Anaesthesia for trauma patients

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Keywords: anaesthesia, trauma patients, challenges

S Afr Fam Pract 2012;54(3)(Suppl 1):S2-S6

Introduction

Anaesthesia for trauma patients presents unique challenges for anaesthetists. Most urgent cases occur at night or during weekend shifts, when more experience anaesthetists are not available. Patient information is limited, and previous medical history and details of chronic medication, allergies, or genetic abnormalities, are unknown.

Patients often present intoxicated, with a full stomach, and with the potential for cervical spine instability. Patients often have multiple injuries, requiring several procedures, sometimes in different positions. A difficult airway is not unusual, and special airway management equipment may be required at short notice. Occult injuries, such as tension pneumothorax or cardiac tamponade, can manifest at unexpected times.

The management of trauma patients may require the participation of a multidisciplinary team, namely a trauma surgeon, orthopaedic surgeon, neurosurgeon, plastics surgeon, vascular surgeon, radiologist, laboratory technician, blood bank technician, intensivist, and of course, the anaesthetist, who will continue the resuscitation, already in progress, and whose role is fundamental to the final outcome of the patient. Trauma patients often present as emergencies in small community hospitals with limited resources, where the multidisciplinary team is all but absent.

This review provide an overview of important areas of trauma care for the anaesthesiologist. It begins with the principles of initial resuscitation, followed by discussion of emergency airway management, induction of general anaesthesia, and new concepts regarding the management of acute and massive bleeding.

Initial resuscitation

In South Africa, the Advanced Trauma Life Support (ATLS) principles of resuscitation are followed.

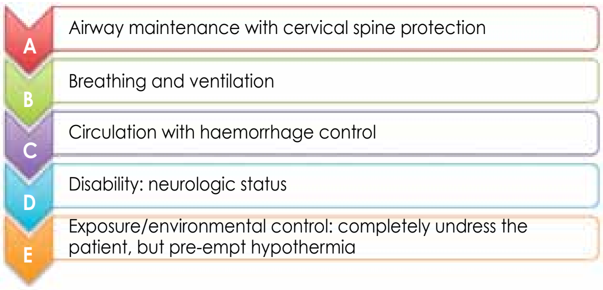

Figure 1: Advance Trauma Life Support® management priorities

These principles provide anaesthesilogists with an organised approach, and can be remembered in a simple way: A, B, C, D, E (Figure 1).

By using this key, anaesthesiologists are able to identify and treat life-threatening injuries first during the "primary survey", and to later proceed to a more detailed patient physical examination, from head to toe, using the "secondary survey".[1]

Surgical priorities are important elements to remember in the management of trauma patients. The anaesthetist is expected to triage patients scheduled for emergency operations during a busy weekend call, a massive casualty incident, or a natural disaster. The anaesthetist plays an important role in determining which procedures will be performed; in which order, and which procedures should rather be postponed until the patient is more stable[2] (Figure 2).

Airway management

Trauma to the face and neck can cause airway compromise, which may result in a life-threatening situation. The scenario is very different from the patient who arrives for an elective procedure, when there is enough time for adequate airway assessment and planning.

The presence of blood, secretions or tissue oedema, in addition to the potential for injury to the cervical spine, a full stomach, and the urgency of the situation, makes the airway management of such patients very challenging.

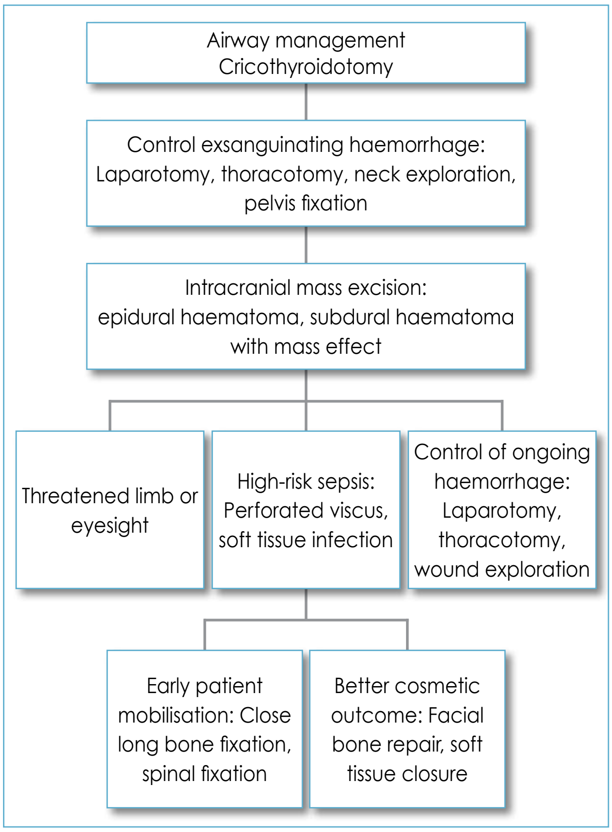

Figure 2: Surgical priorities in trauma patients

It is important for the anaesthesiologist to be familiar with the available equipment and airway management strategies. The ability to improvise under stressful, and often rapidly changing, circumstances, is required.[3]

