Paediatric Trauma Service
Trauma Manual
2016
Paediatric Trauma Service Trauma Manual

8th Edition

The Trauma Manual incorporates the (original) Trauma Guidelines with annual updates. It relies heavily on the E-Learning component of the Paediatric Advanced Care in Trauma Course.

These trauma guidelines were initially created by Dr Andrew Blanch (ED Consultant), drawing on material from:

- Existing guidelines of the former Royal Children’s Hospital (Brisbane)
- Advanced Paediatric Life Support course material
- PACT E-Learning Programme
- Early Management of Severe Trauma course material
- Early Management of Severe Burns course material
- Extensive review of trauma literature (see References & Further Reading sections)

Acknowledgements

The Paediatric Trauma Service would like to thank Dr Andrew Blanch for the exceptional work in creating and publishing the first edition of the Paediatric Trauma Guidelines in 2008.

Also, thank you to Dr Sally John and Dr Geoff Pearce for their extensive input into the E-Learning component of the Paediatric Advanced Care in Trauma Course. Finally thank you to each and every sub speciality that reviewed and updated their component of the trauma guidelines.

This series of guidelines will continue to be revised and updated. If there are any queries/suggestions regarding the material in this booklet, please email:

The Trauma Service

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Introduction

The term ‘trauma’ refers to patients who have sustained physical injury. Injury is defined as unintentional or intentional damage to the body resulting from acute exposure to thermal, mechanical, electrical or chemical energy (Royal College of Surgeons England, 2000). The spectrum of trauma encompasses patients who have sustained minor injuries that can be quickly treated at local emergency departments, through to major or severe trauma which usually requires hospital admission and access to specialised resources such as at designated Major Trauma Centres (MTC). There are currently 27 MTC in Australia.

In Australia, injury remains a leading cause of death and disability, accounting for 5.8% of all deaths (ITIM NSW Health 2004). Queensland has the highest mortality of all other states (due to its vast geography – A Trauma Plan for Queensland (QLD) 2006).

From a pediatric perspective, trauma is the leading cause of death and disability in the first four decades of life. It accounts for approximately 50% of all childhood deaths and 75% of adolescent deaths.

Trauma results in 10% of all hospital admissions and accounts for 40-60% of all hospital presentations and is estimated to cost the economy $2.6 billion each year in whole-of-life costs.

A Trauma Plan for Queensland 2006, endorsed in 2007, was an initiative to develop strategies to improve trauma care in Queensland. The following agencies were involved in the Trauma Plan For Queensland – the Queensland Government, Royal Australasian College of Surgeons, Motor Accident Insurance Commission, The Centre of National Research on Disability and Rehabilitation, Retrieval Services QLD and the QLD Emergency Medical System Advisory Committee. There were up to 300 stakeholders involved in the Trauma Plan for Queensland.

According to the Trauma Plan for Queensland - paediatric care was often suboptimal, particularly in adult hospitals. It recommended a Paediatric MTC be established as a matter of urgency. The Royal Children’s Hospital (RCH) Paediatric Major Trauma Centre was developed in 2008 as the lead Paediatric Trauma Centre. The former Royal Children’s and Mater Children’s Hospital have now merged at Lady Cilento Children’s Hospital / Children’s Health Queensland (since Nov 2014) and the LCCH is currently the MTC dedicated to paediatric trauma patients in Queensland.
Major trauma centres

Major Trauma Centres (MTC) are tertiary care facilities which provide all clinical specialties including neurosurgical, cardiothoracic and rehabilitation services. Ideally the hospital requires full diagnostic services including both interventional and non-interventional radiology. The Major Trauma Centre is required to demonstrate consultation, leadership, research and education to its network or state-wide hospitals. (ITIM NSW Health 2005 / RACS Verification Criteria 2014)

**A Level 1** MTC is capable of providing the full spectrum of care which includes the ability to fully resuscitate and provide definitive surgical care to all trauma patients from reception to rehabilitation 24 hours a day. It must also demonstrate leadership, research, education, trauma system overview, data collection, quality improvement program, injury prevention and outreach programs, plus trauma audits. Level 1 MTC acts as the principal hospital for receiving all major trauma patients.

**A Level II** MTC is capable of providing comprehensive clinical care 24 hours a day. It is usually more specialized and may provide specialties such as cardiac or micro vascular surgery. There may be less stringent trauma team requirements but the hospital staff must be committed to trauma and must have available clinical resources. They supplement the MTC in areas of dense population without the necessary addition of leadership, education and research components.

**A Level III** trauma centre is capable of providing high quality care to medium and minor injury patients. It can provide definitive care to a limited number of trauma patients including assessment, initial resuscitation, emergency surgery and stabilization. However, certain sub-specialities are not required e.g. neurosurgery. There should be formal transfer agreements between a level III trauma service and MTC.

**A Level IV** trauma centre is capable of providing resuscitation only. The patient is transferred rapidly to the Major Trauma Service. It is not intended to care for major trauma.
The Paediatric Trauma Service

As a designated Major Trauma Centre (MTC), our mission is to provide the highest level of care to all injured children and provide clinical leadership, education and research at both hospital and state level.

Trauma management involves Injury Prevention, Clinical Care, Communication, Quality Management, Education, Leadership and Research.

Clinical care starts from the scene of the injury with pre-hospital care, it continues in the Emergency Department with reception and resuscitation. The injured patient may require definitive surgical care plus intensive and post-operative care, ward management and rehabilitation. Co-ordination of the patient journey involves various sub-specialties, plus early referrals to the pain service, rehabilitation, orthotics and child advocacy etc.

Communication involves networking with all the stakeholders, Queensland Ambulance Service & Retrieval Services Queensland, Emergency Department, Trauma Service, Paediatric Intensive Care Unit, Operating Theatres, Radiology, wards, rehabilitation service including all allied health specialities. It is important that you communicate with us if there are any issues relating to patient care or any trauma related queries that you may have.

Education. There are regular monthly education sessions and trauma review meetings. We encourage you to attend and participate at these presentations. Monday and Thursday’s are education days and Thursdays are meeting days. We utilise telehealth services to outreach our education programme.

We encourage you to attend the Paediatric Advanced Trauma Course (PACT course) held at LCCH. There are 10 courses per annum, please register with the SToRK team.

We hope you find your time at the LCCH both rewarding and educational.

The Trauma Service team

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director of Trauma</td>
<td>Professor Roy Kimble</td>
</tr>
<tr>
<td>Trauma Nurse Manager</td>
<td>Tona Gillen</td>
</tr>
<tr>
<td>Data Manager</td>
<td>Lauren Harvey</td>
</tr>
<tr>
<td>Administration Officer</td>
<td>Reena Prasad</td>
</tr>
</tbody>
</table>
The Paediatric Trauma Service at Lady Cilento Children’s Hospital

The Paediatric Trauma Service coordinates the management of injured children by working collaboratively and in conjunction with all the various disciplines at Lady Cilento Children's Hospital (LCCH) to promote and provide optimal trauma care.

The Trauma service provides a consultancy service to all trauma patients (admitted for more than 24 hours) and their families, and provides a liaison service between the multidisciplinary teams and the allied health professionals.

It coordinates the care of approximately 900 trauma admissions (of greater than 24 hours) each year.

The roles of the Trauma Service team are highlighted to demonstrate their involvement within the trauma patient journey and the trauma system.

**Trauma Director** - Professor Roy Kimble
The Director provides the leadership required of a trauma service to function within the hospital, the Area Health Service, as well as the State-wide Trauma Network. He leads the multidisciplinary activities of the trauma system. The Director continually evaluates the delivery of trauma care and is responsible for the development and implementation of protocols and clinical practice guidelines, for optimal trauma management. His role is to plan, direct and oversee the entire trauma service from its development, progress and advancement to meet the needs of the hospital and the community. His vision is enhanced by his productive research team performing both clinical and basic research in the fields of paediatric burns and injury prevention. He leads a multidisciplinary, representative hospital trauma committee meeting, chairs the monthly trauma education meetings, and is a member of the Queensland Injury Prevention Council.

**Trauma Nurse Manager (NM)** – Tona Gillen
The Paediatric Trauma Coordinator and Clinical Nurse Manager role involves coordinating the management of injured patients admitted to LCCH for more than 24 hours, by providing leadership, education, support and advice in trauma related matters to patients, their families and health care providers. This commences at resuscitation reception, and continues by monitoring and evaluating patient care throughout their hospital journey, until rehabilitation and ultimately the discharge of the trauma patient. Identifying any “system” issues and making recommendations for change where appropriate. The Trauma NM coordinates the day-to-day hospital activities required of the trauma service. The NM is also responsible for updating and informing staff of new protocols available for trauma management. The NM role includes a strong emphasis on clinical education and training which includes coordination of internal and external trauma education such as monthly video conference education presentations, the monthly in house trauma education meetings plus coordinator of Early Management of Severe Trauma (EMST) courses and faculty member of the PACT course.

**Trauma Data Manager** – Lauren Harvey
The Data Manager is responsible for the development, coordination and maintenance of the Trauma Service Registry and focuses on collecting data for patients admitted to hospital for over 24 hours. The purpose of this registry is to monitor the incidence of various injuries and their outcomes. The role is accountable for providing statistical data, reports and specialised data analysis for use in research, quality projects and clinical audits. The Data Manager conducts systematic checks of the reliability and validity of the database through regular auditing of patient charts and consultation with the Trauma NM. This data is required to provide evidence regarding the effectiveness of the Injury Prevention campaigns and allows the identification of trends / differences across the State. Data is also required to measure patient information, clinical performance indicators and system performance. This allows for review of practice and implementation of change. The Data Manager also contributes to the Monash University Bi-National Burns Database which captures the admission details of all burns patients admitted for longer than 24 hours.

**Trauma Administration Officer** – Reena Prasad
Administrative support is essential to the trauma service and includes general administration activities within the Paediatric Trauma Service, such as minute taking and distribution, appointments and meetings. She is happy to assist with any queries regarding the Paediatric Trauma Service.
Trauma team activation

Procedure: Trauma Team Activation


Purpose

The purpose of this procedure is to describe the processes for activating a Trauma Call at the Lady Cilento Children’s Hospital (LCCH).

Scope

This procedure applies to all CHQ clinical staff at LCCH, especially to those in Emergency, the Paediatric Intensive Care Unit (PICU), the Operating Suites, Surgery and Trauma Service.

Procedure

Trauma Team Activation is criteria-based at LCCH. If a patient meets the specified criteria (see Appendix 1), a Trauma call is to be activated.

- Emergency or Paediatric Intensive Care Unit (PICU) staff receive information on an incoming trauma patient from Queensland Ambulance Service (QAS) or from Retrievals Service Queensland (RSQ)
Based on this information, it can be determined whether the patient meets the Trauma Team Activation (TTA) criteria:
- A **Trauma Alert** is based on the mechanism of injury
- A **Trauma Attend** is based on anatomical injuries or abnormal physiology
- If the patient meets the criteria, dial ‘555’ and advise Switchboard either:
  - “Trauma Alert Emergency” or
  - “Trauma Attend Emergency / PICU”

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**ALERT**
The ideal time to activate the Trauma Team is 10 minutes prior to the patient’s arrival at LCH to allow for a team brief and preparation

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After Trauma Team Activation

After the Trauma Team has attended and treated the patient, the primary and secondary survey should be completed on the Trauma Assessment Admission Form. This should be documented by the Emergency / PICU team.

A management plan should also be determined and documented for the patient.

The tertiary survey should be completed on the Trauma Assessment Admission Form within 24 hours of the patient’s admission by the admitting team. However, the Surgical / Trauma Registrar must complete the tertiary survey following a Trauma Attends Call or following consultation regarding a Trauma Alert Call.

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**Supporting documents**

Authorising Policy and Standards
- Trauma Manual – Trauma Guidelines

Procedures, Guidelines and Protocols

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**Consultation**

Key stakeholders who reviewed this version:
- Nurse Manager Trauma
- Emergency Medicine – Director/NUM
- PICU – Director/NUM
- Operating Suite - Director/NUM
- Trauma Service - Director

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Proc 62440 – Trauma Team Activation

Children’s Health Queensland Hospital and Health Service
References

Audit/evaluation strategy

| Level of risk | High |
| Strategy      | Monthly Clinical Audit of Trauma Activity |
| Audit/Review attached tool(s) | Monthly Clinical Audit of Trauma Activity available for review |
| Audit/Review date | Annual Review by Trauma Service |
| Review responsibility | Trauma Service |
| Key elements / Indicators / Outcomes | Monitor compliance with criteria |

Standard revision and approval history

<table>
<thead>
<tr>
<th>Version No.</th>
<th>Modified by</th>
<th>Amendments authorised by</th>
<th>Approved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nurse Manager Trauma</td>
<td>Divisional Services</td>
<td>General Manager Operations</td>
</tr>
</tbody>
</table>

Keywords
Trauma Team Activation; criteria-based; emergency; PICU

Accreditation references
EQUIP National Standards: 9 – Recognising & Responding to the Deteriorating Patient; 12 – Provision of Care

Appendix 1: Trauma Team Activation Criteria

Appendix 2: Trauma Team Activation Flow Chart
## Appendix 1: Trauma Team Activation Criteria

### Trauma Alert Criteria

<table>
<thead>
<tr>
<th>Mechanism of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall &gt; 3 meters</td>
</tr>
<tr>
<td>M/V/A &gt; 50kms/hour</td>
</tr>
<tr>
<td>M/V/A - pedestrian</td>
</tr>
<tr>
<td>M/V/A - cyclist</td>
</tr>
<tr>
<td>M/V/A - ejected, rollover, fatality</td>
</tr>
<tr>
<td>High speed collision (including train)</td>
</tr>
<tr>
<td>M/V/A &gt; 30kms/hr cyclist, scooter, motorbike or quad bike</td>
</tr>
<tr>
<td>Horse related - fall, kick</td>
</tr>
<tr>
<td>Explosion / blast injuries</td>
</tr>
<tr>
<td>Attempted hanging</td>
</tr>
<tr>
<td>Reverse over injuries to head, chest, abdomen</td>
</tr>
<tr>
<td>Non-fatal drowning in surf / river OR with history / feature of injury</td>
</tr>
<tr>
<td>Axial load to the head (e.g. diving injury)</td>
</tr>
<tr>
<td>Handlebare injuries to abdomen</td>
</tr>
<tr>
<td>Significant mechanism of injury</td>
</tr>
</tbody>
</table>

### Trauma Attend Criteria

- **Anatomical Injuries**
  - Spinal cord injury, or suspected spinal cord injury with motor or sensory deficits
  - Any C spine fracture
  - Flail chest
  - Major vascular injury
  - Burns > 15% or >10% < 18 month old, or airway burns – smoke inhalation
  - Multiple long bone fractures
  - Crush Injury of limbs, torso, or pelvis
  - Penetrating injury to head, neck, torso
  - Amputation proximal to wrist / ankle
  - Two or more system injuries
  - Suspected fractured pelvis
  - Significant anatomical injury
  - Positive pre hospital FAST scan

- **Physiology parameters**
  - Airway, breathing or circulation compromise
  - Altered level of consciousness, GCS < 14
  - Abnormal vital signs as specified

### Vital Signs (abnormal physiology)

<table>
<thead>
<tr>
<th></th>
<th>Newborn &lt; 2 weeks</th>
<th>Infant &lt; 1 year</th>
<th>Child 1 – 8 years</th>
<th>Child 3 – 15 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Rate</strong></td>
<td>&lt;40 or &gt;60</td>
<td>&lt;50 or &gt;50</td>
<td>&lt;50 or &gt;55</td>
<td>&lt;50 or &gt;55</td>
</tr>
<tr>
<td><strong>Hypotension</strong></td>
<td></td>
<td>&lt;70mm Hg</td>
<td></td>
<td>&lt;70mm Hg</td>
</tr>
<tr>
<td><strong>Pulse Rate</strong></td>
<td>&lt;100 or &gt;170</td>
<td>&lt;90 or &gt;170</td>
<td>&lt;75 or &gt;120</td>
<td>&lt;65 or &gt;120</td>
</tr>
<tr>
<td><strong>Conscious State</strong></td>
<td>GCS &lt;14</td>
<td>GCS &lt;14</td>
<td>GCS &lt;14</td>
<td>GCS &lt;14</td>
</tr>
<tr>
<td><strong>Oxygen Saturation</strong></td>
<td></td>
<td></td>
<td></td>
<td>&lt;90%</td>
</tr>
<tr>
<td><strong>Skin</strong></td>
<td>Cold/Pale/Clammy</td>
<td>Cold/Pale/Clammy</td>
<td>Cold/Pale/Clammy</td>
<td>Cold/Pale/Clammy</td>
</tr>
<tr>
<td><strong>Capillary Refill</strong></td>
<td>&gt;2 see</td>
<td>&gt;2 see</td>
<td>&gt;2 see</td>
<td>&gt;2 see</td>
</tr>
</tbody>
</table>
Appendix 2 – Trauma Team Activation Flow Chart

Information on In-Coming Trauma Patient
(Within 24 hours of injury)

- Meets Mechanism of Injury Criteria AND Normal Anatomy Normal Physiology
  - Dial ‘555’ Instruct Switch: “Trauma Alert Emergency”
  - Trauma Alert Team:
    - Emergency RN
    - Emergency Registrar
    - Emergency Consultant
    - Trauma Nurse Manager

- Meets Abnormal Anatomy Criteria +/- Abnormal Physiology
  - Dial ‘555’ Instruct Switch: “Trauma Attend Emergency” OR “Trauma Attend PICU”
  - Trauma Attend Team:
    - Emergency RN/Registrar/Consultant
    - PICU RN/Registrar/Fellow/Consultant
    - Surgical Registrar
    - Nurse Unit Manager
    - Social Worker
    - Radiographer
    - Wardsperson
    - Trauma Nurse Manager
Trauma team roles

Brisbane was served by two paediatric tertiary hospitals, the Royal Children's Hospital (RCH) and the Mater Children’s Hospital (MCH). Since Nov 2014 these two hospitals have merged and become Lady Cilento Children’s Hospital (LCCH) / Children’s Health Queensland.

Fortunately, paediatric patients do not usually meet the major trauma criteria of an Injury Severity Score of greater than or equal to 12. Therefore, due to the relatively small numbers, and the fact that other medical emergencies may occur simultaneously within the hospital, plus the various levels of experience of medical staff, there needs to be a flexible approach to the trauma team roles with in the LCCH.

Although there is a trauma team at LCCH, additional staff will present in the resuscitation room to ensure the following roles are being addressed:

Team Leader Medical / Nursing
Airway (and Breathing) Medical / Nursing
Circulation Medical / Nursing
Procedure (and monitoring) Medical / Nursing
Scribe Nursing (maybe Nursing Team Leader)
Additional procedure nurse for Trauma calls.

The Trauma Team at LCCH
ED consultant (team leader)
ED Registrar
ED RN
PICU Registrar or fellow or Consultant
PICU RN
Surgical Registrar
Trauma NM (in hours)
Radiographer
Nurse Manager
Social Worker
Wardsman

This team responds 24/7. The only exception is the Trauma NM who responds within business hours only.

The ED consultant is the team leader; this role involves co-ordinating, delegating and directing the care of the trauma patient with a ‘hands on’ or ‘hands off’ approach depending of staffing numbers. If participating in the patient’s care, the Airway role is usually assumed by the team leader. The team leader is responsible for making the decision to stand down the team. After hours (in the absence of the ED consultant) the most senior medical person assumes the role of team leader until the ED consultant arrives and takes over the role.

The ED registrar or PICU registrar (Fellow or Consultant) usually assumes the Airway role (allowing the team leader to have a ‘hands off’ role). This role involves assessing and securing patency of the trauma patient airway and intervening as needed. This role also involves ensuring C spine protection, assessing breathing and responding to all life threatening breathing problems immediately. His / her role involves reporting all findings to the team leader.

The ED registrar or PICU registrar (fellow or consultant)if not assuming the Airway role, he / she will assume the circulation / procedure role, this involves securing IV / IO access and acquisition of bloods for relevant tests as directed by the team leader.

The PICU RN tends to assume the Airway Nurse role; this involves assisting with securing the airway (including intubation) and ensuring C spine protection using correct immobilisation devices. Reporting the breathing status of the patient is relayed by the airway nurse (respiratory rate and effort and oxygen saturation status) to the airway doctor and to the team leader.

