tetanus. This includes giving:

- anti-tetanus human immunoglobulin (3,000 – 10,000 IU) as a single large dose given intravenously and as soon as possible. The actual dose ordered is dependent on the severity of the disease and the age of the patient. It is diluted in 20 ml of normal saline and given slowly over a period of 15 minutes. In some regions, human immunoglobulin is in short supply or not available at all. In these circumstances, one must rely on equine anti-tetanus serum. A test dose must be administered before giving the full dose (20 000 IU).[2]

Antibiotics: Against clostridium. Metronidazole 500mg qds IV. Erythromycin and penicillin G are also active against clostridia.[2]

Muscle spasm control: **Diazepam** 5 mg IV titrated to control spasms without excessive sedation (children 0.2 mg/kg every 2 hrs titrated). Large doses may be required – up to 600 mg/day. **Magnesium** 5 g slow IV loading dose (75 mg/kg children) then 1-2 g/hr until spasms are under control may be used as an alternative or as an adjunct to diazepam. The combination works best to reduce excessive sedation. Monitor the patellar reflex. **Baclofen** may also help.

Autonomic dysfunction: **Magnesium** as above. Do not use B blockers as they can cause hypotension and sudden death.

Airway: This is of the utmost importance given the aspiration risk. Early tracheostomy may well be required, especially if persistent laryngospasms are a problem.

Fluids and nutrition: Tetanus spasms result in high metabolic demands and a catabolic state. An ng tube may need to be passed if the patient is unable to eat. This should only

be done once spasms are well controlled as there is a risk of laryngeal spasming.

Treatment is likely to be needed for 1-2 weeks. Good nursing and medical care can reduce mortality by 50% even without access to mechanical ventilation.

- Following a crisis, there is a significant threat from clostridium tetani.
- Established tetanus has a high mortality, potentially exacerbated by limitations in the field of intensive care.
- Despite the challenges, good basic care can have a positive impact on survival.

References

1. Taylor, A.M., "Tetanus", *Continuing Education in Anaesthesia, Critical Care & Pain*, Vol. 6, No. 3, June 2006, pp. 101-104.
2. Giannou, C., and Baldan, M., *War Surgery,* Vol. 1, ICRC, Geneva, 2009.

28. CHRONIC DISEASE MANAGEMENT

One of the challenges in the perioperative management of patients in the austere environment is what to do about chronic disease management. The traditional view has been that patients presenting for surgery tend to be otherwise young and fit and that it is not a major issue. However, conflict situations are occurring increasingly in countries that previously had well-developed medical care, longer life expectancies and more Western diets and where patients were previously on medication.

Common conditions which may be diagnosed on the patient's admission to hospital include hypertension and diabetes.

With the other members of your team, including the hospital project manager and country health coordinator, and in consultation with health unit at ICRC headquarters, you need to decide whether you have the drugs to treat these chronic diseases and if so, whether you will treat them. If you do decide to treat them, will you treat them just for the duration of the patient's stay in hospital or over the long term? It is important for this decision to be taken at the programme level.

If the decision has been made to treat over the long term, a few other questions also need to be considered:

- How is this condition normally managed in this country?
- When the ICRC leaves, will the patient still have access to this medication?
- Does the patient have to pay for the medication and if so, can they afford it?
- Is there anyone to monitor the effects of the treatment, e.g. BP and BM monitoring?

- Am I creating a demand for a service without the availability of the necessary resources? Can I do this for every patient?

There are no right or wrong answers to these questions. In some contexts it may be entirely reasonable to manage these conditions, while in others it may simply not be possible. Chronic disease management will depend on the circumstances of the mission. It is important to remember that decisions regarding chronic disease management should not be taken on a patient-by-patient basis or even at the local level alone; the country health coordinator and the ICRC health unit should be involved. Having said that, even in the absence of medication, lifestyle advice can be given, meaning that it is still worth discussing the diagnosis with the patient.

- Chronic disease may be considered as the "boundary" between classic ICRC activity and medical care provided by the host nation. There are no textbook solutions for an ICRC anaesthetist's role in managing long-term health issues.

29. CRITICAL CARE

Critical care is one of the most challenging areas in the austere environment. There is a large gap between what you can provide at home and what can be done in the field. At the same time, the stakes are very high.

Decisions regarding the level of critical care provided in the ICRC hospital projects in which you will be involved will often have been made prior to your joining the project. Those decisions should be respected. If during your mission you have questions or difficulties regarding the level of critical care provided for patients, they should be discussed with the hospital project manager and if necessary, taken up with the country's health coordinator.

