Update in Anaesthesia

Stabilisation and preparation for transfer in paediatric trauma patients

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Summary

Stabilisation of paediatric trauma patients and preparation for transfer of these patients, should follow the same principles as when dealing with adult patients in similar circumstances. Attempting to return physiology to normal as soon as possible and transferring in a safe and timely fashion to a hospital with the appropriate facilities to provide the best possible care, will allow for the best outcomes after paediatric trauma.

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INTRODUCTION

The principles of trauma management in paediatric patients are the same as those that apply to adults who have been involved in trauma. These principles are those taught in courses such as Advanced Trauma Life Support (ATLS), European Trauma Course and Primary Trauma Care.

This article will focus on recent developments in trauma management and in the stabilisation of the traumatised patient. Many of these come from experience gained from the military. It is important to note that many of these developments have occurred in relation to patients with penetrating trauma and the lessons may not apply in the same way to blunt trauma.

STABILISATION

Patients who have suffered significant trauma are likely to require stabilisation as part of their treatment. This may either be as part of their definitive treatment or, in smaller units, prior to their transfer to a larger trauma centre or hospital with specialist facilities. Patients should be as stable as possible prior to transfer in order to reduce the risks of a complication occurring during transit.

In order to stabilise the patient it is important to consider what is happening at a physiological level.

Massive haemorrhage caused by trauma is associated with poor tissue perfusion, which leads to multi-organ dysfunction and death. Stabilisation of a trauma patient will involve restoration of normal physiology as soon as possible in order to maintain adequate organ perfusion and so minimize damage and improve outcome.

Coagulopathy, acidosis and hypothermia are termed 'the lethal triad of trauma' (Figure 1). This term is used to describe factors in major trauma that, if present, are associated with increased risk of death.

Coagulopathy

Approximately one third of trauma patients have a coagulopathy on admission to hospital, and these patients have a worse outcome than patients without a coagulopathy.[1] Therefore treatment of major trauma should involve identification of any coagulopathy.

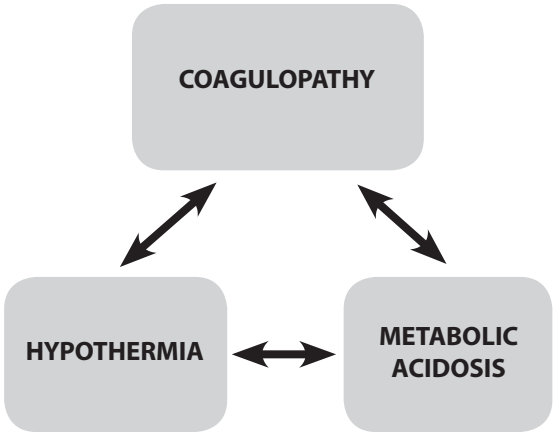

Figure 1. *The lethal triad of trauma*

Management of coagulopathy, as part of management of massive transfusion, will be discussed in a separate article in this journal.

Acidosis

Acidosis is associated with poor tissue perfusion and will be associated with a low pH, high base deficit (negative base excess) and raised lactate on blood gases. If blood gases are not easily available, then other factors associated with poor tissue perfusion should be considered. These clinical markers of poor tissue perfusion include factors such as prolonged central capillary refill time, tachycardia and reduced urine output. Treatment of acidosis in these circumstances involves adequate fluid resuscitation. Where injuries are life-threatening or where fluid requirements are expected to be more than 20ml.kg^{-1} it is best to start fluid replacement using blood products wherever available. Restoration of circulating volume to provide adequate tissue perfusion and thus allow resolution of the acidosis is the aim here, so if blood is not available, use crystalloids instead. Where hypotension is present due to loss of blood volume from haemorrhage, it should be treated by replacing circulating volume in the first instance, not with inotropes or vasoconstrictors, which will only serve to worsen tissue acidosis. Once the patient has adequate tissue perfusion and has become haemodynamically stable the acidosis should begin to resolve.

Hypothermia

Hypothermia is likely to be seen in trauma patients, even in warm environments, and has negative effects on many bodily functions including, for example, causing coagulopathy. It should be actively avoided in major trauma patients and simple treatment solutions adopted. Minimise the exposure of the patient where possible using blankets and covers in the pre-hospital environment and continue this in the emergency department. Use of active warmers, such as forced warm air devices will reduce hypothermia further and can be used to actively warm children if they have become cold despite best efforts. If the operating theatre has temperature control, this should be raised to ensure a warm environment for surgery and if fluid warmers are available these should be used as well. Monitoring of the patient's temperature is important because once children start to warm up it can be easy to overshoot and for the patient to become hyperthermic. This is particularly important in head trauma where hyperthermia worsens secondary brain injury, so every attempt should be made to maintain normothermia. Regular temperature checks should form part of the standard management of these patients.