The ED RN role usually involves the circulation / procedure role due to their familiarity with the area. Assisting with IV / IO access and volume resuscitation, plus ensuring full monitoring of the trauma patient. Preparing and assisting with all procedures is also part of this role.
The **Surgical Registrar** role involves surgically assessing the trauma patient to determine the need for surgical management. They are also responsible for liaising with the surgical consultant concerning all aspects of surgical care, early discussion with the surgical consultant is required (preferably before the patient goes to the CT scanner). This role also involves conducting any surgical procedures that may be required, such as venous access, insertion of chest drain, thoracotomy etc. The team leader determines who should conduct the secondary survey; this can be delegated to the surgical registrar. The surgical registrar completes the tertiary trauma survey within 24 hours of the trauma patient’s admission following the trauma attend if the admitting team have not already done so.

The **Trauma NM** role involves auditing the process to ensure best practice for each trauma patient. Usually the scribe role is the role assumed by the trauma NM, this involves documenting the sequence of trauma resuscitation events, plus patient details such as allergies, weight etc. Audit reviews are presented at the monthly trauma review meetings to allow discussion to facilitate improved practice. A second ED RN (or the Nurse Manager) fulfils the scribe role after hours.

The **Radiographer’s** role is to perform the trauma series as determined by the team leader and scans the films onto the electronic x-ray system (PACS).

The **Nurse Manager’s PFSU** role is to ensure that there is adequate staffing in the resuscitation room and in the main department of emergency room and also to prepare OT, PICU or the ward for the impending trauma patient. Early Notification of Operating Theatre (OT) is of vital importance and contact with the floor coordinator or the reception area (during hours) is imperative as soon as possible for all category one / urgent patients. After hours they follow the on call list and call in procedures for emergency cases.

The **Social Worker’s** role involves the provision of emotional, psychological and practical support both to the child, and their parents and family (of the injured patient). For unaccompanied children the SW takes an active role in locating and informing the child’s guardians. In this instance they liaise closely with QPS and the medical and nursing team leader. They respond to all trauma attend calls.

The **Wardsman’s** role is to be available to transport the patient and assist with any lifting / log rolling etc. under the direction of the team leader. If the Massive Transfusion Protocol (MTP) is activated – there is a specific role card for the wardsperson to follow.

The relevant specialities should be contacted as soon as possible in regard to specific injuries related to their areas of expertise – anaesthetic, neurosurgical, orthopaedic, cardiac, ophthalmology, plastics, ENT, burns etc.
Urgent referral requiring possible resuscitation

<table>
<thead>
<tr>
<th>Time of call:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETA:</td>
<td>Name of DEM RN/DR:</td>
</tr>
</tbody>
</table>

**PATIENT DETAILS**

**SITUATION**

**BACKGROUND**

**ASSESSMENT**

- Airway Patent: [ ] Yes  [ ] No
- Resp Rate / Effort
- O₂ Sats
- Heart rate
- BP
- GCS
- Temp
- BGL

**RECOMMEND**

Is this a Trauma ALERT [ ] or Trauma ATTEND [ ] (Please refer to criteria sheet)

- Patient name:
- Age (DOB):
- Estimated weight:
- Name of Caller:

**Referral Source:**

- Queensland Ambulance Service
- Retrieval Services Queensland
- Queensland Clinical Coordination Centre
- Other:

**Mode of transport:**

- Road
- Rotary
- Fixed wing
- Other:

**Patient origin:**

- Home
- Scene
- Hospital (please state name of hospital)
Trauma Assessment/Admission Form LCCH (CHQ)

**Review of radiology reports and laboratory investigations**

- Name: 
- DOB: 
- UPI No: 

**Mechanism of injury:**

- Vehicle: 
- Vehicle velocity: 
- Collision type: 
- Alcohol present: 
- Intoxication level:

**Missed injury:**

- Yes
- No

**Plan**

**MUST**

- Vital signs on route: 
- Pulse: 
- Respiration: 
- O2 saturation: 

**TREATMENT TEAM LEADER:**

**Weight:**

**MORPHINE**

**Interventions prior to arrival:**

- Hard collar
- IV access
- IV fluid by GFS (mL)

**TREATMENT AND MEDICATIONS STARTED BY GFS:**

**PRE-HOSPITAL DETAILS OF TRAUMA**

- Time of incident: 
- Scene location: 
- Direct: 
- Transfer trauma patient—referring hospital:

**TRAUMA TEAM ACTIVATION CRITERIA**

**MECHANISM (if any = alert)**

- Fall > 3 meters
- MVA > 60km/hr
- IMVA: pedestrian
- IMVA: cyclist
- IMVA: alcohol/overdose
- High speed collision (180km/hr)
- MVA > 90km/hr (pedestrian, motorcycle, quad bike)
- Other related—fall / lack

**INJURY (if any = alert)**

- Suspected spinal cord injury with motor or sensory deficit
- Any C spine fracture
- Fractured pelvis
- Major abdominal injury
- Burns > 10% or > 12%
- <10 months old, ear, arm, leg, or extremity
- Arterial bleeding: head, neck, torso
- Amputation proximal to undetectable
- Two or more popliteal pulse
- Suspected 4 pelvis
- Significant anatomic injury
- Positive pre-hospital FAST exam

**TISSUE VIOLATION**

- Shoulder / elbow / wrist
- Spine
- Thorax / abdomen
- Head

**DO NOT WRITE IN THE FOLLOWING MARGIN**

- Name: 
- DOB: 
- UPI No: 

**Medical Officer (Attending Team):**

- Signature: 
- Date: 

**Medical Officer (Surgical Team):**

- Signature: 
- Date: 

**Medical Officer (Admitting Team):**

- Signature: 
- Date: 

**Medical Officer (Surgical Team):**

- Signature: 
- Date: 

**Medical Officer (Admitting Team):**

- Signature: 
- Date: 

**Medical Officer (Surgical Team):**

- Signature: 
- Date: 

**Medical Officer (Admitting Team):**

- Signature: 
- Date: 

**Medical Officer (Surgical Team):**

- Signature: 
- Date: 

**Paediatric Trauma Service | Children's Health Queensland**
### Secondary Survey

**Secondary Survey (ideally to be completed within 20 minutes)**

**Head to Toe Assessment**

- Head / face / neck
- Chest / back / leg / roll
- Abdomen / pelvic / perineum
- Limbs / extremities (go to next page)
- Neurological (CNS/PNS)

**Steps:**

1. **Head to Toe Assessment:**
   - Complete within 24 hrs and must be completed prior to discharge.

**Disposition and Consultations**

- **Admitting Consultant:**
- **Time contacted:**
- **Family notified:**
- **Social Worker:**
- **Disposition:**
  - Operating Theatre
  - Ward specific
  - ICU
  - Observation ED / SSU
  - Discharge
- **Team Leader (doctor):**
  - **Name:**
  - **Signature:**
  - **Time:**

**Trauma Manual 2016**

Paediatric Trauma Service | Children’s Health Queensland
Initial assessment & management of trauma (flowchart)

**Preparation**
- Notify ED Consultant on-duty
- Collect Information from Pre-hospital personnel
- Activate Trauma Call System (See Appendix 2 & 3)
- Assemble team and assign roles
- Notify services external to ED (eg. Medical Imaging, PICU, Surgical Registrar, Blood Bank)
- Team to don protective apparel and airway doctor wears lead gown
- Calculate drug / fluid doses, prepare x-ray and pathology forms

**Primary Survey (Usually first 5-10mins)**
- Apply Monitoring
  - **A:** Airway maintenance and C-spine protection
  - **B:** Breathing & Ventilation
  - **C:** Circulation with haemorrhage control
  - **D:** Disability – Conscious level (AVPU), pupils, posture
  - **E:** Exposure with temperature control

**Resuscitation associated with Primary Survey**
- **A:** Apply High Flow Oxygen
  - Airway support as needed (eg. Jaw thrust, Oropharyngeal Airway, Intubation)
  - In line cervical spine immobilisation +/- Collar & Sandbags
- **B:** Ventilation – Assist as required
  - (Management of tension or open pneumothorax, large segment flail chest, or massive haemothorax)
- **C:** 2 x large bore IV cannulae (Consider RIC or IO if indicated)
  - Take blood for FBC / ELFT / Lipase / Group & Hold (or Crossmatch) / Coag Profile / Venous Blood Gas
  - Fluid boluses if signs of shock (0.9% Saline 20ml/kg aliquots)
  - Consider Packed Cells 10ml/kg aliquots after 40ml/kg crystalloid
  - If significant amount of blood products are required refer to Massive Transfusion Protocol
- **D:** If signs of raised ICP consider:
  - Urgent Neurosurgical involvement
  - Ventilation (to avoid hypercarbia aim for pCO₂ 28-32mmHg)
  - IV Mannitol 2.5-5.0ml/kg (0.5-1g/kg) or 3% Saline 2-6ml/kg as a bolus
  - Tilt bed (head up) 20 degrees
  - Prompt treatment of seizures
  - Adequate analgesia and sedation to blunt response to noxious stimuli

**Adjuncts to Primary Survey**
- **Trauma Series Radiology - Lateral C-spine, Chest & Pelvis +/- FAST Scan**
- **NGT (or OGT if risk of base of skull #)**
- **IDC - If need to accurately measure urine output (eg. hypotensive, comatose, intubated, severe burn requiring fluid resuscitation)**
- **Analgesia - usually IV morphine or fentanyl**

**Secondary Survey**
- Head to Toe examination – Record on Trauma Proforma
- Collect Full History (AMPLE)

**Other Investigations**
- CT Scan (Head, Chest, Abdomen, etc) – as appropriate (See Separate Guidelines for Details)

**Definitive Care**

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See Trauma Guidelines for Further Details
Initial assessment and management of major trauma

Injury continues to be the major cause of childhood mortality, after the first year of life. Although the injury death rate has dropped in the past few decades, deaths from medical illness have decreased at a greater rate than those from trauma-related causes. Severe trauma-related injuries can also lead to significant morbidity, which may extend into adulthood at great cost to society.¹

In Australia, falls, transportation-related injuries (particularly motor vehicle accidents (MVAs) and bicycle accidents), and burns continue to be the three most common injury mechanisms requiring hospitalisation in children aged 1 to 14 years. Head injury continues to be the most common type of injury requiring hospital admission at any age.²

When compared with adults, children have many distinct anatomical and physiological characteristics which need to be accounted for when managing the severely injured child. The most important of these is the fact that small children are more prone to multiple injuries. This is because a child's smaller body size allows for a greater distribution of traumatic injuries when compared with an adult at any given external force.

Treatment of the seriously injured patient requires rapid assessment of the injuries and early institution of life-preserving measures. Because the situation is time critical, the same systematic approach is used in both adults and children. The Early Management of Severe Trauma (EMST) and Advanced Paediatric Life Support (APLS) courses both teach a structured approach to the early assessment and management of injured patients which include:

1. Preparation
2. Primary Survey (A, B, C, D, & E)
3. Resuscitation (occurs in conjunction with the Primary Survey)
4. Adjuncts to Primary Survey and Resuscitation
5. Secondary Survey (head-to-toe evaluation and history)
6. Adjuncts to the secondary survey
7. Continued post-resuscitation monitoring and re-evaluation
8. Definitive care

The Primary Survey should be repeated frequently to assess for any deterioration in the patient’s status. This allows for any potentially life-saving treatments to be initiated at the time an adverse change is identified.

With all of this in mind the child who has sustained anything more than a trivial injury must be considered at risk of decompensation. The primary survey should therefore include an estimation of the severity of trauma. The level of severity can be gauged through a consideration of both the mechanism and vital.

Preparation

The severely injured child or young person has been shown to be best served by being rapidly transported to definitive management. For this to occur efficiently and safely a coordinated approach between the pre-hospital personnel and the receiving hospital must take place. Effective communication allows for early mobilisation of all necessary personnel and resources. The Trauma Call System is part of this communication process. It allows for a coordinated team to be assembled in the emergency department prior to the time that the patient arrives (refer to pages 9 & 10).

Ideally, the resuscitation area should be prepared prior to the arrival of the patient.

- Appropriate airway equipment should be organised, tested, and placed where it can be immediately accessible.
- Warmed 0.9% Normal Saline should be available and ready to infuse intravenously when the patient arrives.
- Appropriate monitoring capabilities should be immediately available.
- Appropriate laboratory sample tubes with a pre-written request form should be prepared.
- A trauma series x-ray request should be pre-written.
- The weight of the patient should be estimated (by using the Best Guess). This allows for appropriate dosages of required resuscitative drugs to be pre-prepared.
**Key personnel will be notified via the Trauma Team Activation System prior to arrival of the patient.**

- The Emergency Consultant, as team leader, should brief the other members of the trauma team and assign roles. **Team members should familiarise themselves with their roles prior to arrival of the patient.**
- The Paediatric Surgical Registrar is part of the Trauma Team, and they attend the Emergency Department. They should also notify Operating Theatres and the on-call Paediatric Surgical consultant asap.
- The Radiographer is also part of the Trauma Team. They will prepare the mobile x-ray equipment for use within the resuscitation area without delay. The Radiologist is not a formal member of the Trauma Team but they can be notified regarding potential imaging studies that may be required.
- Paediatric Intensive Care is also part of the Trauma Team. They to attend the Emergency Department, while a bed area can be prepared, as necessary in PICU.

See Trauma Team Roles (page 13 & 14).

Personal Protective Equipment (PPE) / Lead aprons / & Identity role labels are available and should be used. All personnel who have contact with the patient must be protected from communicable diseases. If contact with body fluids is likely, a facemask with eye protection, a gown, and gloves should be applied. X-ray protection (i.e. Lead gowns) should also be applied so that the rapid assessment and early resuscitation can occur whilst the trauma series of radiographs are taken. Team members should also attach their role labels (available in the Resuscitation Room) with their designation to the outside of their gown to allow for easy identification.
Primary survey

The primary assessment and resuscitation should take place over the first 5-10 minutes of the patient's arrival in most cases. This process involves a rapid evaluation of vital signs and a quick review of the functioning of all essential organs. The emphasis is on uncovering treatable life-threatening injuries and also the prevention of complications (e.g. paralysis from an unstable cervical spine fracture).

This process constitutes the universally taught A, B, C, D, & E of paediatric trauma care. By following this sequence life threatening conditions can be quickly identified and treated:

A  Airway maintenance with cervical spine protection
B  Breathing and ventilation
C  Circulation with haemorrhage control
D  Disability: Neurologic status
E  Exposure / Environmental control: Completely undress the patient, but prevent hypothermia.

During the primary survey, when a life-threatening condition is identified the appropriate management is instituted immediately.

Airway maintenance with cervical spine protection

Airway assessment following trauma has the highest priority and should follow the:

LOOK      LISTEN      FEEL      approach

This rapid assessment for signs of airway obstruction should include inspection for foreign bodies and facial, mandibular, tracheal or laryngeal fractures that may result in airway obstruction. If the child, or young person, is able to communicate verbally the airway is not likely to be at immediate risk, however repeated assessment of the adequacy of the airway should occur. This is particularly the case if there is any sign of deterioration.

The cervical spine should be protected from the outset (unless the mechanism of injury clearly excludes the possibility of cervical spine injury). This protection should remain in place until such an injury can be excluded by the combination of an adequate clinical evaluation and (when indicated) radiological examination. This requires that either the child should be immobilised on a firm surface with the neck placed in a soft collar with side supports provided by sandbags or that the head should be held in manual in-line immobilisation by a competent assistant.

These techniques are described in more detail in the Cervical Spine Injuries guideline.

Plain lateral c-spine film should be taken as part of the trauma series

Breathing and ventilation

After dealing with any immediate airway problems, breathing should be assessed as the next priority. Ventilation requires adequate function of the lungs, chest wall and diaphragm. The following must be examined and evaluated rapidly:

- Expose the chest wall to assess movement & symmetry of both the chest and the trachea
- Palpation to detect injuries to the chest wall that may compromise ventilation
- Percussion, which may detect the presence of air or blood in the chest
- Check pulse oximetry to assess the effectiveness of ventilation
- Auscultate the lungs to assess for the quality of gas flow into each of the lung fields.

Injuries that pose an immediate threat to life, taught by the EMST are remembered by the acronym 'ATOMFC'
ATOMFC

<table>
<thead>
<tr>
<th>Airway obstruction</th>
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<tr>
<td>Tension pneumothorax</td>
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<tr>
<td>Open pneumothorax</td>
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<tr>
<td>Massive haemothorax</td>
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<tr>
<td>Flail chest</td>
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<td>Cardiac tamponade</td>
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These injuries should be identified during the primary survey, pre-CXR, and treated promptly. Otherwise, a CXR may add further information. CXR is done as part of the trauma series (c-spine, CXR, pelvis XR).

**Circulation with Haemorrhage Control**

Circulatory assessment in the Primary Survey involves the rapid assessment of heart rate and rhythm, pulse volume and both central and peripheral perfusion (colour, temperature and capillary return). In addition, a rapid check should be made for significant external haemorrhage (and direct pressure applied). Tachycardia and poor peripheral perfusion are often the initial signs of circulatory failure in children. Hypotension, on the other hand, is a late sign of hypovolaemia, due to a child’s increased physiologic reserve.

The circulatory state of an injured child can often be difficult to assess. A single abnormal sign is not predictive of shock, but two or more of these signs are predictive of the requirement for fluid replacement. In blunt paediatric trauma large volume losses are the exception rather than the rule. It is also important to remember that an abnormal respiratory rate and altered mental status, in the presence of circulatory compromise, may indicate the secondary effects of shock on those organ systems.

Focussed Assessment with Sonography for Trauma (FAST) has been used extensively in the early assessment of the haemodynamically unstable adult trauma patient. In children, FAST can be used to rule intra-abdominal fluid and organ injury in, but a negative ultrasound does not rule intra-abdominal injury out.3-5

**Disability**

A rapid neurologic evaluation is performed after the A, B, & C of the Primary Survey. This assesses three aspects of the neurological examination,

1. The child’s level of consciousness,
2. Pupil size and reaction, and
3. Posture.

The conscious level is described by the child’s best response to voice and (where necessary) to pain. The AVPU method is a rapid assessment and is outlined below:

<table>
<thead>
<tr>
<th>A</th>
<th>Alert</th>
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<tbody>
<tr>
<td>V</td>
<td>Responds to Voice</td>
</tr>
<tr>
<td>P</td>
<td>Responds only to Pain</td>
</tr>
<tr>
<td>U</td>
<td>Unresponsive to all stimuli</td>
</tr>
</tbody>
</table>

An AVPU level of P is approximately equivalent to a Glasgow Coma Score (GCS) level of 8. A decrease in the level of consciousness may be secondary to either direct cerebral injury or a decreased level of cerebral oxygenation. Any disability assessment which identifies an altered level of consciousness should lead to an immediate re-evaluation of the patient’s Airway, Breathing and Circulation. The pupils and posture are included within the Primary Survey as asymmetry of these signs may be secondary to raised intracranial pressure (ICP).
Exposure

In order to fully assess a seriously injured child complete exposure is necessary, through removal of his or her clothes. Children become cold very quickly and at this point the child’s core temperature should be noted. Although complete exposure is essential, a child’s dignity should always be considered. With this in mind the duration should be minimised and then warmed blankets provided.

Resuscitation

Aggressive resuscitation and management of life-threatening injuries as they are identified is essential to maximise patient survival.

Airway

The airway should be protected in all patients and secured when the potential for airway compromise exists. Airway support can be provided in different ways depending on the clinical situation. In the trauma patient the jaw thrust manoeuvre should be used rather than the chin lift due to the potential for cervical spine injury. A nasopharyngeal airway may occasionally help to establish and maintain airway patency in the conscious patient (however use is contraindicated in suspected base of skull fracture). If the patient has a reduced level of consciousness (P or U on AVPU scale) and has no gag reflex, an oropharyngeal airway may be helpful temporarily; however this often highlights the need for a more definitive airway (endotracheal tube (ETT) intubation). The severely head injured patient (GCS ≤ 8, P or U on AVPU scale) usually requires the placement of a definitive airway. When considering the GCS level, the motor component most reliably implies the need for definitive airway management. If an ETT is required inline immobilisation should be utilised throughout.