Some useful questions to ask yourself and your colleagues when joining a project include the following:

Where is my critical care area?

A dedicated area may have already been set up, often called the "high dependency unit" in ICRC structures. It will be either a stand-alone unit or a separate area on the ward, in the emergency room or in the recovery area. If such an area has not already been designated, you should discuss this with the hospital project manager, recommending that one be set up. The recovery area is usually the most convenient for you but you need to bear in mind what will happen when you are not there and theatres are not running – will the nursing staff stay with the patient?

What equipment do I have?

An ideal minimum requirement would be suction, an O_2 concentrator, a pulse oximeter and a sphygnomanometer. Be very cautious of more complex equipment and check it carefully. Ventilators frequently do not work correctly. Infusion pumps may not run at the correct speed; test them with a stopwatch and a syringe of saline.

Who are my staff?

The staff are the most important aspect of your critical care area. What training do they have; how exhausted are they; how motivated are they? Are they expected to do anything else? Even in the absence of the usual technology and drugs, excellent results can be obtained for patients with meticulous attention to detail and very good nursing care.

What normally happens with these patients?

This is a very important question to ask. It gives you useful information about local expectations and capabilities. It is important to plan in advance for what you will do with the more common types of critical care patient, e.g. head injuries, severe burns, cerebral malaria and tetanus. The plan needs to be understood and agreed with both international and national staff as well as with the hospital project manager. Plans may include ongoing management in your own hospital, with or without intubation, or transfer to another facility.

What are the cultural expectations regarding end-of-life care?

In some cultures any sort of withdrawal of care is unacceptable, i.e. once an ET tube is down, it cannot be removed; once on a ventilator, the patient cannot be disconnected. When making decisions with limited resources, it is important for these aspects to be understood and taken into consideration.

29.1 DECISION TO INTUBATE

The decision to intubate/ventilate for critical care reasons is a very difficult one in the austere environment. It is usually reserved for specific, reversible, short-term conditions only. Some possible indications include:

- Airway compromise (fractures, burns, tetanus) prior to tracheostomy;
- To facilitate transfer to another facility;
- Prior to theatre if an extradural is clinically diagnosed;
- Anaphylaxis;

- Suxamethonium apnoea;
- As a post-operative, short-term (few hours) measure to allow warming and filling prior to extubation

It is unlikely that anyone other than you will have the skills to manage a patient on a ventilator; surveillance for the patient in your absence will therefore be poor. You will be unable to manage a ventilated patient safely for longer than a few hours without compromising the care of other patients. For these reasons it is extremely unlikely that it will be appropriate to intubate and ventilate a patient to manage respiratory failure, organ failure or head injury.

29.2 TRANSFER

Critical patients can sometimes be transferred. It is important to be aware of the available facilities to which they can be sent, the quality of care in the referral facility, its willingness to accept patients from your hospital, its distance from your hospital and the practicalities of transferring patients (transport, security, escort) as well as to consider who will bear the costs of the transfer and subsequent care and the costs of the carer who must accompany the patient and to know whether transfer is acceptable to the family in the light of the above.

The answers to all these questions except the last one must be clear before patients are admitted.

- In the ICRC environment the clinical decision to offer critical care to a patient must always be balanced against local logistical and cultural realities.
- In particular the risk vs benefits of endotracheal intubation and ventilation must receive very careful scrutiny.

References

1. Singer, M., Webb, A., *Oxford Handbook of Critical Care*, Oxford University Press, Oxford, 2009.

F. ANNEX

ANNEX 1: ICRC ANTIBIOTIC PROTOCOL

ICRC ANTIBIOTIC PROTOCOL

FOR ADULTS WITH WEAPON WOUNDS

ICRC

PROPHYLAXIS

Loading doses – administer < 60 min. before surgery and continue for 2 days.

- Penetrating craniocerebral wounds

  CEFTRIAXONE 2 g IV 1x/day
  in a shot with 10 ml water for injection

- Eye and maxillofacial wounds affecting a cavity (nasal, oral, sinus)

  CEFAZOLIN 2 g IV
  in a shot with 10 ml water for injection

  - Single dose
    - Surgery or delayed primary closure on minor soft-tissue wounds
    - Chest-drain placement for haemothorax
  - 2x/day
    - Amputations
    - Open fractures
    - Major soft-tissue wounds

    < 72hrs

    + METRONIDAZOLE 500 mg IV 3x/day
    over 30 min.