All parts of the lethal triad should be considered and appropriately managed when treating trauma patients in order to reduce trauma related deaths.

Recent developments in trauma management have considered how to correct the physiological disturbance associated with trauma as quickly as possible, in order to try to reduce multi-organ dysfunction. Whilst many of these involve use of new and technical solutions, which may not be easily available worldwide, the principles behind them can be applied in many situations.

Catastrophic haemorrhage control

Any patient who presents with major trauma has the potential to be unstable, particularly from a haemodynamic perspective. In recent years, it has been recognised that in situations of overwhelming haemorrhage, in order to save life, quick interventions to stop further blood loss need to be undertaken before airway measures. This has led to the development of a new paradigm, changing Airway, Breathing, Circulation (ABC) to <C>ABC with <C> being catastrophic haemorrhage control.[2]

Catastrophic haemorrhage control involves the use of tourniquets to control massive haemorrhage (applied ideally at the point of wounding). Tourniquets are used for any traumatic limb amputation or limb injuries where there is blood loss which would be significant enough to threaten life and which is not controlled by direct pressure. Tourniquets cannot be used in head and neck trauma or to control chest or abdominal bleeding. Other methods of haemorrhage control include direct pressure and the use of novel haemostatic agents such as Quiclot®, Haemcon® and Celox®. Quiclot® is a kaolin based product which initiates the intrinsic coagulation pathway, whilst Haemcon® and Celox® are both polysaccharide based haemostatic agents, which are non-exothermic. If none of these novel agents is available, then direct pressure should be used and can be applied in areas where a tourniquet would not work. If possible use a sterile dressing and if bleeding occurs through the dressing then apply a second dressing over the top of the first, rather than removing the first and disrupting any clot that may be forming. This approach should be used both in the pre-hospital setting and also within the Emergency Department (ED). Controlling catastrophic haemorrhage has resulted in improved numbers of patients surviving who previously may have exsanguinated in the pre-hospital setting.[3]

When using tourniquets, try to apply the tourniquet as close as is feasible to the proximal edge of the wound in order to preserve as much tissue as possible, in particular saving joints where practicable. Ideally tourniquets should be applied directly onto exposed skin to avoid slipping. If one tourniquet adequately tightened does not control the haemorrhage then a second tourniquet can be applied proximal to the first. It is important to remember that a tourniquet which is tight enough to control haemorrhage is going to be painful and that the patient may try to remove it. Reassuring the patient is very important and in paediatric patients parental presence in this situation may be vital. Always bear in mind that that permanent lethal damage can be caused to the tissues distal to the tourniquet, so tourniquets should only be used where the distal limb is not viable or the haemorrhage is life threatening.

In paediatric patients, control of blood loss is vitally important due to the reduced total blood volume in comparison to that of an adult. Whilst commercially available tourniquets may be too large for the paediatric patient, tourniquets can be improvised or adapted to ensure haemorrhage control. Improvised tourniquets may be created by the use of belts or similar devices with cloth used under the tourniquet to act as padding. The same principles apply when using an improvised tourniquet as when using a commercial device. Experience shows that hospital surgical tourniquets are more effective than field tourniquets, even those that are purpose designed. It is therefore appropriate to change to surgical tourniquets as soon after arrival as is felt safe to do so, which will usually be once large bore venous access or an intra-osseous needle is sited and fluids/blood products are available for resuscitation.

Damage control resuscitation (DCR)

This is a term that has been used to describe a systematic approach to trauma management, combining <C>ABC with attempts to minimise blood loss, maximise tissue oxygenation and optimise outcome.[4]

DCR begins with haemorrhage control at point of wounding and continues with use of advanced resuscitation techniques during casualty evacuation. On arrival in hospital this involves the use of a consultant led trauma team and aggressive management of the lethal triad of trauma.

Early use of diagnostic imaging including chest Xray, pelvic Xray, Focused Abdominal Sonography for Trauma (FAST) and CT allows decisions to be made in a timely manner. DCR may involve an early decision to transfer to theatre for 'damage control surgery' if haemorrhage control is difficult, and surgical haemorrhage control is required.