Breathing and ventilation

All patients who suffer serious injury require, as a minimum, supplementary oxygen via a non-rebreather mask. This should be initiated immediately on arrival, if not already in place. In patients who have compromised airways due to mechanical factors, and have ventilatory problems, or are unconscious, a definitive airway is achieved by endotracheal intubation. With this in mind any child who requires bag-mask ventilation initially following trauma will usually require subsequent endotracheal intubation to control the airway. Endotracheal intubation is outlined in Appendix 1 – Endotracheal Intubation.

If on auscultation the breath sounds are unequal then a pneumothorax, haemo-pneumothorax, misplaced tracheal tube, blocked main bronchus or pulmonary collapse, diaphragmatic rupture, pulmonary contusion and aspiration of vomit or blood should all be considered, and the appropriate management should be taken (see Thoracic Trauma in Children guideline).

Circulation

All seriously injured children require urgent vascular access. Two relatively large intravenous (IV) cannulae are mandatory. The maximum rate of fluid administration is determined by the internal diameter of the catheter and inversely by its length, not by the size of the vein in which the catheter is placed. A 22 G (Blue) cannula can infuse fluids at rates up to 35ml/min whilst the 14 G (Orange) cannula is exponentially higher at up to 330ml/min.

The preferred site of IV access is the antecubital fossa, however any site that allows for large bore IV access is acceptable. Intraosseous (IO) infusion is warranted from the outset in very urgent situations or later if other options have failed.

If relatively small gauge cannulae are inserted these can be upgraded via the Seldinger method to Rapid Infusion Catheters (RICs) which allow large volumes of intravenous fluids to be given rapidly.

At the time of IV insertion, blood should be taken for:

- Group and Hold (or Cross match if appropriate).
- Venous Blood Gas (with lactate if available)
- FBC
- ELFTs, lipase
- Coagulation profile
- Creatinine Kinase (CK) (if mechanism consistent with a significant crush injury)
- Cardiac Troponin (if signs of significant chest trauma)
- Beta HCG for females > 12 years of age
Blood tests, on the whole, have a low sensitivity for identifying serious injuries in the paediatric population. The laboratory test that is most likely to affect early management is the Crossmatch. This is because it allows for a rapid change from O-negative to fully Crossmatched blood products, if required. All other blood tests should be considered adjuncts to a complete clinical assessment, with the addition of radiological investigations where appropriate.

Warmed intravenous fluid therapy should be initiated with 0.9% Normal Saline infused rapidly (in smaller children, and those with IO access, this may be best performed by pushing fluids via a syringe) in 10ml/kg aliquots. Boluses of IV or IO 0.9% Normal Saline should be given until there has been stabilisation / improvement in the child’s intravascular volume. This is best estimated by regular reassessment of the central capillary refill (aiming for <2 seconds), heart rate, and level of consciousness.

If crystalloid bolus has been administered to a child who remains unstable, packed cells should be used for further fluid replacement in 10ml/kg aliquots. O-negative blood is available from blood bank and also from the blood fridge of ORS Level 4 of the Lady Cilento Children’s Hospital. Please source blood from pathology blood bank in the first instance.

Group-specific blood can become available 10 minutes after arriving at the blood bank. A full Crossmatch takes between 30 and 45 minutes after arrival of the specimen in blood bank. If significant requirements for blood products are anticipated then consideration should be given to activation of the Massive Transfusion Protocol (MTP)/ Damage Control Resuscitation DCR). This protocol allows for rapid access to blood products in pre-arranged pack of packed red cells, fresh frozen plasma (FFP), platelets and cryoprecipitate. Again blood products should be given, as per the MTP until there is stabilisation of the child’s haemodynamic status. (See MTP / DCR guideline).

Surgical involvement is also essential for any patient requiring blood products in trauma, to allow for the rapid definitive management of the source of ongoing bleeding.

If the patient is suspected to have an unstable pelvic fracture as the cause of haemodynamic instability, a pelvic binder should be applied (see Pelvic Trauma in Children guideline).

**Disability**

If the primary survey reveals that the child has evidence of a decompensating head injury, neurological resuscitation is required. If the head injury is severe, identified by a GCS less than 8 and there is evidence of raised ICP, immediate intervention is necessary. Lesser degrees of unconsciousness or the presence of focal signs may still indicate the need for urgent action. Avoidance of hypotension and hypoxia are paramount in the severely head injured patient as these can have a significant effect on the long-term outcome.

**Interventions to be considered include:**

- Tilt bed head up to 20 degrees
- Oxygenation
- Control of pCO₂ (by controlling ventilation)
- Maintenance of blood pressure to support cerebral perfusion
- Mannitol or 3% NaCl (depending on practitioner preference) to temporarily lower the ICP
- Anaesthesia / sedation / analgesia to reduce cerebral metabolism
- Prompt treatment of any seizures
- Hypothermia, or at least avoidance of hyperthermia

**Adjuncts to Primary Survey and Resuscitation**

The trauma series - C-spine, chest and pelvis xrays, contribute to resuscitation and subsequent decision making, but they should not delay patient resuscitation. We have nominated that the trauma series be completed at LCCH usually during the primary survey but on occasion they may be completed during the secondary survey.

Focused Assessment with Sonography for Trauma (FAST) is used routinely in the adult trauma patient, however as outlined previously its role in paediatric trauma remains less clear.

*A positive FAST can be used to rule in intra-abdominal fluid and organ injury.*

*A negative FAST does not rule out intra-abdominal injury.*

An indwelling urinary catheter (IDC) should be inserted if the child cannot pass urine spontaneously or if continuous accurate output measurement is required to achieve stabilisation after a serious physiological insult.
All severe burns requiring fluid resuscitation must have an IDC inserted, as this will guide ongoing fluid requirements. An IDC should not be inserted if there are signs of potential urethral trauma (e.g. blood at urethral meatus). If this is the case appropriate investigations / surgical review should be performed prior to insertion of the IDC. A mid-stream or catheter specimen of urine should be collected and a ward test performed, particularly if renal or crush injury is suspected.

Acute gastric dilatation is common in children and can lead to respiratory embarrassment. The stomach should be decompressed early in the resuscitative phase by an orogastric or nasogastric tube. If there is evidence or suspicion of basal skull fracture, the tube should not be passed by the nasal route. Ideally this should be done prior to radiology.

Analgesia can usually be administered during, or just after completing, the primary survey and resuscitation. Intravenous morphine (or fentanyl) is the standard analgesic agent used in acute trauma care.
Secondary survey

The Secondary survey doesn’t begin until the Primary survey has been completed, resuscitative efforts are well established and the child is demonstrating vital signs that are trending towards normal.

The secondary survey is a head-to-toe evaluation of the trauma patient. This includes a complete history of the event, any significant past medical history and a detailed physical examination. Each region of the body is completely examined. The likelihood of missing injuries is not insignificant, particularly when normal clinical signs and symptoms of injury cannot be relied upon - for example in the unresponsive or unstable patient.

If the patient remains unstable and requires definitive management in theatre, handover and documentation that the secondary survey has not yet been done/completed is necessary to ensure injuries aren’t missed.

The history of the events leading up to the injury and the injury itself should be sought from the child, pre-hospital personnel, relatives and witnesses of the accident. Information should be gained regarding the injury mechanism, as some injuries can be predicted based on the direction and amount of energy force. Past medical history, allergies, immunisations, and any regular medications should also be noted. One approach is:

- Allergies
- Medications
- Past Medical History
- Last Meal
- Events leading up to the injury

The secondary survey is a simple but thorough search for key anatomical features of injury. One approach that is well accepted is:

- Surface (head to toe, front and back)
- Orifice (mouth, nose, ears, orbits, rectum, genitals)
- Cavity (chest, abdomen, pelvis, retroperitoneum)
- Extremity (upper limbs including shoulders; lower limbs including pelvic girdle).

The anterior portion of the secondary survey is often performed first out of convenience. The head restraints and cervical spine collar are then removed, while a trained assistant performs inline immobilisation. This allows for examination of the head, neck, face, ears, nose and mouth. With the assistant still immobilising the neck (maintaining in-line immobilisation) a log roll may be performed to examine the occiput, spine, scapula, flanks, sacroiliac joints and other posterior structures. The soft collar is usually then reapplied.

Head (see Management of head injury)

A head examination includes re-evaluation of pupillary size and reactivity, a conjunctival and fundoscopic examination for haemorrhage or penetrating injury, and in the awake patient a quick assessment of visual acuity. Visualisation of blood in the external auditory canal or behind the tympanic membrane raises suspicion for a basilar skull fracture. A thorough inspection and palpation of skull and mandible may detect fractures and dislocations.

Cervical spine and neck (see Cervical spine injury guideline)

Injury to the cervical spine is uncommon in children, but the risk of injury must still be considered. This is especially true for any child with significant injury or impact above the clavicles. Patients at highest risk are young children who:

- fall one or more floors ( > 3 metres)
- have been hit by a motor vehicle (pedestrian or cyclist)
- passengers in a high-speed MVA

The neck should also be assessed for

- tracheal deviation
- contusions, haematomas
- penetrating injuries
- crepitus, if felt anteriorly in the neck may be indicative of subcutaneous emphysema – which can be caused by a laryngeal fracture, oesophageal rupture, or a pneumothorax.
Chest (see Thoracic trauma in children)

Visual inspection of the chest may identify a sucking chest wound, a major flail component, or a penetrating wound. The chest should also be palpated for crepitus or tenderness. Non-tension pneumothorax and haemothorax can be difficult to diagnose clinically in children. A prompt CXR may be helpful in detecting these conditions in stable patients.

Mechanisms associated with serious injury include high impact acceleration-deceleration mechanisms (e.g. MVA). If there are any abnormalities on CXR with a high-risk mechanism, urgent CT-Angiography of the Chest should be performed.

Abdomen (see Abdominal trauma in children)

Inspection, auscultation, and palpation of the abdomen are aimed at determining whether or not visceral injury may be present. It is not meant to provide an exact diagnosis. Visceral injury should be suspected in the presence of:

- abdominal wall contusion
- distension
- abdominal or shoulder pain
- signs of peritoneal irritation
- gross haematuria
- shock.

Patients with such findings should undergo an abdominal CT scan as soon as possible, with surgical review prior to CT.

A digital rectal examination (DRE) should not be performed routinely in the paediatric major trauma patient. The DRE has poor sensitivity for the diagnosis of spinal cord, bowel, rectal, bony pelvis, and urethral injuries. However it should be preformed when indicated, particularly if there is any suspicion of penetrating trauma.

Extremities (see Orthopaedic injury in children)

All limbs should be thoroughly examined for any swelling, deformity, bruising, abrasions, penetration, and perfusion (including checking all distal pulses). Any soft-tissue injuries should be thoroughly inspected for both foreign bodies and the presence of devitalised tissues. Long bones should be palpated with both rotational and three-point pressure for tenderness, crepitation or abnormal movement. Pressure should be applied to the pubis and anterior iliac spines to assess for the presence of a pelvic fracture.

Severe extremity angulations should be straightened, immobilised and traction splints should be applied. This will help improve both perfusion and analgesia. Compound fracture sites should be covered with sterile dressings.

Neurology

Neurologic assessment includes a:

- re-evaluation of the level of consciousness
- repeat pupil examination
- thorough sensorimotor examination.

Any evidence of paralysis or paresis suggests a major neurologic injury. Until a spinal cord injury is confirmed or ruled out in any patient with signs of central nervous system injury, maintain the patient in a semi-rigid cervical collar and immobilise him or her on a firm surface. It should be noted that a significant proportion of children who have suffered cervical spine injury also have evidence of head injury.

Adjuncts to the Secondary Survey

Specialised diagnostic tests may be performed during the secondary survey to identify specific injuries. This may include additional x-rays of the spine and extremities; CT scans of the head, chest, abdomen and spine, etc.

If not already done during the primary survey, useful adjuncts to consider include:

- FAST scan
- urinary catheterisation
- arterial line (for blood pressure monitoring or frequent blood sampling)
orogastric/nasogastric tube (to decompress the abdomen)
- further imaging - may include additional plain films (e.g. spine and extremities) or CT scans (e.g. head, chest, abdomen, pelvis, and spine)
- splinting fractures
- pelvic binder
- 4 As - analgesia, antibiotics, ADT, advise the family.

Re-evaluation

In the trauma patient it is important to repeatedly re-evaluate. This ensures that changes in the patient’s state are not missed. As initial life-threatening injuries are managed, other equally life-threatening problems and less severe injuries may become apparent. A high index of suspicion is necessary to facilitate early diagnosis and management.

Conclusion

The injured patient must be evaluated rapidly and thoroughly. It is important to follow a structured approach so that no steps in the process are missed. Assessment, resuscitation or treatment, re-evaluation and diagnosis may occur simultaneously, but priorities should not change. An adequate patient history and accounting of the incident with clear, concise documentation are important in evaluating and managing the trauma patient.

References

3. Logan P & Lewis D Focused Assessment with Sonography for Trauma (FAST) Emergency Ultrasound UK, 2004
4. Lee LK & Fleisher GR Trauma management: Approach to the unstable child In: UpToDate, Rose, BD (Ed), UpToDate, Waltham, MA, 2009

Further Reading

4. Hampers, L Approach to the Injured Child In: UpToDate, Rose, BD (Ed), UpToDate, Waltham, MA, 2009.
5. Reyes Mendez, D Initial evaluation and stabilisation of children with thoracic trauma. In: UpToDate, Rose, BD (Ed), UpToDate, Waltham, MA, 2009.
Tertiary survey

The tertiary trauma survey is a comprehensive review of the patient, his/her medical records with an emphasis on the mechanism of injury and the age of the patient. It is performed with the aim of identifying injuries that have been missed during initial assessment.

It includes the repetition of the primary and secondary surveys, a complete history of the event, any significant past medical history and a detailed physical examination. Each region of the body is completely examined and it includes a review of all laboratory data and a review of all radiographic studies with a radiologist.

It is a patient evaluation that identifies and lists all injuries after the initial resuscitation and operative intervention.

This typically occurs **within twenty four hours after admission** and is repeated when the patient is awake, responsive and able to communicate any complaints.

Any new physical findings require further studies to rule out missed injuries. The Advanced Trauma Life Support (ATLS / EMST) course uses a systematic approach to evaluate the trauma patient and utilizes primary and secondary surveys to ensure that all injuries are identified. However, not all injuries are detected by these two surveys. In fact, 2 to 50% of combined life threatening and non-life threatening injuries are missed.

Injuries that may be missed during primary survey, and need to be identified during the tertiary survey, often have great functional importance and impact the return of the patient to normal occupational, family and social functions. They usually pose little threat to life but often would lead to locomotor or manipulative disability if undetected and untreated. Examples include cervical spine injury without neurological deficit, fractures of small bones in the hands and feet, ligamentous injuries to the knee or ankle, dislocated acromioclavicular joint and peripheral nerve injuries.

Review of previous X-rays will sometimes result in a new diagnosis of pneumothorax, widened mediastinum, pelvic fracture or rib fractures that may require specific management.

At the LCCH we have elected that the admitting team complete the tertiary survey ideally within 24 hours of the patients admission, however the surgical register is the default person for all trauma patients that have received a trauma attend call.

Further reading:

http://www.trauma.org/archive/nurse/tertiarysurvey.html

http://www.surgwiki.com/wiki/Principles_of_trauma_management
Procedure: Management of Unknown Patient


Management of the Unknown Patient at LCCH Emergency Department

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<td>Applicable to</td>
<td>All staff in Emergency Department and Health Information Services (HIS)</td>
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<tr>
<td>Authorisation</td>
<td>Executive Director Hospital Services (EDHS)</td>
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Purpose

This procedure describes the process for allocating UR numbers to unidentified patients, requiring emergency care, presenting to the Emergency Department (ED) of Lady Cilento Children’s Hospital (LCCH) and the process to be followed should this occur.

Scope

This procedure applies to LCCH Emergency and HIS staff.

Procedure

An unstable patient of unknown identity presenting to LCCH ED will be allocated a dedicated “Unknown patient” UR number.

The ED flow coordinator must authorise the allocation of an “Unknown Patient” UR number with a signature in the ED Unknown log book attached to the Administration Officer (AO) Resus Workstation on Wheels (WOW). This signature confirms that the patient is unknown at the time of registration in ED.

The details of the patient are to be entered into all relevant information systems including Hospital Based Corporate Information System (HBCIS), Emergency Department Information System (EDIS) and Integrated electronic medical record (ieMR) with this UR number. This includes the safety feature of ‘one’ ‘two’ ‘three’ etc. from the log book.

Due to the legalities of administering blood and blood products, cross matched blood should not be relabelled as patient details are updated. Therefore for patient safety reasons, no details are to be changed for this patient in the “family name” and “given name” and “date of birth” fields on HBCIS or EDIS within the first 24 hours of their admission.
In the case that within eight (8) hours the patient identification is still unknown, the Queensland Police Service (CPS) needs to be contacted to continue with the identification process. The social worker can help with this process.

Emergency Department (ED) Procedure

An unidentified patient presenting to the LCCH Emergency Department must be issued a new medical record with a new UR number. The ED flow coordinator is to sign the ED Unknown Patient Log Book held in the red zone AO WOW authorising the issue of an “Unknown Patient” UR number.

1. Register patient in HBCIS as:
   a. Family Name – UNKNOWN ‘ONE’
      (‘TWO’ ‘THREE’ ‘FOUR’ etc. this correlates with the logbook)
   b. Given Name – UNKNOWN
   c. Day of Birth – enter *** for unknown
      (this will register downstream as ‘15’)
   d. Month of Birth – enter *** for unknown
      (this will register downstream as ‘June’)
   e. Year of Birth – estimate the year of birth from the age of the patient. *This is important so that Pathology can apply appropriate reference ranges for some tests.*

   This will link with EDIS and ieMR

2. Place the ieMR label in ED ‘Unknown Patient Log Book’ in the same section as the ED Nursing Flow Coordinators signature. This allows verification of the ‘unknown patient’. The log book is located in the Admin Red Zone / Resus WOW basket.

3. Inform HIS staff by email of the unknown patient registration, CHQ_HBCIS@health.qld.gov.au. The Emergency Data Manager receives an automated daily report of all Emergency presentations with the family name of ‘Unknown’.

4. An armband must be secured on the patient’s right arm (first preference).

5. All pathology requests must be marked with the “Unknown Patient” UR number and labelled with the exact same information as in HBCIS.

**ALERT**
DO NOT CHANGE ANY DETAILS FOR THE UNKNOWN PATIENT REGISTRATION WITHIN 24 HOURS

Once the patient is correctly identified:

Once the patient’s correct identification has been determined and the parents or family identify the patient, a patient search is to be conducted on HBCIS to establish whether or not the patient has an existing LCCH Medical Record.

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If the patient has an existing LCCH Medical Record:

Contact the HBCIS Manager via email – CHQ_HBCIS@health.qld.gov.au – to inform them of the Unknown Patient and request merging of the records.

Record identity in the “ED Unknown Patient Log Book” located in the Red Zone AO WOW - next to the ED Flow Coordinator’s signature.

The ED Admin Officer can update the HBCIS record by entering the patient’s correct name in the ‘Alias’ field ONLY - keeping the UNKNOWN name within the first 24 hours of their admission as per the above process.

The patient’s name (when identified) should be entered into the ‘clinical comments field’ on EDIS to allow Emergency staff to identify the patient by name.

Please organize a recollection (group & hold) so a current sample is available if more blood products are required or anticipated.

If the patient does not have an existing LCCH Medical Record:

After the initial 24 hour period, replace the ‘unknown’ details with the patient’s full and correct details in HBCIS and EDIS. Reprint the patient labels and replace the unknown patient labels in the ED chart.

Do not place updated patient labels over the ‘unknown’ patient labels affixed in the patient’s medical record.

Please organize a recollection (group & hold) so a current sample is available if more blood products are required or anticipated.

Procedure in other areas

An unknown patient transferred into another department (e.g. Peri-operative Services, Paediatric Intensive Care Unit (PICU), wards or Mortuary) from ED with an “Unknown” medical record will be identified by the Unknown UR and Unknown safety number (one / two etc.) until discharge or appropriate merging of the Medical Records with the assistance of the HBCIS Manager.