The well known American Society of Anesthesiologists' (ASA) algorithm for the management of difficult airways in trauma patients can be used. However, some modifications have been made to adapt it to unstable trauma patients, where reawakening the patient is not an option because of the need for emergency airway control (Figure 3).[4]

Anaesthetists working in high-volume trauma centers should determine their own algorithm, based on available skills and resources. The surgeon must always be present during the induction, ready to perform an expeditious cricothyroidotomy.[4]

Blunt trauma victims are always assumed to have an unstable cervical spinal, until proven otherwise.

It is very important for the anaesthesiologist to maintain in-line immobilisation of the cervical spine at all times, especially during the laryngoscopy and intubation. Failure to do so may exacerbate the spinal cord injury, with disastrous consequences.

Ideally, four providers are required to intubate these patients, namely:

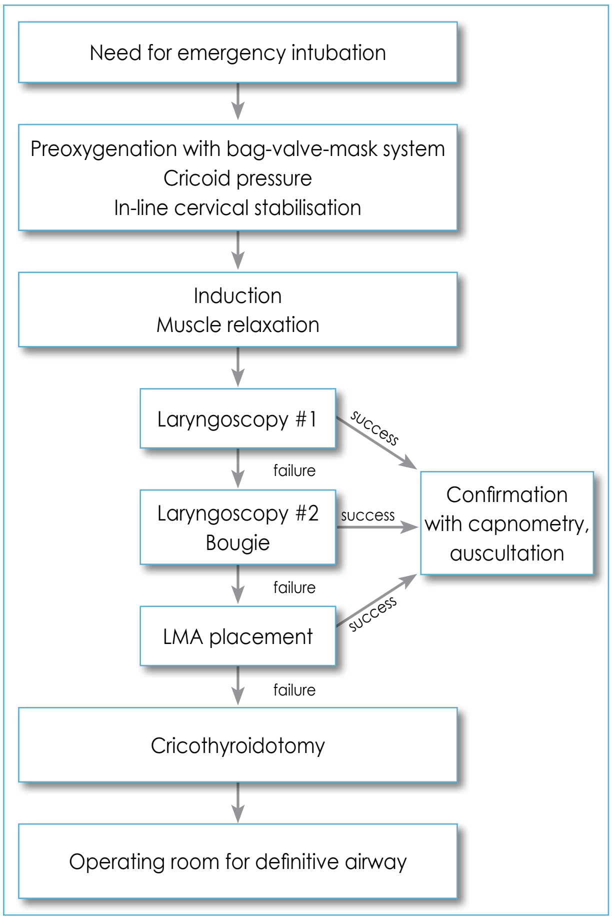

Figure 3: Emergency airway management algorithm used at the R Adam Cowley Shock Trauma Center[4]

- *Nurse 1*: Hold the neck, and provide in-line cervical stabilisation.
- *Intubating physician*: Hold the mask, perform laryngoscopy, intubation and ventilation.
- *Nurse 2*: Maintain the cricoid pressure.
- *Physician 2*: Administer the anaesthetic medications.

Once the airway has been secured (endotracheal tube position checked, and the cuff inflated), the neck immobilisation devices should be returned in position.[1,4]

Induction of general anaesthesia

There is no ideal anesthetic drug for patients with haemorrhagic shock. The key to safe anaesthetic management of shock patients is to administer small incremental doses of whichever agents are selected.

Propofol and thiopentone may potentiate profound hypotension. Both drugs are vasodilators, and both have a negative inotropic effect. Etomidate is widely used in the trauma population because of its cardiovascular stability, relative to other induction agents. However, etomidate may still produce profound hypotension due to its inhibition of catecholamine release. Another undesirable effect of etomidate is adrenocortical suppression. This had led to many trauma centres abandoning its use in the trauma setting. Ketamine is very popular for the induction in trauma patients. However, it is also a direct myocardial depressant. In normal patients, the effects of catecholamine release mask cardiac depression and result in tachycardia and hypertension. In patients with severe haemorrhagic shock, the cardiac depression may be unmasked, and lead to cardiovascular collapse.[4]

Maintenance of anaesthesia can be achieved with intermittent, small doses of ketamine (25 mg every 15 minutes), which is usually well-tolerated, a low concentration of a volatile agent (< 0.5 MAC), a muscle relaxant (usually rocuronium or vecuronium), and titrated doses of fentanyl (1-3 µg/kg).[6] Small doses of midazolam may be used to reduce the incidence of patient awareness.