Diagnostic peritoneal lavage (DPL) could be considered if diagnostic imaging is not available, although this is no longer used in areas where the technique of DCR has been developed. DPL has a significant false positive rate and so will result in some unnecessary laparotomies being performed. It is also invasive and there are risks of organ perforation associated with it. However, a positive DPL in a haemodynamically

unstable child with abdominal trauma would be an indication for laparotomy. If there is life-threatening haemorrhage and clinical examination identifies the abdomen as the obvious source, it is appropriate to proceed straight to laparotomy as part of the damage control resuscitation strategy and not waste time preceding this with DPL.

Fluid resuscitation is carried out using blood and blood products instead of crystalloid or colloid. This, as well as correction of coagulopathy as part of management of paediatric massive transfusion, will be discussed in another article within this journal and so will not be covered here. Early use of intra-osseous access, if venous access is not available, should also be considered.

Right turn resuscitation (RTR)

This phrase refers to the movement of the trauma team from the ED into the operating theatre in order to carry out DCR at the same time as surgical haemorrhage control.[5] The intent is to reduce the time needed to restore normal physiology by carrying out resuscitation in the operating theatre at the same time as surgical damage control.

This approach to the most critically injured relies upon having a full trauma team on standby and also an immediately available operating theatre. It may not be possible to replicate this in all hospitals, but the principles can still be used. If a patient is determined to be critically injured, and in need of immediate surgery to control the haemorrhage at the same time as resuscitation, then the decision is made to run the resuscitation in the operating theatre. The entire team from the ED move into the theatre, provide immediate airway control and anaesthesia and continue trauma resuscitation as they would have done in the ED at the same time as the surgeon is obtaining haemorrhage control as quickly as possible. This may include clamping large vessels or performing a thoracotomy. Whilst this is ongoing, the ED consultant and ED team will be present and continuing to run the trauma until stability is achieved.

The decision to begin RTR may be made before the patient arrives in the hospital if reports from any pre-hospital team suggest it is necessary. Alternatively an early decision made by the trauma team leader very shortly after the arrival of the patient ED will optimise the usefulness of this strategy for the most seriously injured trauma casualties.

A team working together to reduce blood loss, particularly of non-compressible haemorrhage, use of blood products to resuscitate the patient and early airway control and ventilation will give the patient the best chance of survival. These new developments when used in combination with the standard principles of trauma management will allow the best possible care to be delivered to the severely injured patient.

PREPARATION FOR TRANSFER

Introduction

The need to transfer children who have been involved in trauma between hospitals is well recognised. Children may need to be moved urgently to specialist centres for treatment, to be moved to larger hospitals for definitive treatment or may need to be repatriated for care closer to home once the need for specialist care is finished. This part of the article will look at the safe management of the transfer of children for emergency or urgent care.

Decision to transfer

When considering the need for transfer a number of questions need to be considered in order to ensure that the right patient is moved at the right time to the right place and with the right team to carry out that transfer safely.

These questions can be considered as a list:

Why?

Where?

When?

How?

Who?

Is it safe?

Why?

This question should focus on "Why are we transferring this child?"

Is this move for urgent care – for example a child with an extra-dural haematoma being transferred for urgent neurosurgery, or could this urgent care be provided in the current location? This can also be thought of as a risk/benefit balance: What are the benefits to the child of being moved at this time and what are the risks associated with the transfer.

It may be that the risks for transferring an unstable child are greater than the benefits of movement to a specialist centre and so the child may need to undergo damage control surgery in order to be made stable enough for the transfer.

Where?

This question should focus on "Where are we moving this child to?"

Is the closest specialist centre the most appropriate to look after this child or may it be more appropriate to move the child to a more distant hospital, but one that has the facilities to provide better care? For example, not all neurosurgical facilities can provide paediatric care and so the local neurosurgical unit may not be the best place to transfer the child to, it may be better to move further to definitive care, if the child is stable enough, rather than transfer to the closest unit and then have a second transfer within a short period of time.

Answering this question requires local knowledge and understanding of the facilities and capabilities of the local units and good communication between departments will allow a critically injured child to be moved to the appropriate location for treatment.

When?

This question should focus on "When is the appropriate time to transfer this child?"

Answering this question will depend on the injuries the child has sustained. A child with a traumatic amputation or significant penetrating abdominal injury is likely to require damage control surgery before they are stable enough to transfer to a specialist centre. This is likely to involve haemorrhage control, airway management, ventilation, massive blood transfusion and warming, as they are being stabilised. Alternatively, a child with a head injury who requires

neurosurgery that cannot be carried out in the local hospital, may have to be transferred before they are "stable" because the only way to stabilise them is at the specialist centre.

How?

This question should focus on "How are we going to carry out the transfer?"