Processes to identify patients who have not been identified in ED will continue.

Merger of Medical Records

Medical Records Department is responsible for merging medical records and notifying ED, Pathology Queensland and/or any other applicable third party systems (e.g. Pharmacy or Radiology Information System) at the time of the merge. This usually occurs following discharge of the patient; however a merge can be arranged with the Medical Record Department whilst the patient is still an inpatient. Pathology is to be notified of the merge via email to OHPH-Central@health.qld.gov.au and Pathology-LCCH@health.qld.gov.au. If the merger is performed outside normal hours, please contact Core Lab via switch.

Consultation

Key stakeholders who reviewed this version:

- Trauma Service
- Health Information Service (HIS)
- Emergency Department / Emergency Director NUM, AO lead and DM

CHQ-PROC-17023 – Management of the Unknown Patient at LCCH Emergency Department
• Pathology
• Patient Safety and Quality Service (PSQS)

Definition of terms

<table>
<thead>
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<th>Term</th>
<th>Definition</th>
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<tr>
<td>ED</td>
<td>Emergency Department</td>
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<tr>
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<td>Administration Officer</td>
<td></td>
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<tr>
<td>HIS</td>
<td>Health Information Services</td>
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<tr>
<td>WOW</td>
<td>Workstation on Wheels</td>
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References
1. Queensland Hospital Admitted Patient Data Collection (QHAPDC) 2013-2014

Audit/evaluation strategy

<table>
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<tr>
<th>Level of risk</th>
<th>Strategy</th>
<th>Audit/Review tool(s)</th>
<th>Audit/Review date</th>
<th>Review responsibility</th>
<th>Key elements / Indicators / Outcomes</th>
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<td>Annually</td>
<td>ED or/and Trauma Service</td>
<td>ED audit / Include no. of unknown registrations in end of year trauma audit – from ED log book</td>
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Procedure revision and approval history

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<th>Version No.</th>
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<th>Amendments authorised by</th>
<th>Approved by</th>
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<td>Director, Health Information Management Service</td>
<td>General Manager Operations</td>
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<td>2.0</td>
<td>Tonia Gillen, Trauma Nurse Manager</td>
<td>Divisional Director, Surgery</td>
<td>Executive Director Hospital Services</td>
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Keywords
17023, unknown, patient, identification, emergency, medical records, unidentified

Accreditation references
NSQHS Standards (1-10): 5
EQuIP National Standards (11-15): 14

CHQ-PROC-17023 – Management of the Unknown Patient at LCCH Emergency Department

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Imaging in major trauma

Trauma series

Lateral c-spine, chest and pelvic x-rays contribute to resuscitation and subsequent decision-making; however they should not delay patient resuscitation and APLS (Advanced Paediatric Life Support). Completion of the entire trauma series is recommended at LCCH.

General Considerations in the Paediatric Patient

The use of CT technology in the paediatric patient has increased exponentially over the past 30 years. It is estimated that approximately seven million CT scans are performed on children in the US each year.¹ It has also been determined that CT scans contribute to approximately 70% of the overall radiation dose to children, despite only 15% of imaging examinations being CT scans.¹,² Below is an estimate of the radiation dose of head, chest & abdominal CT when compared with chest x-ray.

<table>
<thead>
<tr>
<th>Imaging Study</th>
<th>Equivalent Number of chest x-rays</th>
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<tr>
<td>CT Head</td>
<td>200</td>
</tr>
<tr>
<td>CT Chest</td>
<td>150</td>
</tr>
<tr>
<td>CT Abdomen</td>
<td>250</td>
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Children are much more vulnerable to ionising radiation when compared with adults. This is because growing children have rapidly dividing cells, making them more sensitive to radiation (in fact 10 times more sensitive). Children also have a longer life expectancy than adults, also contributing to their increased lifetime risk of developing fatal cancers. Overall it has been estimated that 1 in 1000 children who receive a CT scan will develop a fatal cancer as a result.

CT scans still remain an essential aspect in trauma care. The benefits provided by the imaging examination must however be weighed up with the potential risk of the ionising radiation. The following series of CT guidelines may assist with this decision making process.¹,²

CT Head

As per the CHALICE decision rule:

For children aged < 16 years presenting after trauma involving the head, a CT scan is recommended if any of the following criteria are present:

1. History
   - Witnessed loss of consciousness of > 5 minutes duration
   - History of amnesia (either anterograde or retrograde) of > 5 minutes duration
   - Presence of abnormal drowsiness
   - ≥3 vomits following the head injury
   - Suspicions of non-accidental injury (suspected child abuse)
   - Any seizure after a head injury in a non-epileptic patient

2. Examination
   - Glasgow Coma Scale (GCS) <14, or GCS <15 if under 1 year old
   - Suspcion of penetrating injury
   - Suspcion of depressed skull fracture
   - Tense fontanelle
   - Signs of basal skull fracture
   - Any focal neurological deficit/abnormality
   - Presence of bruising/swelling or laceration >5cm in an infant

3. Mechanism
   - Head trauma in the setting of a high speed (>60km/hr) motor vehicle accident as either pedestrian, cyclist or occupant
   - Head trauma in the setting of a fall from over 3m height
Head trauma related to a high speed projectile

If none of the above features are present, the child is at a low risk of having intracranial pathology.

The CHALICE rule has a sensitivity of 98% and a specificity of 87% for detecting a clinically significant head injury. Implementation of the CHALICE rule resulted in a CT scan rate of approximately 14%.

Other considerations

CT scanning is a safe, accurate and readily available investigation for older children who are able to lie still for the procedure. In younger children, particularly those under 5 years, general anaesthesia or procedural sedation may be required to achieve CT scanning. In addition, the risks of cranial irradiation need to be considered. Therefore, particularly in younger children, the risk of the investigation (CT) should be balanced against the risk of delayed diagnosis. Observation in ED for a period of at least six hours from the time of the injury, may be used as an alternative approach in children <5 years old whose indications are marginal (e.g. vomiting, impact seizure, etc.) with CT reserved for those children who develop any of the above criteria during the period of observation.

CT-Angiography of the Chest (see Thoracic Injury in Children guideline)

For children, CT-Angiography of the Chest is used primarily to identify vascular injury. Traumatic injury to the aorta occurs much less commonly in children sustaining severe blunt trauma than adults (0.1% in one study\textsuperscript{5}). Early diagnosis however, is imperative.

CT-Angiography of the Chest should be considered for the following indications:

- When there is suspicion of aortic injury
  - Mechanism of injury
    - Car vs. pedestrian – runover / signs of significant impact
    - High speed MVA (>60kph), particularly if child was in front seat and no airbag deployed.
    - Fall greater than 6m
  - Physical examination
    - thoracic ecchymoses
    - thoracic and back tenderness
    - multiple trauma with significant distracting injury
  - Findings on CXR
    - widened mediastinum, obscured aortic knob, tracheal deviation, NG tube deviation, left apical cap, significant pulmonary contusions, or large left haemothorax
  - Signs of great vessel injury
    - asymmetric, diminished, or absent peripheral pulses
    - paraplegia

Doppler USS of the Neck should be performed on the rare occasion of significant injury to the neck only. In paediatric patients Doppler USS provides adequate clarity of vascular structures. It therefore should be used in preference to CT-angiography of the neck in patients who do not require CT for identification of other types of injuries.

CT Abdomen (see Abdominal Trauma in Children Page 78)

Life-threatening abdominal injuries may be occult, or may be suggested by the presence of abdominal bruising, distension, shock, etc. The following list outlines suggested reasons for performing an abdominal CT in the seriously injured child:

- History or physical examination suggestive of intra-abdominal injury
  - Abdominal pain and/or tenderness
  - Other injuries associated with increased risk of intra-abdominal injury
    - Pelvic fracture
    - Lumbar spine fracture
    - Lower rib fracture
- Mechanisms of injury suggestive of abdominal trauma
  - high speed MVA (>60kph)
  - lateral motor vehicle collisions
  - seat belt usage
  - falls from a height greater than 6 metres
- Declining haemoglobin without clear explanation
- Unaccountable crystalloid or blood product requirements
- Inability to perform adequate abdominal examination or serial abdominal examinations (in the setting of abdominal trauma):
  - ventilated children
  - children younger than two to three years
  - substance use
  - head injury
  - altered sensorium
  - planned general anaesthesia
- Haematuria

A single dose of oral contrast should be given via NG or OG tube at the earliest possible occasion if abdominal CT is planned. Thirty minutes is generally sufficient for the contrast to opacify proximal small bowel (the region of most concern). However it is important that the administration of oral contrast does not unnecessarily delay the CT. Therefore if the patient is ready and the situation is urgent CT may need to be performed without oral contrast.

A simple dosage regime for **oral contrast** in this context is:

- **< 3 years of age** - 50mls
- **≥ 3 years of age** - 100mls

If no NG/OGT, **water** can be given as an alternative but the volume is larger

- **< 3 years of age** - 125mls
- **≥ 3 years of age** - 250mls

If ill effects (e.g. vomiting) occur in response to the oral contrast, administration should be ceased and the CT scan performed.

**References**


**Further Reading**

Management of head injury

Approximately 1-2% of all Paediatric Emergency Department presentations are for head trauma. Fortunately, about 2/3 of these cases are of a trivial nature (i.e. no concerning symptoms on history and no significant findings on physical examination) and the risk of intracranial injury is exceedingly small. In children with non-trivial head injuries (i.e. those with significant history or symptoms or signs), intracranial injury is still uncommon (<5%).

Estimates are that only about 20% of head injuries in children will be moderate and just 2% will be severe.

Trauma involving the head is the leading cause of death in children aged 1-15 years (~15% of deaths in this age group). The most common situation in which death occurs from head injury is after road traffic accident (particularly pedestrian children or cyclists). In younger children, falls are the most common cause of head injury. Boys sustain head injuries twice as often as girls and have four times the risk of sustaining a fatal head injury.

The incidence of subdural haematoma (SDH) is higher in infants and adolescents. Extradural haematomas (EDH) are rare in children <4 years but then the incidence steadily increases with age. SDHs usually present with more clinical findings than EDHs where findings may initially be mild.

Early recognition and surgical treatment of certain intracranial injuries (ICI) improves outcome but predicting the presence of ICI by clinical history and examination alone is difficult, especially in younger children. CT scanning is a very sensitive means of detecting intracranial haemorrhage, but many younger children require sedation or general anaesthesia for this procedure.

The main principles in the management of head injuries are:

- adequate resuscitation

Most children who present to an emergency department with a head injury will have a minor head injury.

The key questions are:

- which patients can be safely discharged home?
- which patients require admission for a period of observation?
- which patients justify performing a CT scan?

Management of raised intracranial pressure (ICP) in ED

In the setting of head trauma, raised intracranial pressure (ICP) may be the result of either a generalised swelling or focal haemorrhage/swelling. Generalised increase in ICP in the supratentorial compartment initially causes transtentorial (uncal) herniation and later, if unabated, progresses to transforaminal (central) herniation i.e. “coning”. Unilateral increase in ICP (due to local haemorrhage) can cause ipsilateral uncal herniation. In these cases, the 3rd cranial nerve may be compressed against the tentorium causing ipsilateral pupillary dilatation.

Raised ICP

Cerebral perfusion pressure (CPP) in children is between 50-60mmHg. Mathematically it is expressed as the difference between mean arterial pressure (MAP) and intracranial pressure (ICP).

\[
CPP = MAP - ICP
\]

In children with head trauma, raised ICP should be suspected in the presence of:

- Depressed or deteriorating level of consciousness
- Abnormal oculocephalic reflexes – doll's eye movement or dysconjugate upward gaze
- Abnormal posture – decorticate or decerebrate (may be elicited with painful stimulus)
- Abnormal pupillary responses, unilateral or bilateral dilatation
- Abnormal breathing patterns (may vary - hyperventilation, Cheyne-Stokes, apnoea)
- Cushing's triad (late sign) – bradycardia + hypertension + breathing pattern abnormality
- Papilloedema (late sign) – may not be present in acutely raised ICP
- Headache
Vomiting
Bulging fontanelle
Blurred vision/papilledema
Seizures

In children, the most common cause of raised intracranial pressure is cerebral oedema. Other causes in the setting of head trauma include expanding extradural, subdural or intracerebral haematomas. Management is aimed at preventing further rises in ICP and/or removing its cause (surgical evacuation of haematomas).

**Emergency management of raised ICP includes:**

- Raise head of bed 20°
- Intubate and ventilate – aim for pCO2 of 28-32 mmHg
- Mannitol 0.5-1.0 g/kg (2.5-5.0 ml/kg), or 3% Saline 2-6ml/kg as a bolus, if evidence of impending coning (e.g. Cushing’s triad)
- Ensure adequate systemic blood pressure - remember Cerebral Perfusion Pressure (CPP) = Mean Arterial Pressure (MAP) – Intracranial Pressure (ICP)
- Urgent referral to Neurosurgeons for potential surgery

**Cerebral herniation**

Many cerebral herniation syndromes exist but the one most feared is ‘coning’ which is where the cerebellar tonsils protrude through the foramen magnum. Another common herniation is uncal (or tentorial) herniation where the hippocampus and the temporal uncus herniate through the tentorial notch compressing the brainstem and the third cranial nerve.

**Signs and symptoms associated with this herniation include:**

- symptoms of raised ICP plus
- headache
- altered level of consciousness
- ipsilateral or bilateral pupillary dilatation from compression of the third cranial nerve
- hemiparesis
- decerebrate posturing
  - o bradycardia,
  - o hypertension,
  - o irregular breathing from brainstem compression
- death.

**Extradural haematoma**

Also called an ‘epidural haematoma’ this injury is a collection of blood between the skull and the Dura.

Usually the cause is a middle meningeal artery injury but can also be due to an injury of the middle meningeal vein, diploic veins, or venous sinuses. Extradural haematomas are:

- commonly found in the temporoparietal and temporal regions
- most commonly caused by traumatic blunt injury (particularly falls)
- also result from falls from relatively short heights (differs to subdural haematomas which tend to occur following high level blunt force injury).

Classically, adult patients may experience an acute loss of consciousness followed by a more **lucid interval** and then neurological deterioration as the extradural expands and raised ICP becomes an issue.

**Paediatric patients may present with just:**

- headache
- vomiting
- lethargy
- altered level of consciousness
Extradurals are identified on CT scans as biconvex lesions in the temporoparietal or temporal regions. A midline shift would indicate a large extradural or a rapidly expanding extradural - both scenarios require emergency neurosurgical intervention for clot evacuation and repair of the damaged vessel.

Subdural haematoma
Subdural haematomas (SDHs) are a collection of blood between the dura and the brain parenchyma. Subdural haematomas:

- Usually result from injury to the cortical bridging veins
- Can result from high velocity shearing injuries such as acceleration/deceleration injuries
- Can result from 'shaking' injuries i.e. non-accidental injuries and falls
- Are also associated with contusions or diffuse axonal injury

Loss of consciousness and altered mental state are common presentations with over half of these patients presenting in a coma. Most patients will present acutely, although some will present a few days/weeks later with ongoing headaches and may have a chronic SDH. Again this raises the suspicion of non-accidental as delayed presentations are can suggest a concealed initial injury.

SDHs appear as a hyper dense crescentic collection that is only bound by the midline and tentorial margins on CT head scan. Any signs of brain swelling or midline shift need urgent neurosurgical intervention for craniotomy and evacuation of clot. All children with a SDH should be admitted and referred to the neurosurgical team.

Subarachnoid haemorrhage
Subarachnoid haemorrhage (SAH) occurs following injury to vessels in the subarachnoid space.

These injuries usually do not necessarily require emergent intervention unless CSF outflow is obstructed.

SAHs:

- Are a common finding in head trauma (particularly blunt head injury and significant shear forces)
- Tend to occur in association with other head injuries such as subdural haematoma, cerebral contusion, and intracerebral bleed
- May therefore present with a wide range of signs and symptoms.

CT scans have lower sensitivity for detecting SAHs (about 90%) and this decreases if the patient presents more than 24 hours after the initial injury. Hyper dense fluid in CSF spaces indicates an SAH. Pre-existing aneurysms should be identified on CT scan and should raise the suspicion of an SAH. All patients with an SAH should be admitted for observation.
Diffuse axonal injury

Diffuse axonal injury (DAI) of the white matter of the brain is often at the grey/white interface secondary to shearing forces (severe acceleration / deceleration forces, rotational forces). Common mechanisms include motor vehicle accidents and inflicted injuries. Loss of consciousness is a frequent feature and changes are often seen on CT Scan though MRI of the brain is more sensitive for identifying the changes associated with DAI.

All patients with DAI should be admitted to hospital (even with a normal neurological status, although most children with DAI will be comatose i.e.: have a GCS<8). Children tend to have a better outcome than adults with DAI.

Scalp laceration

The goal of treatment here is hemostasis by:
- direct compression
- ligation of exposed arteries

Closure is possible if the wound is able to be adequately cleaned, and if the patient is compliant. If a skull fracture is evident on inspection or palpation, then treat as an open fracture which would require washout in theatre. Local anaesthetic with adrenaline can be useful in an oozing wound as the scalp has a generous blood supply. Sutures or surgical staples can be used.

Imaging in Head Trauma

Several groups have published recommendations for neuro-imaging in paediatric head trauma based on results of large trials or literature review. Over the last decade, a number of decision rules have been developed to identify high risk adults with head injury who require a CT scan. More recently, the CHALICE study published in November 2006 was a landmark study because for the first time a clinical decision rule, derived from the clinical profiles of a very large number of children (22,772), became available for the management of minor head injuries in children. Patients in the CHALICE study were recruited from the emergency departments of ten hospitals located in the north west of England (three children’s hospitals, three teaching hospitals, and four district general hospitals). Patients recruited were those < 16 years old who had sustained head injuries of any severity, not just those patients in the apparent mild end of the spectrum. Data on 40 clinical variables were collected and correlated against the outcome measure ‘clinically significant intracranial injury’ (defined as death as a result of head injury, requirement for neurosurgical intervention, or marked abnormality on CT scan). Those clinical variables which best correlated with clinically significant intracranial injury were used to derive the following clinical decision rule (see next page).

Our guideline for imaging is based on the CHALICE publication.
Indications for CT Head: The CHALICE decision rule

For children aged < 16 years presenting after trauma involving the head, a CT scan is recommended if any of the following criteria are present:

**History**
- Witnessed loss of consciousness of > 5 minutes duration
- History of amnesia (either anterograde or retrograde) of > 5 minutes duration
- Presence of abnormal drowsiness
- ≥3 vomits following the head injury
- Suspicion of non-accidental injury (suspected child abuse)
- Any seizure after a head injury in a non-epileptic patient

**Examination**
- Glasgow Coma Scale (GCS) <14, or GCS <15 if under 1 year old
- Suspicion of penetrating injury
- Suspicion of depressed skull fracture
- Tense fontanelle
- Signs of basal skull fracture
- Any focal neurological deficit/abnormality
- Presence of bruising/swelling or laceration >5cm in an infant

**Mechanism**
- Head trauma in the setting of a high speed (>60km/hr) motor vehicle accident as either pedestrian, cyclist or occupant
- Head trauma in the setting of a fall from over 3m height
- Head trauma related to a high speed projectile

If none of the above features are present, the child is at a low risk of having intracranial pathology.

The CHALICE rule has a sensitivity of 98% and a specificity of 87% for detecting a clinically significant head injury. If we assume that the risk of intracranial pathology in our population of children presenting to the emergency department with head injury is similar to those in the CHALICE study population (1.2%), using the CHALICE criteria to order CT scans would result in us missing an intracranial abnormality in 1 out of every 5700 children we see with a head injury (NPV 99.9%; 95%CI 99.9% to 100%). The PPV (true positive rate) would be 8.6% (95%CI 7.7% to 9.7%) i.e. approximately 1 in every 12 scans would be positive.

Implementation of the CHALICE rule resulted in a CT scan rate of approximately 14% CT scanning.