Fentanyl is the opioid of choice in trauma patients, due to its minimal effects on haemodynamic status.

Succinylcholine remains the neuromuscular blocker with the fastest onset (30 seconds) and shortest duration of action. Therefore, it is the agent of choice for rapid sequence induction (RSI), and is especially indicated in trauma patients presenting for an emergency procedure with a potentially full stomach.

However, succinylcholine's side-effects can be disastrous in trauma patients.

Special considerations include:

- Increases in serum potassium. Use cautiously in burn victims (after first 24 hours) and in patients with crush injuries (before and after reperfusion).
- Increased intraocular pressure, use cautiously in patients with intraocular trauma.
- Increased intracranial pressure (ICP): In patients with head injury; the risk must be weighed in each individual situation. The damage caused by hypoxia and possible aspiration must be weighed against the transient increase in ICP.[4]

Rocuronium can be used safely during RSI (1 mg/kg), with an onset of relaxation of 60 seconds. Unfortunately, at this dose the duration of action will be of one to two hours.[7]

An exciting development is that this profound block can be immediately reversed with sugammadex, which is not available in South Africa yet.

Management of massive haemorrhage

The need for speed in severely injured patients is to avoid the trauma of the "lethal triad" (Figure 4).

Hypothermia is defined as a core temperature of less than 35°C. In trauma patients, hypothermia may result

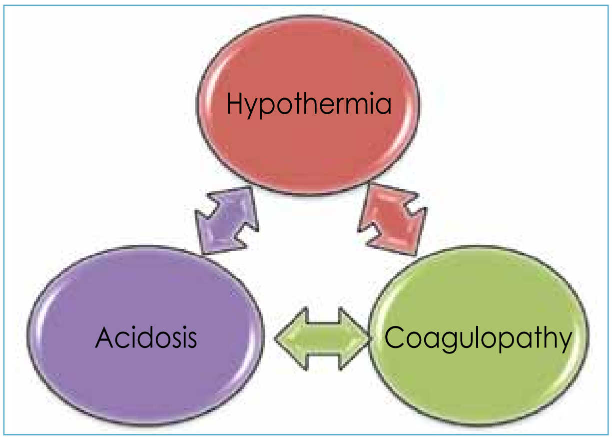

Figure 4: The "lethal triad" of trauma: hypothermia, coagulopathy and acidosis

from net patient heat loss, from external exposure, open body cavities (laparotomy, and thoracotomy), cold fluids administration during resuscitation, and blood loss.[8]

There is a linear relationship between mortality and the degree of hypothermia. As the body temperature drops, there is a prolongation of coagulation mechanisms. Temperature-dependent enzymatic reactions, that constitute the coagulation cascade, become ineffective. Platelet dysfunction also occurs.

Resuscitation with crystalloids and colloids also contributes to coagulopathy due to the dilution of coagulation factors and platelets.

Metabolic acidosis occurs as result of lactate overproduction from ischaemic tissues during hypovolemic shock. Acidosis causes cardiac arrhythmias and inotropic unresponsiveness to cathecholamines, and is also linked to coagulopathy.

All efforts during resuscitation should focus on reversing the acidosis, hypothermia and coagulopathy, as the vicious circle of the lethal triad is invariably fatal.[8,9]

Simple ways to prevent and treat hypothermia are as follows: All intravenous fluids should be pre-warmed through a warming device, the solutions that are used to wash the body cavities should be warm, the patient should be covered with warm blankets whenever possible, forced hot air warming (Bair Hugger®) can be used, and the theatre environment should be kept warm.

Damage control resuscitation

Damage control resuscitation (DCR) is a strategy that combines the techniques of permissive hypotension, haemostatic resuscitation and DCS (Figure 5).[10,11]

Permissive hypotension

Before definitive haemostasis, vigorous fluid administration increases the rate of bleeding from injured vessels. Elevation of blood pressure leads to increased bleeding as

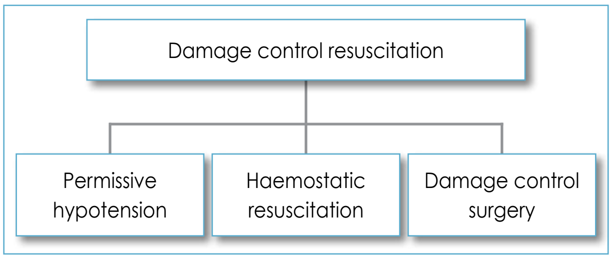

Figure 5: Components of damage control resuscitation

a result of disruption of clots and reversal of compensatory vasoconstriction ("pop the clot" phenomenon). The result of aggressive fluid administration is often a transient rise in blood pressure, followed by an increase in the rate of haemorrhage and a subsequent deterioration, which in turn begets further fluid administration, leading to the "bloody vicious cycle" of hypotension, fluid bolus, re-bleeding, and deeper hypotension.