    + GENTAMICIN 5 mg/kg IV 1x/day
    in 50–100 ml of 0.9% NaCl, over 30 min.

    - Eye and maxillofacial wounds not affecting a cavity
    - Amputations
    - Open fractures
    - Major soft-tissue wounds

    > 72hrs

    - Injuries to limbs from anti-personnel mines
    - Abdominal wounds

TREATMENT

- Sepsis
  Initial treatment if no antibiogram available

- Sepsis
  2nd line of treatment

  MEROPENEM 1 g IV 3x/day
  in 100 ml 0.9% NaCl, over 15–30 min.

- Sepsis
  3rd line of treatment

  + VANCOMYCIN 1 g IV 2x/day
  in 10 ml water for injection
  + 100–500 ml of 0.9% NaCl, over 2hrs

ICRC ANTIBIOTIC PROTOCOL

FOR CHILDREN WITH WEAPON WOUNDS

ICRC

PROPHYLAXIS

Loading doses – administer < 60 min. before surgery and continue for 2 days.

- Penetrating craniocerebral wounds

CEFTRIAXONE 80 mg/kg IV 1x/day

- Eye and maxillofacial wounds affecting a cavity (nasal, oral, sinus)

CEFAZOLIN 25 mg/kg IV
Children > 1 month

Single dose

3x/day

+ METRONIDAZOLE 7.5 mg/kg IV 3x/day

+ GENTAMICIN 7.5 mg/kg IV 1x/day
Children > 10 years = Adult dose

- Surgery or delayed primary closure on minor soft-tissue wounds
- Chest-drain placement for haemothorax

- Amputations
- Open fractures
- Major soft-tissue wounds

< 72hrs

- Eye and maxillofacial wounds not affecting a cavity

- Amputations
- Open fractures
- Major soft-tissue wounds

> 72hrs

- Injuries to limbs from anti-personnel mines
- Abdominal wounds

TREATMENT

- Sepsis
  Initial treatment if no antibiogram available

- Sepsis
  2nd line of treatment

MEROPENEM 15 mg/kg IV 3x/day
Children > 3 months

- Sepsis
  3rd line of treatment

+ VANCOMYCIN 15 mg/kg IV 3x/day

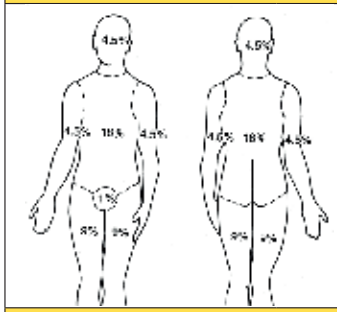
ANNEX 2: ICRC BURNS OVERVIEW

BURNS OVERVIEW

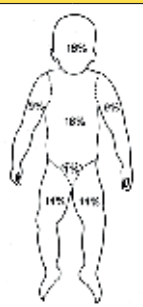
FOR HOSPITAL STAFF

ICRC

SIMPLIFIED CALCULATION OF THE PERCENTAGE OF TOTAL BODY SURFACE AREA (%TBSA)



Adult homunculus for %TBSA



Child homunculus for %TBSA

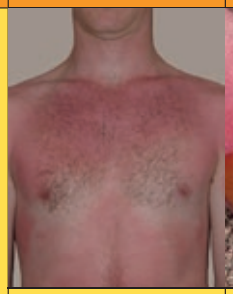
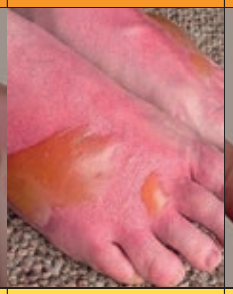
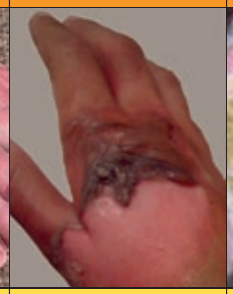
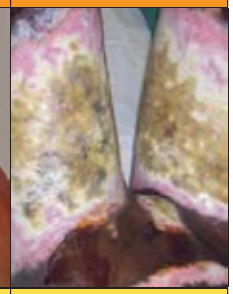
Or use patient's palm to calculate %TBSA
1 palm (without fingers) = 1%TBSA