The answer to this question will depend on the methods of transport available. The main alternatives are road ambulance, rotary aircraft (helicopter) or fixed wing aircraft (aeroplane). Access to aircraft may be limited both by availability and also by weather conditions. If all the alternatives are available, then timelines for transfer need to be considered. It may actually take longer to task an aircraft, move the patient to the airport/helipad, load the patient, fly between points, move the patient out of the aircraft and transfer to the destination hospital, than it would to carry out a road transfer between the two points. Again, knowledge of the local area and what alternatives are available will dictate the method of transfer between locations. Any vehicles used should be well maintained and appropriately equipped. Ability of transferring staff to access the patient and ability to control temperature and light should be considered.

Who?

This question should focus on "Who is going to carry out this transfer?"

Again the answer to this question will vary depending on the situation and the type of transport to be used. Staff who transfer children should ideally have completed a training course on transfer. Those staff carrying out the transfer should be competent in the management of the paediatric airway, including intubation, and in the management of the acutely unwell child. Ideally a doctor and nurse should carry out a transfer, in addition to the usual crew of the vehicle. Which staff go will depend on individuals' levels of experience, the need to provide appropriate cover at the hospital and the injuries sustained by the child. Parental presence also needs to be considered at this point.

Is it safe?

This question covers two areas: "Is it safe for the child and is it safe for the team?"

Is it safe for the child? This means, is the child in a safe condition to transfer? Are they stable enough, or do they require further treatment prior to the journey? Is the airway and are all lines secured, or should further access be obtained first? Is there anything that can be done to make this child safer for transfer? Intubation during transfer can be difficult and even dangerous. Consider if it is safer to secure the airway with an endotracheal tube prior to transfer than to attempt this during the transfer.

Is it safe for the team? This means, are there external factors, such as poor weather, that make carrying out the transfer a risk to the medical staff, and therefore the patient? If this is the case, the risk of carrying out the transfer and the potential loss of medical staff, needs to be balanced with the need to carry out the transfer.

Preparation for transfer

Once the decision to carry out the transfer has been made, then preparation for transfer needs to begin. Preparing to transfer a child requires communication, preparation of equipment and preparation of documentation.

Communication

Communication is one of the most important parts of carrying out a transfer. Communication allows all those involved in the child's care to work together to ensure the best outcome for the child. This will involve communication by a lot of people, both external and internal to the team carrying out the transfer.

Communication with the receiving hospital

Before a transfer can be made, the receiving hospital needs to have accepted the patient. Often the team taking over the care will have been contacted, but this may not mean that a bed has been arranged or that there is space in the intensive care unit. All of this should be verified before starting the transfer and the patient's destination within the hospital should be confirmed. Communication with the receiving unit should also include patient information such as whether they are intubated and ventilated, what lines are in situ and what drugs are running. This allows the receiving unit to prepare in advance of the patient's arrival.

Communication within the hospital transfer team

Once the decision has been made about who is going on the transfer then the members of the transfer team need to discuss the plans for the transfer. This will include discussion about what equipment and drugs need to be prepared and drawn up and what else may be required. "Actions on" plans may also need to be discussed. This means planning in advance what roles people will carry out in an emergency scenario. This may include planning who will take what role in the event of a cardiac arrest, an accidental extubation or need for intubation. Discussion about what to do in the event of oxygen failure or power failure should also be considered.

Communication with the vehicle team

Whatever type of transport is used, the team on the vehicle will all need to know the destination of the patient, any concerns about what may occur during the transport and how urgent the transfer is. Further details required will depend on the type of transport being used. Good communication will enable the transfer to go as smoothly as possible and will help to minimise the risk to the patient.

Communication with the patient and their relatives

The patient and their relatives will also need to know about the transfer. This will include the reasons for transfer, the destination and arrangements for transfer. If a parent is to travel with the child this will need to be arranged, or if the parents are to travel independently, then they will require information about how to get to the receiving hospital. Contact details for the parents should also be obtained and given to the receiving hospital and contact details of the receiving hospital should be given to the parents.

Equipment

The exact equipment needed on a transfer will vary from location to location. Many units have transfer bags pre-prepared and stocked with a full range of equipment to carry out a transfer. Often there

will be different bags for neonatal or infant transfer and transfer of an older child.

This reduces the need to carry all the possible sizes of equipment on every transfer and may also mean taking a different ventilator dependent on the child's age. If these bags are used it is important to ensure those carrying out the transfer are familiar with the equipment and where it is stored in the bag. Table 1 (following page) lists some essential requirements: please note this is not an exhaustive list and other equipment may be needed depending on the individual situation.