The goal of permissive hypotension is to maintain the systolic blood pressure in the range of 80-100 mmHg, deferring or restricting fluid administration until haemorrhage is controlled, while accepting a limited period of suboptimal end-organ perfusion.

Currently, permissive hypotension is contraindicated in patients with severe head injuries where maintaining cerebral perfusion pressure is a priority.[12,13]

Haemostatic resuscitation

Treatment of coagulopathy associated with major injury is now recognised as central to improve outcome. Strategies include a limited amount of crystalloids and colloids, administration of fresh frozen plasma, platelets, cryoprecipitate, fibrinogen concentrate, tranexamic acid and calcium replacement.

Recombinant factor VIIa should be reserved as a rescue therapy for refractory coagulopathy.[11] Tranexamic acid should be considered for the treatment of trauma-induced hyper-fibrinolysis, and should be administered within three hours of onset of treatment. This practice substantially reduces transfusion requirements and improves outcomes.[14]

The profound impact of coagulopathy mandates timely treatment. Commonly available diagnostic tests are inappropriate for guiding treatment owing to their poor sensitivity and the delay in obtaining results, so the decision to initiate clotting factor replacement is often a clinical one.

Whole blood viscoelastic tests such as thromboelastometry (ROTEM) or thromboelastography (TEG) allow a more accurate assessment of trauma-induced coagulopathy, and are substantially faster than the standard coagulation test.

Table I: Damage control shock resuscitation: the 10 "must do's"

1.	Shock packs with 1:1:1 ratios
2.	Resus with limited systolic blood pressure of 90 mmHg
3.	Limited crystalloid use
4.	Avoid vasoconstrictors
5.	Anti-fibrinolytics
6.	Calcium (target > 1.0)
7.	Potassium (treat hyperkalaemia actively)
8.	Factor VIIa (NovoSeven®)
9.	Fresh whole blood
10.	Avoid hypothermia (< 36°C)

The goal-directed therapy approach is based on the combination of viscoelastic tests and target coagulation therapy according to the patient's needs, and aims to maintain or restore clot strength by early transfusion of haemostatic agents.[15-17]

Massive blood transfusion protocols

Massive blood transfusion is defined as the replacement of the whole blood volume within 24 hours, or 50% of the blood volume in three hours.

The need for massive blood transfusion protocols have been shown to improve survival, prevent waste of limited resources, avoid errors, and improve delivery of products in a timely fashion to the point of care.

Current evidence justifies the use of transfusion of fresh frozen plasma (FFP):red blood cell (RBC):platelets ratios of 1:1:1, in the resuscitation of severely bleeding patients.[13,18,19] In South Africa, mega-units of pooled platelets are used. Therefore, one mega-unit should be given for every six units of RBC and FFP given. However, due to blood and blood product shortage, this is not always possible. Ratios approaching 1:2 or even 1:3 are also shown to reduce mortality.[20]

In our institution, we recently implemented a massive blood transfusion protocol, which we have adapted according to our resources and products availability.

Damage control surgery

DCS has been established as the standard of care in severely injured patients. The concept arose from the fact that a patient who is bleeding profusely doesn't have the physiological reserves to survive complex and prolonged surgery. The aim of DCS is to control all sources of haemorrhage and gastrointestinal contamination in the quickest way possible.

Resuscitation is then continued in the intensive care unit, until haemodynamic normality, and normal or acceptable laboratory values, are obtained.

The patient is then returned to the operating theatre for definitive operative control and repair of injuries, usually 24-36 hours after the initial abbreviated procedure.[8,9,21]

Conclusion

Anaesthesia for trauma patients presents unique challenges for the anaesthetist. Anaesthetists working in high-volume trauma centers should determine their own difficult airway management algorithm based on available skills and resources. There is no "ideal" anesthetic drug for patients with haemorrhagic shock. The key to the safe anesthetic management of shocked patients is to administer small incremental doses of whichever agents are selected.

All efforts during resuscitation should focus on reversing the acidosis, hypothermia and coagulopathy, as the vicious cycle of the "lethal triad" is invariably fatal. DCR is a strategy that combines the techniques of permissive hypotension, haemostatic resuscitation and DCS. Currently, DCR is accepted worldwide as the standard of care in the management of severe trauma victims. Massive blood transfusion protocols should be implemented in each trauma centre, and can be adjusted according to resources and blood product availability.

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