Other considerations

CT scanning is a safe, accurate and readily available investigation for older children who are able to lie still for the procedure. In younger children, particularly those under 5 years, general anaesthesia or procedural sedation may be required to achieve CT scanning. In addition, the risks of cranial irradiation need to be considered. Therefore, particularly in younger children, the risk of the investigation (CT) should be balanced against the risk of delayed diagnosis. Observation in the emergency department, for a period of at least 6 hours from the time of the injury, may be used as an alternative approach in children <5 years old whose indications are marginal (e.g. vomiting, impact seizure, etc.) with CT reserved for those children who develop any of the above criteria during the period of observation.

Skull radiograph

Many studies have illustrated that the presence of a skull fracture significantly increases the risk of intracranial injury. However, the absence of a skull fracture has a poor negative predictive value, as approximately 50% of intracranial injuries will not have an associated skull fracture. In addition, skull radiographs can be difficult to interpret and skull fractures may be easily missed by non-radiologists. However the neuro-surgical team at LCCH recommend the use of plain skull radiographs for children with moderate to severe head trauma.
Indications for Neurosurgical referral

- Penetrating skull injury
- Base of skull fracture
- Depressed skull fracture
- Focal neurological signs
- Depressed level of consciousness at time of examination
- Decreasing level of consciousness
- Any child to be admitted to inpatient ward for observations because of a head injury.

Criteria for discharge of patients after head injury

- Any child in the CHALICE rule negative group (as long as they can be discharged into the care of a responsible adult who can continue to monitor their condition)
- Any child with a GCS of 14 or 15 with a normal CT head scan (this includes simple linear vault fractures with no haematoma)
- The absence of any symptoms that cannot be handled at home (i.e. confusion, persistent vomiting, headache requiring more than simple analgesia)

Although the risk of deterioration after discharge (using these discharge criteria) is minimal, it is not zero. Parents/carers should be instructed regarding the need for continued observation at home and the warning signs that should prompt immediate return to the emergency department. These are detailed in our "Head Injury Advice" sheet which should be given to each family prior to discharge.

Further reading

Ophthalmology

Introduction
Eye disorders in the infant and child are relatively common. About 3% of children will fail to develop their full visual potential in at least one eye. The ability to detect eye disorders and eye trauma during the examination is essential for all doctors who deal with children.

Assessment of the eye in Children
The first priority when examining the visual system of a child is an assessment of the child's visual performance. Make your examination into a game and you will get results. Toys to catch the child's attention are essential. A good ophthalmoscope, preferably with a rechargeable handle and a quartz halogen bulb (to give a constant bright illumination) is also required. Keep the uncomfortable parts of the examination (such as eye drops and fundus examination) for last.

This may be limited by the co-operation and developmental stage of the child. The examination should be directed by the parent's complaints and the child's symptoms. The basic tests in a child under three years of age are:

- Gross examination (External)
- Visual interest (visual following and fixing) (a toddler with normal vision should be able to identify 100's and 1000's in the palm of your hand at 1 metre)
- Bruckner reflex (see later)
- Ocular Alignment
- Pupil responses
- Ophthalmoscopic examination through dilated pupils including an assessment of the red reflex

Ophthalmoscopic Examination
Fundus examination in the infant requires skill and patience, and is best left to last. The fundus must be examined through a dilated pupil if you are serious about seeing anything. For infants below one year of age use one drop of 0.5% Cyclopentolate (Cyclolgyl) or 1.0% Tropicamide (Mydriacyl) for mydriatic purposes.

At arm's length, assess the red reflex (the defocused fundus reflection); this will detect any opacities in the ocular media such as cataracts. Also look at the Bruckner reflex (simultaneous comparison of the fundus red reflexes [see later]). Then examine the external eye with the ophthalmoscope racked up to +10. Then set the ophthalmoscope at your own refractive error or leave your glasses on with the ophthalmoscope set at 0. Come in to examine the fundus about 15° off axis temporally. This will bring the optic disc into direct view. The additional lenses which you need to rack up on the ophthalmoscope to obtain a clear image of the retina will provide you with a rough assessment of the patient's refractive error. After examining the disc for cupping, swelling or pallor, follow the retinal vessels out in each quadrant and complete the examination of the fundus by looking at the macular area, found about 1½ disc diameters temporal to the disc. The Welch-Allyn Panoptic ophthalmoscope is easier to use than the conventional direct ophthalmoscope. The Optyze is easy to use and much cheaper than other ophthalmoscopes.

Trauma
Major trauma is particularly devastating to the eye of a child; not only will there be damage to vital structures but even with successful repair, the damage to the eye may be such that the potential for normal visual development is lost. A thorough history is part of the ophthalmology assessment.

A. Penetrating injuries
Children's eyes are frequently damaged by sharp objects such as pencils, scissors, darts or sticks.

The child with a penetrating injury will usually be in considerable distress. Accordingly, the correct diagnosis of a penetrating injury is often made difficult by noncompliance on the part of the child. If a penetrating injury is suspected and co-operation is not forthcoming, examination under general anaesthetic may be necessary. This is best carried out in a hospital where the expertise and equipment are available to proceed to definitive repair if a penetrating injury is discovered.

The cardinal sign of a penetrating injury is disruption of the coats of the eye. This is usually associated with prolapse of intraocular contents. In the case of a penetrating injury involving the cornea, there will usually be iris prolapse which will almost always result in a peaked pupil with a prolapsed iris at the apex of the ‘peak’.
However, the penetration site from a sharp object such as a dart may not be obvious on superficial examination.

Immediate referral to a centre equipped to deal with major eye trauma is called for. The eye should be covered by a shield or a non-compressive pad. Never instil ointment into eyes with penetrating injuries. Sedation, as well as anti-emetics, may be called for during transport. If there is likely to be a delay in obtaining definitive closure of a perforated globe, parenteral antibiotics should be considered.

Penetrating injuries of the eyelids caused by objects such as pencils or scissors sometimes cause penetrating eye injuries or even penetration of the orbital roof with brain damage. Traumatic eyelid injuries are always worse than they look on superficial examination. Secondary injuries to the eye and orbit should always be excluded when examining a child with a penetrating injury to the eyelids.

B. Blunt injuries
These are common in childhood. They are usually the result of injury during sports such as squash, tennis, cricket, or from blunt objects such as stones. The rapid rise in pressure in the anterior chamber from a blunt injury may cause tearing of the ciliary body and anterior chamber angle structures. The result is bleeding into the anterior chamber which, if macroscopic, can be recognised as a hyphaema. Macroscopic hyphaemases are usually managed by bed rest in hospital to minimise the risk of a disastrous secondary haemorrhage.

The posterior structures of the eye may also be injured by blunt trauma; this can result in retinal oedema or a choroidal rupture.

C. Foreign Bodies
Corneal foreign bodies usually cause intense discomfort. The child may not admit to a history of a foreign body entering the eye or may not be able to tell you. This diagnosis should be suspected in a child with a unilateral red eye associated with the signs of corneal disease. The child is often extremely distressed. Put some local anaesthetic drops in first to see if this relieves the child's distress and makes examination easier.

The removal of a corneal foreign body requires a co-operative patient, good topical anaesthesia, good lighting, a sharp instrument (such as a 19G needle mounted onto a 2cc syringe), magnification and support for the operation's hand. In the younger child general anaesthesia is often necessary to allow an adequate examination for diagnostic purposes and to allow the removal of corneal foreign bodies.

Other causes of the red eye which enter into consideration in adults such as scleritis and angle closure glaucoma are extraordinarily rare in childhood and for practical purposes need not be considered in the paediatric age group. Uveitis does occur but it is uncommon unless associated with a systemic disease such as juvenile rheumatoid arthritis (where routine ophthalmic surveillance is always necessary).

D. Non-Accidental Injury (NAI)
The possibility of NAI should always be considered when confronted by eye trauma, particularly if the history and the signs are inconsistent with one another. Cigarette burns to the lids, periorbital haemorrhage (black eye) and widespread retinal haemorrhages in particular should raise suspicion. The ophthalmic manifestations of child abuse are numerous; in addition to the commoner signs mentioned above they include retinal detachment, cataract, dislocated lenses, traumatic mydriasis, papilledema, squint, corneal opacity and optic atrophy. If suspected, a search for other sites of trauma e.g. old fractures should be carried out. Mandatory reporting of suspicious cases applies throughout Australia. If NAI is suspected, all clinical findings should be documented photographically as well as thoroughly described in the patient's chart for use in possible legal proceedings.

E. Chemical Burns
Burns with alkalis are potentially destructive of an eye and are a true ophthalmic emergency. Unfortunately they are amongst the commonest chemicals which are accidentally spilled into the eye. Alkalis readily penetrate the cornea, resulting in serious intraocular injury which can lead to corneal necrosis and melting, glaucoma and cataract. Acids are usually precipitated near the ocular surface and by and large do not have the same deleterious effects as alkalis.

The treatment of chemical burns is immediate copious irrigation of the eye with water or sterile saline. Local anaesthesia may be necessary to permit irrigation which should be carried out for at least 10 or 20 minutes. In the case of lime burns the conjunctival fornices should be swept clear of any particulate alkali.

Ophthalmic advice should always be sought. Contact the eye clinic during hours and the on call ophthalmology registrar after hours.

Assessment of possible cervical spine injury in children suffering blunt trauma

Queensland Paediatric Trauma Service

**Purpose**

This document provides clinical practice guidelines to aid clinicians involved in the emergency management of children with possible cervical spine injury (CSI) following blunt trauma.

**Scope**

This document relates to emergency staff involved in the care and management of children with possible cervical spine injury.

**INTRODUCTION**

Serious paediatric cervical spine injury following blunt trauma is uncommon, occurring in approximately 1% of all paediatric blunt trauma cases, with incidence ranging from 0.4% in the preschool population to 2.5% in the adolescent age group (Mohseni 2011). Of these injuries, the majority are stable injuries, with approximately 20% requiring bracing or operative fixation (Leonard 2011, Vocolio 2001)

At the Mater Children’s Hospital (MCH) Brisbane, during the five year period 2007-2012, there were 75 patients admitted for possible spinal injury, of whom 37 had resolving sprain/strain injuries, and 38 patients had significant spinal injury (fractures, dislocations, spinal cord injury, or some combination thereof). Fourteen children required operative stabilisation (internal fixation or halo), one was transferred to an adult spinal rehabilitation centre for spinal cord injury, and 2 died. This is on a background of 40,000 annual ED presentations, of which an estimated 8%, or 2,400 (12,000 over 5 years) have had blunt trauma injury (1), and after correction for external transfers yields an incidence in our population of approximately 0.6% admission and 0.1% operative cases of CSI per paediatric blunt trauma presentation to the emergency department.

Great state. Great opportunity.
Identification of this small group of patients with clinically significant CSI is challenging, but especially important in light of the functional sequelae these injuries may cause. Radiological imaging plays a crucial role in defining injuries incurred, but comes with a poorly-defined increase in lifetime risk of malignancy (2, 3).

Risk stratification to determine which patients warrant radiological investigation minimises such risk. Despite good quality clinical rules for identifying adult blunt trauma patients at low risk for C-spine injury (National Emergency X-radiography Utilisation Study (NEXUS), Canadian C-spine Rules (CCR) (4, 5), there remained until recently a paucity of evidence relating to children. Clinical practice guidelines based on the NEXUS and CCR criteria are routinely used in paediatric patients, however there is little or no evidence of their applicability in this population. The paediatric NEXUS subgroup only included 13 children under 16 years of age with true cervical spine injury (6). It is necessary to obtain specific paediatric criteria for identification of the low risk patient because the paediatric C-spine is anatomically different to that of an adult, ad the mechanisms of Injury, and triggers for emergency department presentation, are quite different between these populations (7).

The Paediatric Emergency Care Applied Research Network (PECARN) recently published results of a retrospective study to identify risk factors for cervical spine injuries in children after blunt trauma. In this study, the records of 540 children with true CSI, as well as those of nearly 3000 controls were interrogated. The authors identified eight factors associated with C-spine injury (8), at least one of which was present in 98% of the 540 children with CSI.

These eight factors (some of which are present in the NEXUS and CCR models) are the basis of the clinical practice algorithm and user notes in Appendix A. The next section will detail the clinical assessment of patients according to these eight risk factors.

**ASSESSMENT**

The clinical history is critical in the risk assessment of paediatric patients with suspected cervical spine injury. Features of the clinical history that carry particular significance include mechanism of injury (MOI), history of neurological symptoms or neck pain or ambulation subsequent to the traumatic incident, and history of medical conditions that may predispose to CSI.

**MOI associated with paediatric CSI:**

- **High risk motor vehicle accident (MVA)** – head-on collision, rollover, ejected from vehicle, death in same crash, or speed >88kph
- **Axial load to any part of the head or neck**, e.g. diving or falling from a height
- **Rugby forced hyperflexion** as can occur in scrum collapse predisposes the player to a particular type of injury (facet join dislocation +/- spinal cord injury) which may require urgent reduction and is specifically flagged (9)
- **Medical conditions that may predispose to CSI** include Down syndrome, Klippel-Feil syndrome, achondroplasia, mucopolysaccharidosis, Ehlers-Danlos syndrome, Marfan syndrome, osteogenesis imperfecta, Larsen syndrome, juvenile rheumatoid arthritis, juvenile ankylosing spondylitis, renal osteodystrophy, rickets, history of CSI or cervical spine surgery.
- **Pain vs tenderness**: A traumatic cervical spine injury like any other traumatic deformation causes the conscious infant, child or adolescent to be acutely aware of pain and dysfunction, and to protect the area with muscle spasm. The PECARN study found a complaint of posterior neck pain to be a significant risk factor for true PSCI, rather than “midline tenderness” which was not a good
discriminator between true PSCI and controls without PSCI. Asking the conscious, verbal injured child where they are sore, and assessing mobility and tenderness in pre-verbal children with this in mind, can help discernment.

- **Physical examination of the child with a suspected CSI should commence with the primary survey (airway, breathing, circulation (ABC), with specific attention paid to the maintenance of C-spine precautions (see Appendix C). Patients who are stable from an ABC point of view should be examined from head to toe (secondary survey), with particular attention to the risk factor flagged by the PECARN study as concerning for CSI: torticolis, substantial thoracic injury, focal neurological deficit, or other specific features of spinal cord injury such as unexplained hypotension or paraplegia. It is important to note that assessment of active range of motion should only be undertaken if the patient has no other physical symptom risk factor (pain, abnormal neurology, or altered conscious state) as an indication for imaging. Active neck rotation to 45 degrees bilaterally is considered adequate evidence of appropriate range of motion, although most children have a greater normal range than this.

- **Unstable patients, patients with altered conscious state, and patients with specific focal neurological deficits suspicious of spinal cord injury are straight-forward in their ED management: they require spinal immobilisation and spinal precautions until their situation changes to enable interactive assessment of function. Patients being admitted to PICU are dealt with in Appendix B. Patients with persistent focal neurological abnormality or persistent pain/limitation of movement, particularly in the setting of high risk mechanism, will require consultant review and/or orthopaedic or spinal involvement, regardless of their radiological findings.

- **Special groups:**
  
  **Inter-hospital transfers:** Patients with suspected CSI transferred from other hospitals should have a full C-spine assessment undertaken on arrival in DEM or PICU.
  
  The adolescent with a clinical picture consistent with acute cervical facet joint dislocation (low velocity injury with hyperflexion or axial loading, abnormal focal neurology suggestive of cord injury, and normal conscious state, e.g. rugby scrum collapse) must be immediately assessed and referred to the Spinal service, as time to reduction is critical (0, 10). These children have readily apparent abnormal plain films.

  The **pre-verbal child with suspected CSI** presents a particular challenge for the clinician. While relevant history may be obtained from parents or other witnesses, subjective symptomatology is very difficult to elicit. History and objective examination findings must be synthesised to determine the need for investigations and/or observation. While the incidence of CSI in this group is lower, the sensitivity of plain films for injury or instability is also lower. It is critical that the clinician pays attention to subtle signs of neck pain, torticolis, and the combination of irritability and reluctance to move the head after trauma. Assessment of the young child and interpretation of the young child's radiology may require a high degree of sophistication and experience.

  Children with pre-existing disorders that predispose them to CSI (see above) should be assessed with a high suspicion of injury and a low threshold for imaging, and may require specialist input. However, a predisposing risk factor alone does not mandate imaging in the absence of other concerns.
MANAGEMENT

Clinical clearance – Children with none of the eight risk factors identified by Leonard et al are considered to have had their C-spine clinically cleared. No imaging or immobilisation is required.

If any of the eight risk factors outlined above is found on history or examination, C-spine immobilisation and spinal precautions during transfer and handling should commence or continue.

Immobilisation and spinal precautions: The MOR approach (See Appendix C)

- In contrast to the popular use of hard C-spine immobilisation collars, the recommendation of the Princess Alexandra Hospital (PAH) Spinal Injuries Unit and of the senior surgeons at Children’s Health Queensland is for careful attention to neutral handling and positioning, with soft or two-piece neck collars, thoracic elevation devices in patients under 8 years, and lateral sandbags in unconscious patients.

- Soft collars are recommended in preference to hard collars because of the lack of evidence of hard collar efficacy (11), and increasing concerns about hard collar related morbidity. Cervical spine immobilisation by hard collars contributes to raised intracranial pressure, respiratory disturbance, patient agitation, and soft tissue ulceration (12). Patients admitted for possible or definite spinal injury should be changed from hard to soft or two piece collars within 4 hours of arrival in the emergency department, to minimise the likelihood of pressure ulceration.

- As with all mechanical trauma to the skeleton, deformations causing spinal cord injury or ischemia occur at the time of the initial massive angulating/displacing forces and are unlikely to be reproduced during normal handling. No orthopaedic immobilisation device can prevent angulation during transfers when high level instability is present, and the differences in angulation between one-piece, two-piece and soft devices with cervical spine precautions during handling is small (11). Standard cervical collars cannot prevent anteropulsion of horizontally unstable injuries, or the risks associated with atlanto-occipital instability.

- Patients who become physically agitated with external devices may be at increased risk of instability due to non-anatomical mechanical fixation points. Clinical assessment must consider the risks of alternative management, such as sedation or removal of immobilisation.

- Because of their short submental distance and poor tolerance for immobilisation, children have a tendency to slip their chins under the collars, causing hyperflexion and poor airway positioning. In practice, with young children this is aggravated by reluctance of attendant staff to keep a hard collar snug, and by children’s natural desire to flex their heads to see more than the ceiling. These factors place children at even great risk of malpositioning and unintended negative consequences of immobilisation devices.

- The MOR approach to immobilisation and spinal precautions involves LESS discomfort and risk of pressure complications (the change from stiff to soft collars) but MORE attention to addressing Moments of Risk (MOR) in the smaller number of higher risk patients identified by the PECARN risk factors. These strategies are outlined below and summarised in Appendix C:

MOR: Strategies to Address Moments of Risk for Cervical Spine Malpositioning:

Agitation: early pain relief, change to soft or two-piece collar, prop upright if conscious, stable, and at low risk for thoraco-lumbar spine injury, special handling for high-risk infants and toddlers

Trolley Transfers and Log Roll: Pat slice and dedicated Head/spine nurse or doctor, place directly on TED (Thoracic Elevation Device) on arrival if under 10

Guideline – Assessment of Cervical Spine Injury in Children Suffering Blunt Trauma

Children’s Health Queensland Hospital and Health Service
**Vomiting:** early prophylactic anti-emetic for head injuries or nausea, nasogastric insertion where required, “specialling” of uncleared patients at risk of vomiting

**Imaging:** TED for under 10, dedicated attendant to insist on appropriate neutral positioning for head/neck CTs (no pillows; if head rest is used spine must be suitably elevated)

**Intubation:** Dedicated attendant to hold head inline during intubation, consider fibreoptic laryngoscope. During these Moments of Risk, inadvertent angulation or distraction may occur with or without fixation devices, and a medical or nursing staff member must pay particular care to neutral positioning during these times.

Children under age ten who are kept on a flat trolley or mattress will tend to have a Cobb angle (the difference in inclination of lines drawn parallel to inferior endplates of C2 and C6) in the flexed range. A TED (thoracic elevation device) should be used to improve neutral positioning for spine ad airway (13).