FLUID REQUIREMENTS IN FIRST 48 HOURS

HOURS SINCE BURN	FLUID REQUIREMENTS	
0–24 HOURS	2 ml/kg x %TBSA of compound solution of sodium lactate (Ringer's lactate), ½ in first 8 hours, ½ in following 16 hours	Target urine output = 0.5 ml/kg/hr
24–48 HOURS	Guided by urine output	

SPECIAL CONSIDERATIONS:

- Burns > 50%TBSA: Use 50%TBSA in above calculation
- Inhalation injury / electric burns: Increased fluid requirements, use 3 ml/kg x %TBSA

	SUPERFICIAL	SUPERFICIAL PARTIAL THICKNESS	DEEP PARTIAL THICKNESS	FULL THICKNESS
SKIN DEPTH	Superficial epidermis	Complete epidermis, superficial (papillary) dermis	Complete epidermis, deep dermis	Complete epidermis and dermis, may extend beyond the dermis
APPEARANCE				
		Erythema, no blisters, dry Erythema, moist, blisters	Blotchy red/pale, extensive blisters, sluggish capillary return, drier than superficial partial-thickness burns	White, charred, leathery, eschar, dry
PAIN	Painful	Painful	Painful / limited pain	Limited/no pain
TREATMENT	First aid	First aid Consider clean-up under anaesthesia Dressing	First aid Clean up under anaesthesia Dressing	First aid Clean up under anaesthesia Debridement Split-skin grafting
		Dressings: Apply 1% silver sulfadiazine (3–5 mm thick) directly by hand on all burned areas, then apply greasy dressing. Cover with sterile compresses (do not encircle limb with one compress) and wrap with loose crepe bandage		
		Provide patient with all appropriate tetanus and, in case of surgical intervention, surgical antibiotic prophylaxis		
HEALING TIME	5–10 days	5–21 days	5–21 days	Months–years
OUTCOME	No residual scarring	Minimal scarring	Scarring	If untreated: severe disfigurement, permanent impairment
SPECIAL COMMENTS	Superficial epidermal burns are NOT included in the assessment of % TBSA burnt			

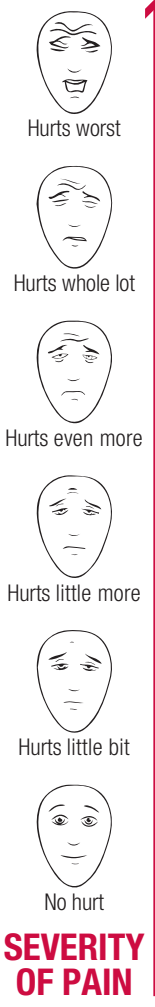
ANNEX 3: ICRC PAIN MANAGEMENT

ICRC

PAIN MANAGEMENT

FOR HOSPITAL STAFF

REVERSED WHO PAIN MANAGEMENT LADDER



SEVERE PAIN	MODERATE PAIN	MILD PAIN
MORPHINE OR FENTANYL	TRAMADOL	PARACETAMOL
MORPHINE IV = 1-2mg dose, titrate to effect S/C or I/M = 5-15mg, every 4 hours PO (fast acting) = 10-20mg, every 2-4 hours FENTANYL IM = 50-100 mcg, 1-2 hourly	IV/PO = 50-100mg, every 4-6 hours Maximum dose = 600mg per day	PO/IV = 1g, every 6 hours
plus PARACETAMOL	plus PARACETAMOL	plus IBUPROFEN
plus IBUPROFEN	plus IBUPROFEN	PO = 200-400mg, every 8 hours **Contraindications** Dehydration / Haemorrhage Renal impairment / Asthma Pre-eclampsia / History of peptic ulcer

FOR USE IN THE RECOVERY AREA/HIGH DEPENDENCY UNIT

In the post-op period consider: PERIPHERAL NERVE BLOCKS

FOR USE ON THE WARDS

NEUROPATHIC PAIN
If residual neuropathic pain: CARBAMAZEPINE
PO = Initially 100mg, every 12 hours. Dose can be increased by 100mg every 12 hours. Maximum dose = 1200mg per day

MISSION

The International Committee of the Red Cross (ICRC) is an impartial, neutral and independent organization whose exclusively humanitarian mission is to protect the lives and dignity of victims of armed conflict and other situations of violence and to provide them with assistance. The ICRC also endeavours to prevent suffering by promoting and strengthening humanitarian law and universal humanitarian principles. Established in 1863, the ICRC is at the origin of the Geneva Conventions and the International Red Cross and Red Crescent Movement. It directs and coordinates the international activities conducted by the Movement in armed conflicts and other situations of violence.

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