Equipment used for transfer should be durable, lightweight and be able to work on battery supply for prolonged periods of time, and replacement batteries should be available. For this reason gas driven ventilators are often used for transport, provided there is an adequate supply of compressed gases. A self-inflating bag may be preferable, and is essential as back-up. The equipment must be able to be adequately secured within the chosen transport, either using brackets or onto a special transport bridge. This could be manufacture locally to suit specific needs. Equipment alarms need to be pre-set appropriately to each child and should be visible as well as audible as conditions during transfer are often noisy. Sufficient equipment should be left at the departing hospital to allow treatment of any further emergencies that occur whilst the transfer team are away.

Equipment should be checked prior to transfer to ensure it is fully working and there is nothing missing. Drugs should be checked to ensure they are in date.

If the patient is receiving drug infusions, then these should be made up in advance of the transfer and spare syringes prepared. The time taken for the transfer should always be considered, allowing for significant delays, and consideration should also be given to the possibility of needing to increase the dose during the transfer. It is better to make up too many spare syringes than to try and draw up further spares in the back of a moving vehicle. Emergency drugs should also be drawn up, labelled and capped off so they are easily accessible during the transfer. Drugs that may need to be bolused during transfer should also be prepared, labelled and capped off for easy use. Consider having two syringes of any emergency or bolus drugs in case one is dropped in the vehicle.

Enough fluid should be taken to provide maintenance fluid as well as boluses during the transfer. In the traumatised child this may include taking blood or blood products and this will need to be arranged prior to transfer and suitable storage organised to keep the products at the correct temperature during the transfer.

Any electrical equipment must be fully charged prior to transfer. If the equipment can be plugged in during the transfer then power cables should be taken. If this is not possible then enough spare batteries should be taken for the equipment to last for the longest possible duration of the transfer.

The amount of oxygen required for the transfer should be calculated. This applies to both ventilated and non-ventilated patients. How much is needed will depend on the FiO_2 of the patient, their minute ventilation, whether the ventilator is driven by compressed oxygen and the availability of oxygen supplies in the vehicle. It is always worth taking double the calculated requirement to allow for delays and equipment problems. A suitable calculation is:

Minute volume x estimated journey time (in minutes) x 2

- Round this up to the nearest cylinder size. The contents of various cylinders are as follows: D cylinder 340L, E cylinder 680L, F cylinder 1360L.

Documentation

Ensuring the correct documentation is taken on the transfer is important. Copies of all notes and all imaging such as Xrays and CT's should be sent with the patient. Blood test results should also be included. If there is specific documentation for the transfer then this should be taken and completed during the transfer. If there is no specific paperwork then a chart such as an anaesthetic chart where observations, drugs and any interventions required can be completed should be used and filled in for the transfer.

Packaging for transfer

Once the decision has been made to transfer the patient will need to be prepared. This will include transferring onto the appropriate transfer trolley, and ensuring all IV access lines, the endotracheal tube and any other lines such as chest drains, urinary catheter and Nasogastic tubes are inserted if required and are secured appropriately. If there is any question about cervical spine injury then the cervical spine will need to be appropriately protected. When packaging the patient for transfer consideration needs to be given to protecting the patient's pressure areas. Once packaged the child's clinical condition should be re-assessed to ensure they remain appropriately stable at point of departure.

Once the team are ready to depart, the receiving hospital should be contacted again to let them know that the patient is on the way. During transfer vital signs should be observed and documented and any interventions carried out recorded, so that the receiving team have a complete picture on handover.

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Table 1. *Suggested equipment for transfer of a critically injured child*

Airway equipment	Oro-pharyngeal airway Naso-pharyngeal airway Facemask Ambu-bag (self-inflating bag) and Ayre's T-piece Endotracheal tubes Bougie Laryngoscope + blades + batteries Ties / tape to secure endotracheal tube Suction device Yankauer suction catheter Endotracheal suction catheter End tidal CO_2 monitoring
Breathing equipment	Ventilator appropriate to child's weight Oxygen Spare batteries / power adaptors for ventilator
Circulation equipment	IV fluids Pressure bags Syringe drivers + spare batteries Cannulae Intra-osseous device Invasive monitoring equipment Defibrillator
Drugs	Sedatives Muscle relaxants Epinephrine Atropine Inotropes Anti-emetics Mannitol / hypertonic saline
Other	Portable monitor giving SpO_2, ECG, Non-invasive blood pressure. Ideally with facility to monitor CVP and arterial BP. Blankets Thermometer Urinary catheter + bag Pen torch Blood glucose monitor Medical + nursing notes Radiology images Transfer documentation
Personal Equipment	Money Mobile phone + contact numbers Protective clothing and footwear Personal protective equipment - gloves