Allowing a cooperative conscious patient to find his/her position of comfort may be appropriate, as realignment of the C-spine from torticollis to normal anatomical position may cause distress or discomfort. This is particularly true if immobilisation is causing distress or agitation. The muscle spasm resulting in torticollis may confer some protection of an underlying CSI. While active movements may be elicited to optimise imaging, an assessing doctor should not force passive realignment of torticollis in a conscious patient who has suffer significant blunt trauma: rather, a senior review should be sought (14).

**Thoracolumbar spinal injury**

Risk factors for thoracolumbar spinal injury include the following:

- High velocity MVA particularly if sash or harness restraint devices have not been worn
- Ejection from MVA
- High speed motor bike or bicycle collisions in which the patient has gone over his head prior to impact
- Multi-trauma victims with un-clear mechanism of injury and altered conscious state
- Abnormal focal neurology
- Localised thoracolumbar pain
- Patients with spinal injury at other levels.

These patients should be kept flat, with neutral positioning of the entire spine and log-rolling. Urinary catheterisation should be considered.

**Imaging:** Plain films

Recommended initial imaging comprises the standard three plain film views (antero-posterior, lateral and odontoid peg) where possible, due to the increased sensitivity of the three-series for detection of clinically-significant CSI, compared to fewer projections (15) (16). If the odontoid view is difficult to achieve, a focussed CT may be required in certain high risk patients after senior discussion. The high proportion (75%) of upper injuries in the younger age group, makes it worth obtaining where possible (15).

Since the collar must be removed for an open mouthed view, a high risk patient who cannot be relied upon to independently maintain safe positioning throughout imaging must have an attendant escort for this.
Imaging: CT/MRI

As described above, patients who sustained an injury via a high-risk mechanism, and those with persistent focal neurological abnormality or persistent pain or limitation of movement require review by an emergency physician and/or orthopaedic or spinal team involvement prior to cessation of immobilisation, even if initial imaging is unremarkable. Consideration must be given to the need for further imaging in this cohort as the sensitivity of the plain film series for the detection of CSI is only about 90% (16) and may be as low as 75% in younger children (17). Despite the limitation of plain x-rays, risk profiling by careful examination and eyewitness historical analysis of mechanism is essential prior to further radiation in order to avoid over-investigation and attendant radiation exposure.

If plain films are not normal, or are inadequate, immobilisation and attendant neutral positioning must continue. The combination of plain x-ray series and selective CT imaging with reconstructions increases identification of CSI to 94%. CT imaging is better for identifying bony injury, and MRI for identifying ligamentous and soft tissue injury, although subtle signs of injury may be present with both modalities (18, 19).

A targeted 'fine cut' cervical CT scan with reconstructed views is the investigation of choice for clarification of most concerns. MRI is preferred when there is consideration of SCIVORA (spinal cord injury without radiological abnormality), to provide further information about ligamentous structures in patients with possible unstable injuries, and to augment understanding of CSI risk in patients requiring prolonged (>48h) immobilisation in PICU.

Clearance:

The patient with normal imaging, without a high-risk mechanism of injury, and without any persistent altered mental status or focal neurological deficit or neck pain or torticollis, can be considered to have a clinically cleared cervical spine.

DISPOSITION

Unstable patients, patients with altered conscious state, and patients with specific focal neurological deficits suspicious of spinal cord injury are straight-forward in their ED management. They require admission with spinal immobilisation and spinal precautions and neutral handling until their situation changes to enable interactive assessment of function.

Patients who have been clinically cleared, with or without C-spine imaging, are considered at low risk of CSI and may be discharged with appropriate advice regarding analgesia and expected recovery. Practically speaking however, many children are slow to mobilise following blunt trauma, particularly if they have been transported with spinal injury precautions. In this group, removal of splinting, adoption of sitting posture where appropriate, simple analgesia, and gradual mobilisation is recommended, with repeat medical review including active range of motion prior to discharge.

Patients who have been assessed by the orthopaedic or spinal team may be discharged home for early outpatient review, with or without ongoing immobilisation, at the subspecialty team’s discretion.

Related documents

Policy and standard(s)

- NSQHS 8.5 Preventing Pressure Injuries

Guideline – Assessment of Cervical Spine Injury in Children Suffering Blunt Trauma
Children’s Health Queensland Hospital and Health Service
Definition of terms

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<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>C-spine</td>
<td>Cervical spine</td>
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<td>CSI</td>
<td>Cervical spine injury</td>
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<td>CCR</td>
<td>Canadian C-spine rules</td>
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<td>NEXUS</td>
<td>National emergency x-ray utilisation study</td>
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<td>MVA</td>
<td>Motor vehicle accident</td>
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<td>MOI</td>
<td>Mechanism of injury</td>
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<td>MOR</td>
<td>Moments of risk</td>
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<td>CT</td>
<td>Computerised tomography</td>
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<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>TED</td>
<td>Thoracic Elevation Device</td>
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Consultation

Key stakeholders who reviewed this version:

**PCSI Working Group:** Dr Robyn Brady, PEM Specialist MCH; Dr Natalie Phillips, PEM specialist RCH; Dr Geoff Askin, MCH Spinal Surgeon; Dr John Tuffley, Spinal Surgeon RCH; Dr Mark Walsh, Paediatric Radiologist MCH; Dr Umesh Shetty, Paediatric Radiologist RCH; Dr Jennifer Williams, PEM Fellow; Dr Katie Rasmussen, PEM Fellow; Dr Roy Kimble, Director, Paediatric Trauma Service, Queensland Health, Tona Gilien, Paediatric Trauma Coordinator, Gerard Duckworth, Chief Paediatric Radiographer, MCH; Tim Flanagan, Nurse Practitioner MCH; Lorelle Maylon, Nurse Educator RCH; Dr Jason Acworth, Director PEM Services QCH.

References and suggested reading

1. Brady RM. A 5 Year audit of cervical spine injuries admitted to Mater Children's Hospital Qld. 2012.

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Guideline revision and approval history

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<td>PCSI Working Group</td>
<td>Dr Robyn Brady, Chair PCSI Working Group</td>
<td>General Manager Operations</td>
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Keywords
- Cervical Spine Injury

Accreditation references
- EQuIP National Standards: 8.5; 12

Appendix A – QPTS Cervical Spine Clearance Algorithm

Appendix B – MCH PICU Cervical Spine Clearance Protocol

Appendix C – Immobilisation and neutral positioning: The MOR strategy

Guideline – Assessment of Cervical Spine Injury in Children Suffering Blunt Trauma

Children’s Health Queensland Hospital and Health Service
Appendix A – Cervical Spine Clearance Algorithm

**STABLE PRIMARY SURVEY**

Any of¹:
1. High-risk MVA
2. Diving or other axial load
3. Conditions predisposing to CSI
4. Substantial torso injury
5. Altered mental status
6. Focal neurological deficit
7. Neck pain
8. Torticollis

**UNSTABLE PRIMARY SURVEY**

Manage ABCD as per APLS

**IMMOBILISE**
- Collar +/- sandbags
- Thoracic elevation device (≤10 years)

**C-Spine imaging**

**C-spine cleared**

Continue immobilisation
ED consultant +/- orthopaedic review (& discuss with spinal fellow)
Consider further imaging (CT/MRI)
Facet joint dislocation with abnormal neurological findings is a time-critical injury → urgent reduction for best neurological outcomes²

Guideline – Assessment of Cervical Spine Injury in Children Suffering Blunt Trauma
Children’s Health Queensland Hospital and Health Service
Notes to accompany Paediatric Cervical Spine Clearance Algorithm

Definitions for risk factors for C-spine injury (CSI):

- High-risk MVA = head-on collision, rollover, ejected from vehicle, death in same crash, or speed >88kph
- Diving or other axial load = falling and landing head first from a height
- Conditions predisposing to CSI include Down syndrome, Klippel-Feil syndrome, achondroplasia, mucopolysaccharidosis, Ehlers-Danlos syndrome, Marfan syndrome, osteogenesis imperfecta, Larsen syndrome, juvenile rheumatoid arthritis, juvenile ankylosing spondylitis, renal osteodystrophy, rickets, history of CSI or cervical spine surgery
- Substantial torso injury = observable injuries that are life threatening, warrant surgical intervention, or warrant inpatient observation
- Altered mental status = GCS < 15 or AVPU < A or evidence of intoxication or other ALOC (e.g. disorientation, persistent anterograde amnesia, delayed or inappropriate response to external stimuli)
- Focal neurological deficit = paraesthesia, loss of sensation, motor weakness, or other neurologic finding consistent with spine injury (e.g. priapism)
- Neck pain = child >2 years complains of neck pain
- Torticollis = torticollis, or difficulty moving the neck noted in history or physical examination; if no other indications for imaging test rotation of neck, and proceed to immobilisation and imaging if unable to rotate to 45 degrees bilaterally

Immobilisation:

- Cervical collar (hard or soft) +/- sandbags
- Allow conscious patient to find position of comfort if torticollis occurs – do not attempt to realign C-spine to normal anatomical position if this causes increased distress or discomfort

C-spine imaging:

- X-ray series - lateral, AP and peg views (where possible) as initial screen
- If pre-existing condition the only trigger for imaging, senior review is mandated prior to imaging

Patients not requiring imaging should have a period of observation:

- Explain to patient and guardian that patient is very low risk for clinically significant
  C-spine injury
- Administer ibuprofen 10mg/kg + paracetamol 15mg/kg if no contraindications
- Prop patient up
- Soft collar optional
- Reassess pain and mobility 30-60 minutes later

Continued immobilisation (>4h):

- Soft or 2-piece collar for age >4months
- Cut-to-size soft collar for age <4months

Urgent reduction:

- Focal neurological deficit plus acute low velocity mechanism and facet joint dislocation requires urgent reduction (<4h) – contact spinal service immediately


Guideline – Assessment of Cervical Spine Injury in Children Suffering Blunt Trauma

Children’s Health Queensland Hospital and Health Service
**LCCH PICU – Cervical Spine Clearance & Assessment**
Any concern should necessitate early referral to specialist spinal team

**Option 1: Clearance performed prior to PICU admission**
- Patient MUST have clear written documentation by DEM/Peripheral hospital consultant physician detailing mechanism of injury, radiological and clinical findings with appropriate conclusion.
- ONLY applies to a patient who is not intubated. Any intubated patient does not have a cleared neck until proven otherwise
- **If inadequate, neck is NOT cleared**

**Option 2: Clearance performed by PICU medical staff**
- Age >8
- Not intubated
- Normal plain films and CT if indicated
- Normal clinical examination
- Documented in Metavision by treating intensivist

**Option 3: Clearance performed by LCCH Spinal Consultant or Spinal fellow (all intubated patients)**
- **If age >8**
  - Plain films – AP and lateral
  - PEG view if deemed safe by referrer and pt likely to cooperate (difficult in < 7 years old pts)
  - PEG view if age >10
  - CT-C-spine if indicated
  - Dynamic views if 5-6yrs (performed by spinal fellow or consultant ONLY)
- **If age ≤8**
  - Plain films – AP and lateral
  - MRI

All agreed spinal plans MUST be documented in Metavision

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Cervical Spine Injury – Assessment and Management in PICU
Children’s Health Queensland Hospital and Health Service
Appendix 3 - The MOR strategy for neutral positioning in possible cervical spine injury

MOR: Moments of Risk and Strategies for Neutral Positioning

Transfers and log rolls:
- Pat slide between same-level surfaces
- Attendant maintains neutral head/neck/spine positioning
- Slide onto TED if under 10 years

Pain/agitation:
- Provide early clinical "low risk" clearance in those without PECARN risk factors
- Replace stiff with appropriately fitting two-piece or soft collars
- Give early pain relief
- Position parent at head
- Consider propping up if conscious, normal neurology and low thoracolumbar risk
- Attendant to reassure and advise family re process

Vomiting:
- Prophylactic ondansetron where necessary
- Attendant or parent present and "nurse call" for log roll if required

Imaging:
- Attendant to accompany to x-ray if manual positioning required
- Attendant to ensure TED used appropriately
- Attendant to ensure CT head neck positioning maintains neutrality

Intubation:
- Specific attendant assigned to neck positioning during intubation

Unconscious/Multi-trauma patients require MOR attention
- Soft or two piece collar or manual inline immobilisation AND lateral sandbags
- These children are higher risk and require a dedicated attendant and MOR attention to handling
- Document limb movements and sensory responses on arrival and prior to paralysis
- There is no such thing as radiological clearance: interactive assessment is required to confirm mobility and lack of pain. Specify in trauma chart that spine has NOT been cleared, and maintain neutral positioning.

Thoracic Elevation Device (TED): Recommended for neutral positioning under 10

- 33 cm W x 14 cm L x 2.5 cm H foam, wrapped in plastic to allow clean/re-use.
- Keep on or by resus trauma trolleys. Position the high end under neck as in picture
- Also may aid in positioning for intubation of infants.

Guideline – Assessment of Cervical Spine Injury in Children Suffering Blunt Trauma
Children's Health Queensland Hospital and Health Service
MOR Immobilisation Strategies
Stiff neck collars should be replaced by soft or two-piece devices for immobilisation in hospital.

3yo in 2-piece “infant” Philadelphia collar:
- Measure around neck and from chin to sternal angle, and identify appropriate collar
- While attendant maintains neutral positioning, remove existing collar and slip back form in place between occiput and upper back
- Slip front component under chin and attach to back with velcro
Support can be obtained from Orthotics during hours

Alternative 1: Soft collar cut to size
Cut along the lower edge of a small soft collar at base of velcro pod matching the chin scallop and fit snugly under chin as in this child with stable AARS being discharged for spinal clinic review.

Alternative 2: Unconscious or severely injured young children may be maintained and imaged in a vacuum splint with careful head neck positioning.

If an immobilisation device is not tolerated and is leading to agitation, a conscious infant can be left to find their own best neck position, for example, in a parent’s arms.
Guideline: Cervical Spine Injury in PICU

Guideline

Cervical Spine Injury in PICU

Assessment and Management in PICU

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Purpose

To guide consistent assessment and management of potential or actual cervical spine injury in patients admitted to PICU following trauma.

Scope

This procedure relates to all CHQ nursing and medical staff caring for patients admitted to PICU following trauma.

Related documents

Policy and standard(s)

Procedures, Guidelines, Protocols

Forms and templates

Great state. Great opportunity.
Guideline for PICU Cervical Spine Assessment and Management in Trauma

Introduction

Traumatic injuries of the cervical spine (C-spine injury: CSI) are uncommon in children. However suspicion of a CSI should be high in any blunt/head/cervical injury, until appropriate investigations prove otherwise.

This document provides a framework for the management of a child with a possible cervical spine injury.

This guideline should be read in conjunction with the “Assessment of possible cervical spine injury in children suffering blunt trauma” guideline from the Queensland Paediatric Trauma Service.

Immobilisation

Patients with suspected or possible cervical spine injury must have their cervical spine properly immobilised.

Who to immobilise/have a high suspicion of a CSI:

- The conscious patient with any of the following:
  - A mechanism of injury that may indicate a high risk of spinal injury:
    - High risk motor vehicle accident (MVA) – head-on collision, rollover, ejected from vehicle, death in same crash; or speed >80 kph
    - Axial load to any part of the head or neck, e.g. diving or falling from a height (>3 m)
    - Rugby forced hyperflexion as can occur in scrum collapse predisposes the player to a particular type of injury (facet join dislocation +/- spinal cord injury) which may require urgent reduction and is specifically flagged (9)
    - Medical conditions that may predispose to CSI include Down syndrome, Klippel-Feil syndrome, achondroplasia, mucopolysaccharidosis, Ehlers-Danlos syndrome, Marfan syndrome, osteogenesis imperfecta, Larsen syndrome, juvenile rheumatoid arthritis, juvenile ankylosing spondylitis, renal osteodystrophy, rickets, history of CSI or cervical spine surgery.
    - Pain vs tenderness: A traumatic cervical spine injury like any other traumatic deformation causes the conscious infant, child or adolescent to be acutely aware of pain and dysfunction, and to protect the area with muscle spasm. The PECARN study found a complaint of posterior neck pain to be a significant risk factor for true PSCI, rather than “midline tenderness” which was not a good
      - Kicked / fall from a horse.
      - Low speed rollover (Backed over by a car).
      - Thrown over handlebars of bike.
      - Severe electric shock.
      - Significant injury above davicles.
      - Trauma & unexplained hypotension.
      - History of neck trauma.
      - Neurological deficit.
      - Other major injuries (e.g. fractured limbs, abdominal injury).

The unconscious patient with a history of possible trauma must be immobilised.

Note: For cooperative patients who arrive with a soft collar in situ and who do not have a mechanism of injury warranting continued immobilisation, the collar should be removed while maintaining inline mobilisation (with a senior clinician present). The neck is palpated for
tenderness, and if none elicited, assessed for pain on active movement. If these are all absent the neck can be cleared.

**How to immobilise the cervical spine:**

- A soft collar is appropriate for conscious children. There is lack of evidence that hard collars are very effective, and on a statewide level soft collars are now employed. Patients with possible or definite CSI should be changed to a 2 piece collar (Philadelphia collar).
- If uncooperative avoid rigidly fixing head to trolley or spinal board unless body also strapped to board as more damage can be done by a child that is thrashing their body around while their head is strapped to the board. If they are moving around too much don’t strap head to board.
- If the patient’s head is attached to the bed, be particularly aware of vomiting and risk of aspiration. Someone must be with the patient at all times.
- Children <3yo are especially difficult. They should be immobilised with a soft collar and parents or staff holding the head and body, or sandbags in situ.
- In the acute phase there is no place for sedation without intubation to aid cervical spine immobilisation. However analgesia is an important aspect in trauma patients and must be provided as needed.

**Thoracolumbar spine injuries:**

In addition to CSIs thoracolumbar spine injuries should be considered in the following cases (some overlap with above criteria)

- High velocity MVA particularly if sash or harness restraint devices have not been worn
- Ejection from MVA
- High speed motor bike or bicycle collisions in which the patient has gone over his head prior to impact
- Multi-trauma victims with un-clear mechanism of injury and altered conscious state
- Abnormal focal neurological
- Localised thoracolumbar pain
- Patients with spinal injury at other levels

These patients should be kept flat, with neutral positioning of the entire spine and log-rolling. Urinary catheterisation should be considered.

**Radiology**

**Who to x-ray:**

- **X-ray**
  - Patient has altered conscious state or
  - Adequate assessment of neck symptoms not possible due to distracting injury or intoxication/sedation or
  - Neck tenderness or pain or limitation of movement or
  - Abnormal neurological signs
- **Do not x-ray**
  - Patient is alert and has normal conscious state and
  - No painful distracting injury, intoxication or sedation etc. and
  - No neck pain or tenderness or limitation of movement and
  - Normal neurological examination

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Cervical Spine Injury – Assessment and Management in PICU
Children’s Health Queensland Hospital and Health Service
A doctor from Emergency or Intensive Care MUST accompany the patient to radiology for imaging to ensure maintenance of cervical spine immobilisation.

**What to x-ray:**

a. Lateral Cervical spine will be taken in ED for all major trauma patients (along with trauma series). This does **not** exclude an unstable injury.

b. Cervical series will usually be taken in radiology. (Lat./AP/Odontaoid view). A lateral horizontal view with the collar in place will be taken first. This will be checked by a radiologist during office hours and by an ED or ICU physician after hours. If satisfactory, the collar may be temporarily removed, maintaining in-line stabilisation, for the remainder of the films which will consist of an AP film and, in patients ≥9 years of age, an AP peg view.

- A satisfactory lateral cervical spine view will include the C7/T1 junction (it is not necessary to see all of T1 body).
- CT scan replaces oblique views (if these were specifically requested).
- Flexion and extension views are inappropriate in the acute stage and will not be performed.

**Cervical MRI:**

MRI is indicated in the **acute** setting to delineate soft tissue/cord injury in the presence of abnormal neurology and/or concerning findings on plain films or CT scan. An MRI is no substitute for plain films/CT for bony injury. Spinal team consultation is indicated.

**Clearing the c-spine of injury**

**Who can clear the c-spine?**

**In conscious patients** the spine is **clinically** cleared by the PICU specialist on-call once any standard radiological imaging has been reported as normal by a consultant radiologist (if indicated—see ‘who to x-ray’ above). Once cleared in-line stabilization precautions can be removed. Consultation with the spinal team is recommended if doubt exists.

**In unconscious patients** or patients that are to remain intubated, sedated and ventilated following initial resuscitation the cervical spine is cleared by the spinal team in consultation with the PICU specialist on call.

**When impaired consciousness is felt likely to persist** and thus the spine will not be able to be cleared clinically, cervical MRI can be used to clear the spine. This is a screening study and should be performed within the first 48 hrs after admission, with preference for the study to be done during normal working hours. Once the MRI, and all other radiology have been reported as normal by a consultant radiologist, cervical spine precautions may be discontinued after consultation with the spinal team.

**How to clinically clear the c-spine**

It is imperative that the person making the decision has both examined the patient and viewed the films. Clinical clearance of the neck can only be done with a consultant intensivist present.

- **View the films:** The examining doctor will view the films. If there is any doubt about the ‘normality’ of the films a second opinion must be sought.
- **Re-examine the patient:** Soft collar is removed and, while a senior staff member maintains the head alignment, the examining doctor checks for the following points:
- Can pain and tenderness be assessed?
- Are there other distracting (painful) injuries?
- Is there neck pain?
- Is there tenderness over the cervical spine?
- Are there any motor or sensory abnormalities?
- Is there limitation of active neck movement?
- Is there limitation to head control?

If all these questions cannot be adequately answered the cervical soft collar should remain in situ and spinal precautions be continued.

Suspected or Proven Cervical Spine Injury
- Attention to ABC
- Careful neurological examination
- Refer all patients to the spinal team registrar on-call.
- Admit all major trauma patients under general surgery.

Ongoing Care

Due to the change to soft collars many pressure area concerns from hard collars are now obsolete in the conscious patient.

The unconscious patient still needs C-spine immobilisation which should be done with sandbags +/- paralysis in severe TBI.

Nursing out of collar:

Intubated patients whilst paralysed, or heavily sedated (no cough or active neck movement), should be nursed with sandbags only. The child must continue to be nursed with all precautions for spinal injury, and sandbags used to maintain head stability. The bedscape should be clearly marked as to the continued requirement for full spinal precautions. If the patient is to be moved (eg. log rolling or transport to the radiology department), a staff member must maintain in line immobilisation. Upon waking, a Philadelphia collar will be reapplied to those children who have either a “high risk” mechanism of injury (see page 1), and/or have abnormal radiology. Children who do not meet these criteria can be woken with a soft collar collar in-situ, but must have the cervical spine clinically cleared as soon as practical, though most intubated patients should have an early C-spine MRI to clear the spine.

Pressure area care:

Children <3 years old – greatest area for pressure ulcer is the occiput.
Children >/=3 years old – greatest area for pressure ulcer is sacrum & heels.

- Children must be removed from spinal board as soon as possible.
- Pressure area care must be considered throughout the resuscitation phase.
- Every 2-4 hours (Pressure must be relieved from all bony prominence at least every 2 hours)
- Log roll: Depending on size of patient: 2-4 people to log roll (supporting head, shoulder and torso, hips and legs) Observe the heels, hips, and occiput for pressure areas.
- Feet and legs: Passive range of motion and PAC with particular attention to heels. Orthotics may be required to keep feet in alignment.

Positioning:

- Ideal positioning
  - flat on back

Cervical Spine Injury – Assessment and Management in PICU
Children’s Health Queensland Hospital and Health Service
- hourly PAC
- quarter turns allowed (spinal precautions apply)

**Bed tilting – (if the head is to be elevated for neurological reasons)**
- If none of the spine has been cleared the bed should be tilted maintaining body alignment— Trendelenburg tilting.
- If everything but the c-spine has been cleared then the bed can be tilted from the hips.

**Air mattresses**
- Should not be used for patients that have not had their cervical spine cleared.
- May be used once the c-spine has been cleared or spinal fusion has taken place.
- If cervical spine cannot be cleared but the mattress is required for pressure area care, the case must be discussed with the spinal team looking after the patient.

- **High Dose Steroids in Spinal Cord Injury**

  The role of high dose steroids in acute spinal cord injury is controversial in adults; most studies fail to show a beneficial effect and deleterious effects cannot be ruled out. In addition, there is very little published information on the pharmacological management of cord injury in children. Steroids should not be routinely prescribed in children with spinal cord injury.

  - **Hyperbaric therapy**
  - There is no role for hyperbaric therapy of patients with spinal injuries.

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**Consultation**

Key stakeholders who reviewed this version:

- Adrian Mattke
- Anthony Slater
- Geoff Askins

**Definition of terms**

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**References and suggested reading**


Guideline revision and approval history

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Keywords
- Cervical spine clearance

Accreditation references
- EQuiP and other criteria and standards: [Enter details]
- NSQHS Standard: [Enter details]
LCCH PICU – Cervical Spine Clearance & Assessment
Any concern should necessitate early referral to specialist spinal team

Option 1: Clearance performed prior to PICU admission

Patient MUST have clear written documentation by DEM/Peripheral hospital consultant physician detailing mechanism of injury, radiological and clinical findings with appropriate conclusion. ONLY applies to a patient who is not intubated. Any intubated patient does not have a cleared neck until proven otherwise

If inadequate, neck is NOT cleared

Option 2: Clearance performed by PICU medical staff

- Age >8
- Not intubated
- Normal plain films and CT if indicated
- Normal clinical examination
- Documented in Metavision by treating intensivist

Option 3: Clearance performed by LCCH Spinal Consultant or Spinal fellow (all intubated patients)

- If age >8
  - Plain films – AP and lateral
  - PEG view if deemed safe by referrer and pt likely to cooperate (difficult in <7 years old pts)
  - PEG view if age >10
  - CT-C-spine if indicated
  - Dynamic views if 5-8yrs (performed by spinal fellow or consultant ONLY)
- If age ≤8
  - Plain films – AP and lateral
  - MRI

All agreed spinal plans MUST be documented in Metavision
Appendix 2: Guidelines for obtunded or ventilated patients with suspicion of cervical spine injury

X-rays

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<td>Lateral</td>
<td>PEG view where possible &gt; 7yo</td>
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<tr>
<td></td>
<td>AP</td>
<td>Swimmer’s view for C7/T1 visualisation if age &gt;10</td>
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**NOT** to perform oblique or flexion/extension views in these patients

**Where:** Consider medical imaging department in cases where other department imaging such as CT to be performed

Otherwise medical imaging department if stable, not mobile x-rays where possible

**When:** Immediate

CT

**Technique:** 3mm helical scans with coronal and sagittal reconstruction

**What:** Base of skull to C7/T1: As a rule CT should cover the whole cervical spine. Targeted imaging, e.g., craniocervical or cervicothoracic junctions, should only be considered in rare instances where the mechanism of injury and clinical evaluation strongly suggests the likely site of injury and radiographic images can reasonably exclude injury at other sites

**When:** Following Cervical Spine X-Rays

MRI

**What:** Screening MR if normal x-rays/CT AND c-spine not cleared but methods other than MRI

**When:** In-hours Mon-Fri within 72 hours from injury

**What:** Diagnostic MRI if clinical, x-ray or CT abnormality

**When:** Determined by clinical urgency and stability of patient

**How:** Often questions over ICP monitoring devices are raised. EVDs and Codman sensors are NOT a contraindication for MRI scans, as long as they are disconnected from the monitoring cables/monitoring box and a 1.5 T MRI machine is used (which the MRI on level 4 is). See the Codman guideline by Johnson and Johnson (available from radiology shared drive).

The Codman sensor cable needs to be rolled up, as shown below, with the coil approximately the size as described:
3. Disconnect all cables and patient monitoring devices attached to the CODMAN MicroSensor prior to transporting the patient into the MR environment.

4. It is important to configure the CODMAN MicroSensor in a specific geometry to minimize the potential for excessive heating of the sensor tip. Leave a straight segment approximately 8 cm in length, as measured from the tip of the implanted sensor. Coil the remaining CODMAN MicroSensor near the base of the connector into 5 or 6 loops approximately 5 cm in diameter. See figure 1. The CODMAN MicroSensor must not be imaged in a “straight line” configuration as testing has shown that this can result in rapid heating at the sensor tip under certain conditions.

Figure 1: CODMAN MicroSensor ICP transducer configuration for MR imaging

5. Insulate the patient’s tissue from the coiled CODMAN MicroSensor and connector using a dry gauze pad at least 1 cm in thickness. If using tape to secure the sensor to the insulating pad, use care when removing the tape to prevent damage to the CODMAN MicroSensor.
Thoracic trauma in children

Severe thoracic injuries are relatively uncommon in children and young people, however when present it is usually related to a blunt mechanism.

Severe thoracic injury is important to consider in children despite its uncommon nature. Multiple essential body structures are placed at risk by certain trauma mechanisms, including direct force and rapid acceleration-deceleration.

Children are particularly vulnerable to injury due to several unique physiological factors.

- A more compliant chest wall, secondary to an incompletely calcified rib cage. This leads to rib fracture being much less common in the paediatric population. Pulmonary injury (e.g., contusion) may be present without any obvious external injury. In children, all of the force of the impact can be transferred to the lung tissues without being absorbed and dissipated by fracturing of the ribs.
- Children have a mobile mediastinum. This has been shown to lead to an increased risk of simple pneumothoraces progressing to tension pneumothoraces. Children are also at risk of great vessel injury. These often lead to death very early after injury and are seen only rarely in the patient who survives to hospital presentation.

The most common mechanisms of thoracic injury in children include:

- Blunt mechanisms (making up at least 85-90% of cases in Australia)
  - Passengers in Motor Vehicle Accidents (MVAs), particularly when the following conditions are met:
    - when they are the front-seat passenger
    - in a high speed MVA (>60 kph) with abrupt acceleration-deceleration
    - in an impact that is head-on or near-side
    - and where there is evidence of significant damage to the passenger compartment (>40cm of intrusion)
  - Car vs. Pedestrian can also lead to thoracic injury, particularly when:
    - the child was run-over / reversed over
    - if the child has other evidence of severe injury (extra-thoracic)
  - Falls from a height greater than 6m
  - Non-accidental injury
    - particularly prevalent in children <3yo who present with rib fractures
- Penetrating mechanisms (<10-15% of cases in Australia)
  - Knife wounds and impalements (70% of cases)
  - Gunshot wounds

As can be anticipated by the types of mechanisms involved, children with thoracic trauma frequently have other associated injuries. A closed head injury is the most common extra-thoracic injury and is important as it has a significant negative effect on patient prognosis.

The thoracic injuries that occur commonly in children include:

- pulmonary contusions (>50% of injuries)
- rib fractures (in 50% of cases)
- pneumothorax
- haemothorax
- cardiac
- vascular injuries.

Thoracic trauma - Primary and Secondary Survey

Children with significant thoracic trauma who have evidence of respiratory or circulatory compromise on primary survey may require immediate resuscitative measures for such life-threatening injuries as a tension pneumothorax, cardiac tamponade, or great vessel injury.
Children with pulmonary contusion, isolated rib fractures, simple pneumothorax, or haemothorax may have less early signs of respiration distress (such as tachypnoea), but importantly delayed respiratory failure can develop.

Re-iterating the Primary survey module, children with significant thoracic trauma who have evidence of respiratory or circulatory compromise on primary survey may require immediate resuscitative measures for such life-threatening injuries as:

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<td>Airway obstruction</td>
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<td>Tension pneumothorax</td>
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<td>Open pneumothorax</td>
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<tr>
<td>Massive haemothorax</td>
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<tr>
<td>Flail chest</td>
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<tr>
<td>Cardiac tamponade</td>
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Children with less life threatening injuries may only have some of the signs of respiratory distress e.g. tachypnoea:
- simple pneumothorax
- hemothorax
- pulmonary contusion
- tracheobronchial tree injury
- blunt cardiac injury
- traumatic aortic disruption
- traumatic diaphragmatic rupture
- blunt oesophageal rupture

It is important to remember that delayed respiratory failure can develop in this second group of injuries.

A complete physical examination must be completed. The following findings are suggestive of significant thoracic injury:
- Abnormal respiratory rate, signs of respiratory distress
- Distended neck veins (tension pneumothorax or cardiac tamponade) – often a difficult sign in young children due to their neck being relatively short.
- Chest wall findings
  - Crepitance may indicate rib fractures or subcutaneous air.
  - Focal tenderness over the sternum, ribs, or scapula may indicate fracture.
  - Abrasions, ecchymoses, or lacerations over the chest wall may correlate with more significant chest wall or intrathoracic injuries.
  - Open wounds, including sucking chest wound
- Paradoxical chest wall movement – a flail segment bulges during expiration
- Abnormal chest auscultation

A complete physical examination is necessary, particularly posteriorly when performing the log roll. Exit wounds from gunshot maybe worse than entry wounds.

Signs of cardiac injury include the following:
- Distant or muffled heart tones suggest haemopericardium – a difficult sign to detect in the noise-filled environment associated with the early assessment and resuscitation of a multiply-injured child.
- An irregular rhythm may develop as the result of a cardiac contusion.

**Signs of cardiac injury**

Signs of cardiac injury include the following:
- dysrhythmia secondary to cardiac contusion.
- hypotension due to blood loss or tamponade.
• distant or muffled heart tones suggest haemopericardium – a difficult sign to detect in the noise-filled environment associated with the early assessment and resuscitation of a multiply-injured child

Signs of great vessel injury

Injury to the great vessels should be suspected with the following signs:
• hypotension
• asymmetric, diminished, or absent peripheral pulses
• paraplegia.

Investigations

Laboratory Tests

Any child who has suffered significant thoracic injury should have blood tests taken with initial intravenous access and the series of tests as described in the Initial Assessment and Management of Major Trauma guideline should be taken for urgent assessment. The cardiac troponin level is a test specifically used in the investigation of a subset of children with thoracic injury.

The following laboratory tests may need to be performed for a paediatric patient with a thoracic injury:
• full blood count - assess haemoglobin
• group and hold
• crossmatch - consider activating massive transfusion protocol if the patient meets criteria
• coagulation studies - particularly if the patient is receiving large volumes of blood products
• electrolytes
• cardiac troponin level is a test specifically used in the investigation of a subset of children with thoracic injury. An elevated cardiac troponin level is a sensitive indicator of myocardial injury among patients with blunt thoracic trauma. However the troponin may be elevated even when the injury is mild. Patients who are haemodynamically stable, have a normal troponin level and a normal ECG are unlikely to have significant myocardial injury. A cardiac troponin level should be performed in any child who appears at risk of myocardial injury (has sustained significant anterior chest trauma, a sternal fracture, or has any arrhythmia (including unexplained sinus tachycardia).

Electrocardiography (ECG)

A 12-lead ECG should be performed in any child at risk of myocardial injury (as described above). An ECG may demonstrate an:
• arrhythmia
• bundle branch block
• ST segment / T wave abnormality in the presence of myocardial injury.

However, in comparison with adults with cardiac contusions, paediatric patients may have significant myocardial injury without ECG abnormality.

Imaging (also see Imaging in Major Trauma Page 41)

The chest x-ray is a routine part of the evaluation of children with major thoracic trauma. Chest x-rays identify many life-threatening injuries, including clinically significant pneumothorax or haemothorax. However time doesn’t always allow the luxury of making / confirming a diagnosis on chest x-ray – it may be necessary sometimes to make a clinical diagnosis and act on this. CXR will also be abnormal in 90% of children with blunt aortic injury.

Most CXRs are performed within minutes of a trauma patient arriving in the emergency department and sometimes the noisy, busy trauma room environment can make clinical assessment of a patient difficult.

CXR will also be abnormal in 90% of children with blunt aortic injury. Evidence on CXR of aortic injury include:
• widened mediastinum
• obscured aortic knob
• tracheal deviation
• NG tube deviation
• left apical cap
• significant pulmonary contusions
• large left haemothorax.
Below are some examples:

**Pneumothorax**

**Haemorthorax**

**Aortic rupture**
Computed tomography (CT) is used extensively to evaluate adult trauma patients. For children, CT of the chest is used primarily to identify vascular injury and should be performed for the following indications:

- Suspected aortic injuries, as suggested by mechanism of injury (particularly abrupt acceleration-deceleration), physical examination, or findings on CXR (wide mediastinum, obscured aortic knob, left apical cap, or large left haemothorax)
- Signs of great vessel injury (such as asymmetric, diminished, or absent peripheral pulses or paraplegia).

Children who have sustained isolated minor thoracic trauma may not require imaging. Those who have normal blood pressures, Glasgow coma scale (GCS) scores of 15, and no localizing findings on chest examination are unlikely to have abnormal CXRs.

**Management**

All children with evidence of a thoracic injury require both airway and breathing support (as appropriate) and supplementary oxygen. Specific management of the child with a thoracic injury is dependent on the injury type identified on Primary, Secondary Survey or on further investigations:

**Pneumothorax**

- uncommon in children
- usually associated with significant pulmonary injury
- usually accompanied by a haemothorax
- unlikely to resolve without therapy, unlike a spontaneous pneumothorax.

A simple pneumothorax is often diagnosed on either CXR or CT chest, other features include:

- external evidence of chest trauma
- tachypnoea
- increased respiratory effort
- hypoxia
- chest pain
- decreased breath sounds on the affected side tend not to be noted due to the wide transmission of breath sounds within the chest cavity.

Management of a simple pneumothorax involves either:

- placement of an intercostal catheter (ICC) or
- Close observation with high flow oxygen in situ - this should only be performed with small (<20%) pneumothoraces in a facility with immediate access to a practitioner skilled in placing an ICC.
Tension pneumothorax

- Children are more vulnerable to the transformation of a simple pneumothorax to a tension pneumothorax due to their mobile mediastinum. They develop when air can leak into the pleural cavity by a one-way valve arrangement. This can lead to a shift in the mediastinal structures to the opposite side, which can compromise cardiac output.

Compromised cardiac output and lung collapse lead to:

- severe respiratory distress
- decreased breath sounds and chest wall movement on the affected side
- shocked appearance with rapidly developing refractory hypoxia, severe tachycardia and hypotension.

Signs described in the adult literature (jugular venous distention and tracheal deviation) are difficult to identify in the paediatric patient because of their short necks and increased soft tissues.

A tension pneumothorax is a life-threatening condition requiring immediate treatment. If suspected, needle decompression should be performed, preferably not after CXR confirmation.

After the immediate needle thoracocentesis an ICC should be inserted on the affected side.

Haemothorax

Significant bleeding into the pleural cavity can occur through injuries to the intercostal/internal mammary vessels or via injury to the lung parenchyma. Development of a massive haemothorax is rare in children and is usually associated with an extremely severe blunt impact or by penetrating trauma.

Children with a haemothorax often present with similar signs to those with a simple pneumothorax. A small haemothorax may be difficult to identify on a supine CXR. The affected side appears ‘whiter’.

A massive haemothorax presents with:

- decreased breath sounds
- dull percussion note
- signs of hypovolaemic shock (severe tachycardia and poor peripheral perfusion)
- hypoxia.

Initial treatment of a haemothorax is insertion of an intercostal catheter and blood product replacement if necessary.

If any signs of hypovolaemia shock are present on primary survey boluses of 0.9% Normal Saline or Blood Products (as appropriate) should be given until there is stabilisation of the child’s vital signs. The treatment of a haemothorax is by insertion of an ICC.

Operative thoracotomy may be required if the initial volume of blood drained from the ICC is greater than 10-15ml/kg, or if ongoing losses are greater than 4ml/kg/hr. Emergency Thoracotomy is described below.

Operative thoracotomy may be required if:

- the initial volume of blood drained from the ICC > 10-15ml/kg
- there are ongoing losses > 4ml/kg/hr.

Pulmonary contusion

More than 50% of children who suffer a thoracic injury severe enough to require admission to hospital will have pulmonary contusions.

Pulmonary contusions occur through blunt force, and may present as:

- external signs of thoracic injury
- increased respiratory effort
- hypoxia
- abnormal breath sounds (crackles) may also be present, however they should not be relied upon in making this diagnosis
- CXR will often show areas of consolidation.
Management is supportive and involves providing appropriate ventilatory support, high-flow oxygen, and analgesia.

Aortic injury

- Injury from blunt trauma to the mediastinum is uncommon but can be devastating. As described previously the child’s mediastinum is more mobile than an adult’s, making it more tolerant of acceleration-deceleration. The great vessels are however less protected from direct force. The aorta can be injured by being crushed between the sternum and the spine, or from compression of the chest causing increased intrathoracic pressure.

- The aorta is most commonly injured in motor vehicle accidents, and adolescents are more likely to suffer this injury than younger children. This may be related to adolescents being more likely to be front seat occupants.

- A great degree of energy is required to cause a blunt aortic injury. It is therefore almost always associated with head, spine or abdominal injuries. Death occurs before getting to hospital in the majority of patients. Of those that survive to hospital presentation the survival rate is high, with few suffering complications of their aortic injury.

- Blunt aortic injuries result from high force mechanisms and are almost always associated with head, spine, or abdominal injuries. Death occurs before getting to hospital in the majority of patients. Of those that survive to hospital, the survival rate is high, with few suffering complications of their aortic injury.

- A high-index of suspicion is required for diagnosis of aortic injury in children. Diagnosis is often based on the mechanism of injury rather than specific examination findings. Chest CT angiography (CTA) is the gold standard investigation for diagnosis.

- Once aortic injury is confirmed on CT-A of the chest early vascular surgical consultation is essential. Depending on both the type and severity of the injury either an operative or conservative management approach may be utilised.

Emergency department thoracotomy

Emergency thoracotomy (defined as a thoracotomy performed as part of the resuscitative phase) may be performed for patients in extremis (cardiac arrest or decompensated shock). It is used to release a pericardial tamponade, control massive haemorrhage or a massive air embolism (usually from a laceration to the hilar region), or perform open cardiac massage. Emergency thoracotomy should only be performed in the ED by experienced clinicians. Following the procedure, the patient must be taken immediately to the operating room for definitive surgery.

Although emergency thoracotomy has been reviewed extensively in adult trauma patients there is very little information regarding its use in children. The overall survival rates in children who have undergone emergency thoracotomy are similar to adult figures, with 11-12% of penetrating trauma victims and 1-2% of blunt trauma victims surviving.

Suggested indications for emergency thoracotomy in all ages include:

- Cardiorespiratory arrest following isolated penetrating thoracic trauma, with evidence of signs of life before arrival in the emergency department
- Post-traumatic persistent hypotension due to intrathoracic haemorrhage, unresponsive to fluid resuscitation
- Persistent severe hypotension, with evidence of systemic air embolism or pericardial tamponade.

Thoracotomy kits (child/adolescent) are available in DEM.
Needle pericardiocentesis

Needle pericardiocentesis in thoracic trauma is controversial and has been largely replaced with the emergency thoracotomy. Clotted pericardial haemorrhage is usually unable to be removed via a needle approach and the advent of FAST ultrasound scanning has made a diagnostic needle pericardiocentesis obsolete.

Emergency thoracotomy for pericardial tamponade has been shown to be a more effective resuscitative measure.

Needle pericardiocentesis may still have a role in the ‘stable but shocked patient with cardiac tamponade’ as a temporising measure, improving cardiac output whilst an operating theatre thoracotomy is arranged.

References


Further reading

Abdominal trauma in children

Abdominal trauma is a significant cause of morbidity and mortality in children.

In Australia almost all injuries are secondary to blunt trauma, most frequently related to:

- Motor vehicle related injury (deceleration injury as a passenger or pedestrian impacted by a motor vehicle)
- Falls
- Bicycle related injuries.

Children are at particular risk from abdominal injury, both because of particular anatomical and physiological differences between children and adults, but also because many serious abdominal injuries are initially unrecognised.

With reference to the risk posed to children by anatomical differences, pre-pubescent children are at higher risk of solid organ injury, when compared with adults, due to a number of factors, including the following:

- proportionally larger solid organs
- less protective abdominal wall (less subcutaneous fat, and less protective abdominal wall muscles)
- horizontal diaphragm that predisposes to lower lying and more anteriorly placed spleen and liver
- flexible (more cartilaginous) rib cage, which allows for compression of solid organs.

Abdominal trauma causes more injury-related deaths in children than all other types, with the exception of head and chest trauma.

Motor vehicle accidents

The majority of children with blunt abdominal trauma related to motor vehicle accidents (MVAs) have a combination of injuries, including head, chest and extremities. However children are also at particular risk of the ‘seat belt syndrome,’ a well-recognised specific pattern of injuries along the plane of the lap type of the seat belt, and one of the major reasons behind the development of size and age-specific child restraint devices.

In an adult the lap belt sits on or below the anterior superior iliac spines. The relatively under-developed pelvis allows the lap belt in the improperly restrained child to ride higher.

This, along with the smaller antero-posterior diameter of a child’s abdomen and the relative lack of protection provided by the abdominal wall leads to an increased risk of injury:

Some of these injuries are:

- small and large bowel and associated mesentery
- stomach
- liver
- spleen
- pancreas
- kidneys
- lumbar vertebra injury (chance fracture) with associated spinal cord injury
- pelvic fractures.

Direct impact from a bicycle handle-bar (usually in a low-speed fall off a bicycle) is another mechanism of injury in children. It often leads to isolated, but often severe, organ injury.

In one study 78% of children who suffered a direct blow to the abdominal wall from a handle-bar had abdominal injury. It most often causes solid organ injury, however almost any intra-abdominal organ can be affected.

This highlights the importance of considering the mechanism of injury when assessing the child with potential abdominal injuries. The history and examination will often hold hints to the identification of serious and possibly occult injury.
Primary and secondary survey

Children have significant physiological reserve, often showing few abnormalities in their vital signs despite significant intra-abdominal injury. With this in mind blunt abdominal injury must be suspected from a combination of historical information (particularly the mechanism of injury) and careful physical examination.

Assessment of the child with abdominal injury starts with a rapid primary survey, with the aim of identifying and then resuscitating possible life-threatening conditions. This follows the previously outlined order of Airway, Breathing, Circulation, Disability and Exposure.

The examination of the abdomen does not take place until the secondary survey, unless there is ongoing haemodynamic instability without obvious cause.

Again, it should be highlighted that hypotension is a late sign of hypovolaemic shock in children. The first sign of reduced intravascular volume is tachycardia.

Fear and pain can lead to children ingesting large volumes of air. Decompression of the stomach through placement of an NG or OG tube (in patients with maxillofacial trauma, or suspected base of skull fracture) should be considered prior to any detailed abdominal examination.

Signs and symptoms that may be consistent with abdominal injury in children include:

- An increased respiratory rate (due to impaired movement of the diaphragm)
- Abdominal abrasions and contusions of the abdominal wall. If abdominal wall contusion is secondary to a lap belt it is considered the ‘seat belt sign.’ The ‘seat belt sign’ may be the only external marker of the ‘seat belt syndrome’ (described above)
- 74% of children with significant abdominal injury had bruising of the abdominal wall, 99% of children without significant injury had no bruising.
- Abdominal tenderness and guarding
- Abdominal distension (a late non-specific finding, but may also be secondary to air swallowing)
- Signs of shock (tachycardia, poor peripheral perfusion are early signs)

Pitfalls in abdominal examination

Repeated examination is necessary in children with abdominal trauma because life-threatening abdominal injury may not be obvious on initial assessment. This is particularly the case with:

- small gastrointestinal perforations
- pancreatic contusions
- duodenal haematomas.

Difficulties with the abdominal examination include:

- Children can lose a significant amount of blood into the intra-abdominal cavity before showing many abdominal signs, and well before becoming hypotensive;
- Abdominal injury can also be obscured by distracting extra-abdominal injuries e.g. head trauma, thoracic trauma;
- Examination can also be made unreliable by a patient’s impaired neurologic status e.g. from brain or spinal cord injury or substance use, in the ventilated child, and in children younger than one year of age.

Nasogastric / orogastric tubes

Decompression of the stomach through placement of an NG or OG tube (in patients with maxillofacial trauma, or suspected base of skull fracture) should be considered - particularly in patients that have been intubated. It is important to note that:

- fear and pain can lead to children ingesting large volumes of air, and
- prolonged bag mask ventilation will also sufflate the stomach.
Digital rectal examination

Digital rectal examination (DRE) is usually a surgical decision and usually performed only once by the surgical team. It should be completed if there is any suspicion of penetrating injury.

The presence of blood on DRE may indicate bowel perforation. It must be noted however that DRE has poor sensitivity for the diagnosis of spinal cord, bowel, rectal, bony pelvis, and urethral injuries.

Investigations

Intra-abdominal injury is often difficult to identify on history or examination alone. With this in mind both laboratory tests and imaging modalities play a special role in the paediatric patient with abdominal trauma.

Laboratory tests

The following bedside tests may need to be performed for a paediatric patient with an intra-abdominal injury:

- FBC
- ELFTs - studies have demonstrated a sensitivity of liver injury of up to 96% for the ALT (≥104 IU/l)
- Venous blood gas
- Lipase - studies have demonstrated a positive predictive value of 75% for the lipase in pancreatic injury
- Coagulation profile
- Crossmatch (or group and hold)
- Beta HCG (females >12 years of age)

Laboratory tests are usually performed as part of a screen for any injury, rather than to confirm a diagnosis. A normal LFT and lipase cannot provide reassurance for the absence of intra-abdominal injury.

Studies have demonstrated a sensitivity of liver injury of up to 96% for the ALT (≥104 IU/l)\(^5\) and a positive predictive value of 75% for the lipase in pancreatic injury.\(^6\) However, laboratory tests are usually performed as part of a screen for any injury, rather than to confirm a diagnosis. With this in mind, although performing the tests above is advocated a normal LFTs and lipase cannot provide reassurance for the absence of intra-abdominal injury.

Imaging (also see Imaging in Major Trauma Page 41)

Abdominal CT

As outlined above, identifying intra-abdominal injury can be difficult in children when relying upon history, examination, or laboratory tests.

Abdominal CT has become the preferred diagnostic modality for detecting intra-abdominal injury in haemodynamically stable children who have sustained significant blunt trauma to the abdomen.

This is because it has excellent sensitivity and specificity in the diagnosis of solid organ injury (liver, spleen, and kidney), which is often managed non-operatively. CT does lack sensitivity in detecting injuries of the pancreas, intestinal tract, & bladder, highlighting the importance of observation and serial examination in the patient at significant risk of intra-abdominal injury.

CT of the abdomen should be considered in the following situations:

1. History or physical examination suggestive of intra-abdominal injury
2. Mechanism of injury suggestive of abdominal trauma
   a. high speed MVA (>60kph)
   b. lateral motor vehicle collisions
   c. seat belt usage
   d. falls from a height greater than 6 metres
3. Declining haemoglobin
4. Unaccountable fluid or blood requirements
5. Inability to perform adequate abdominal examination or serial abdominal examinations:
   a. ventilated children
   b. children younger than two to three years
   c. substance use
   d. head injury
   e. altered sensorium
   f. planned general anaesthesia
6. Haematuria

The accuracy of CT imaging may be increased with the use of oral and intravenous contrast (as described in Imaging in Major Trauma Page 41)

Ultrasonography

The major role for ultrasound in paediatric trauma patients is in the form of Focussed Assessment with Sonography for Trauma (FAST) scanning. Formal USS is not routinely used in trauma

The FAST scan uses four ultrasound views to detect fluid within the pericardium and the most dependant areas of the peritoneum, when the patient is in a horizontal position. In the adult patient a FAST scan can detect as little as 100-250mls of blood.¹

The four views are:
1. Subcostal
2. Right upper quadrant
3. Left upper quadrant
4. Suprapubic

In adults, FAST scanning is indicated in any patient who has sustained blunt abdominal trauma. It has demonstrated a sensitivity of between 86% and 99% when compared with other forms of abdominal imaging.² Children are more likely to have solid organ injury without intraperitoneal fluid. As such, a FAST examination can miss significant spleen or liver injury (Up to 40% of low-grade liver and spleen injury and 11% of high grade liver and spleen injury will be missed on a negative FAST examination. The overall sensitivity of the FAST scan in paediatric populations has been shown to vary between 30-87.5% and the specificity to be 42-100%.³

FAST scanning in the paediatric population is most accurate in the child who presents with hypotension. In one retrospective study, no child who presented with hypotension had intraperitoneal fluid missed by ultrasound.⁴ Therefore a FAST scan can provide critical information that may direct further management in the haemodynamically unstable child.

In the haemodynamically stable child a positive FAST scan (showing intraperitoneal fluid) needs to be followed up by an abdominal CT. Despite being treated conservatively, the detection of solid organ injuries is important, as it may alter the management plan in terms of need for hospitalisation, need for bed rest and follow-up (see Management).

A negative FAST scan (showing no intraperitoneal fluid) often also needs to be followed up by an abdominal CT, particularly if the mechanism of injury is significant. This highlights the limitation of abdominal USS in paediatric trauma.

Overall, the use of ultrasound scanning (USS) in children with blunt abdominal trauma is appealing because it:
- can be performed at the bedside
- is rapidly performed
- has no adverse effects
- is relatively inexpensive.

The disadvantages of USS are:
- inability to accurately detect hollow viscous injury
- poor image quality in the presence of bowel gas or fat
- dependence on the experience and training of the sonographer
- relatively low sensitivity in comparison with that of CT.

The primary utility of diagnostic abdominal USS is in the detection of intraperitoneal fluid.
Management

Like all seriously injured patients, children with evidence of abdominal injury need airway and breathing support (as indicated), along with provision of supplementary oxygen.

Other general resuscitative measures that should be considered include the following:

1. Vascular access should be obtained with large bore intravenous catheters. Fluid resuscitation is often required in patients with blunt abdominal trauma, particularly those with multi-system injury and large volume blood loss.
2. Warming IV solutions before administration may prevent hypothermia.
3. Intravenous analgesia (usually morphine or fentanyl) should be considered in all seriously injured children. Analgesics do not alter abdominal examination findings.
4. Bladder catheterization to facilitate monitoring of urine output may be useful in some cases. However, the procedure should not be performed if urethral disruption is suspected (gross haematuria, blood at the urethral meatus, or a scrotal or perineal haematoma).

At the same time early surgical assessment needs to be arranged.

Conservative management, in the form of careful observation without operative intervention, is now considered standard practice for haemodynamically stable children with solid organ injuries. However this can only occur in a hospital that has 24 hour access to operating theatres, paediatric surgical and anaesthetic specialties. Observation of these patients usually occurs in a Paediatric Intensive Care Unit. Overall, conservative management has been shown to be successful in at least 89% of cases.10

This is particularly seen in children with liver and spleen injuries. Conservation of the spleen is particularly important in children due to the high risk of post-splenectomy sepsis in the paediatric population.

Operative intervention is however sometimes necessary. Below is a list of some general indications for operative management in children with blunt abdominal trauma1:

- Haemodynamic instability despite maximal resuscitative efforts
- Transfusion of more than 40ml/kg of crystalloid, and 20ml/kg of blood products (approx. 50% of Total Blood Volume)
- Radiographic evidence of pneumoperitoneum, intraperitoneal rupture, Grade V renovascular injury
- Evisceration of intraperitoneal or stomach contents
- Signs of peritonitis
- Penetrating abdominal wound

References

7. Logan P & Lewis D Focused Assessment with Sonography for Trauma (FAST) Emergency Ultrasound UK, 2004

Further reading

5. In: UpToDate, Rose, BD (Ed), UpToDate, Waltham, MA, 2007.
Pelvic trauma in children

Pelvic fractures in prepubertal patients are relatively rare, occurring at half the frequency of adults. Although their incidence is relatively low, pelvic injuries account for a significant proportion of paediatric trauma fatalities. The most common causes of pelvic fractures are: MVAs, pedestrian / car collisions, and falls from heights.

The anatomy of the pelvis in a child differs from that of an adult in several ways:

- The bones are less brittle and are covered with thick periosteum.
- The posterior ligaments are relatively stronger than the adjacent bone
- Bone growth centres are present
- The pelvic volume is relatively shallow.

These differences alter the response of the immature pelvis to trauma.

Greater amounts of kinetic energy must be involved to cause fracture.

Greater laxity of the joints in the pelvis also means that single fractures occur more commonly (as opposed to the adult pelvis where double-breaks often occur). However, the shallowness of the paediatric pelvis and its relative flexibility allow damage to occur to the intrapelvic viscera without obvious fracture. The thick periosteum was previously thought to reduce major bleeding, but more recent evidence suggests bleeding remains a significant cause of mortality.

Mechanism of Injury

The three most common patterns of pelvic bony injury are listed below:

1. Up to 50% of all pelvic injuries are related to lateral compression. Some examples of possible mechanisms include children who are passengers in an MVA, where the car is hit from the side; or potentially a pedestrian hit on the side. Lateral compression injuries in children rarely have associated sacroiliac joint disruption. This means that significant haemorrhage does not usually occur.

2. Anteroposterior compression is the next most common (approximately 25% of injuries). The classic example of this injury type is a child involved in a high-speed head-on MVA. Anteroposterior compression injuries are associated with increased pelvic volume and sacroiliac joint disruption. This injury pattern is at high risk for life-threatening haemorrhage.

3. Vertical shear type injuries are the least common. Possible injury mechanisms include a fall from a height

Pelvis injury - Primary and secondary survey

Pelvic fractures are caused by high-energy accidents and are often associated with:

- Head injuries
- Abdominal injuries
- Vascular injuries

Mortality and morbidity in children with pelvic fractures is often secondary to these associated injuries.

As in all children with serious injury, the child with a suspected pelvic fracture must have a primary survey performed to identify potentially life-threatening injuries. Particular note must be made for signs of blood loss. With this in mind, all children who are suspected of having any pelvic fracture, other than an avulsion fracture, should initiate a “trauma attend” response (if available) or alert the surgical team early.

Initial resuscitation of circulatory compromise should be with:

- Boluses of crystalloid to a maximum 40ml/kg, then switching onto blood products
- Given via a wide bore cannula - ideally two cannulae available
- Accompanied by methods to reduce and stabilise pelvic volume
- Consider activating the Massive Transfusion Protocol (if available) or aim for 1:1:1 of packed cells: platelets: fresh frozen plasma regularly checking coagulation status/replacing calcium and clotting factors
- Ensure early orthopaedic (+/- Vascular) involvement
Fracture types
Pelvic fractures in children can be divided into 3 groups:

1. Pelvic ring fractures:
   - **Double breaks in the pelvic ring:**
     - Fractures of the pubic rami or symphysis pubis associated with displaced sacroiliac joint dislocations or sacral fractures fit within this group.
     - The hemipelvis is unstable and displaced cephalad.
     - This group of fractures is associated with a high incidence of complications, including genitourinary, abdominal and vascular injuries.
   - **Single breaks in the pelvic ring:** The following fractures are classified as single breaks:
     - Symphysis pubis diastasis
     - Superior and inferior pubic rami fractures
     - Straddle fractures

   These common childhood fractures often seem worse than they are. Despite being caused by high-energy accidents - are usually stable fractures. A careful search for accompanying genitourinary and neurovascular injuries must be made.

2. Avulsion fractures: occur in children and adolescents most commonly in relation to sporting activities. They occur in this age group because the cartilage is weaker than bone and the muscular attachments to the secondary centres of ossification can be pulled off during strong, active contractions against resistance.
   - Fractures occurring through epiphyseal and apophyseal growth centres may result in growth arrest, leg length discrepancy, and deformity. Children also have increased capacity for remodelling because of the immature bony pelvis.
   - Localised tenderness is usually present.

3. Acetabular fractures: Fractures involving the acetabulum are rare in children. They are often associated with a dislocation of the hip joint. Attention should be directed toward obtaining an early congruent reduction and evaluating the stability of the hip. Acetabular fractures associated with major pelvic disruption should be treated like those involving double breaks in the pelvic ring.

Evaluation
Pelvic fractures are caused by high-energy accidents and are often associated with head, abdominal and vascular injuries. Therefore, when evaluating a child with a suspected pelvic fracture, attention to the surrounding viscera and to signs of blood loss are the most important immediate considerations. In one large series, 19% of the total group had visceral injuries.

With this in mind, all children who are suspected of having any pelvic fracture, other than an avulsion fracture, should initiate a "Trauma Attend" response.

The urogenital system should be specifically evaluated during the secondary survey. Injury to this system is unfortunately often missed if not specifically evaluated, with potentially serious consequences. If there is suspicion of urogenital injury, a retrograde urethrogram is recommended.

In particular lacerations of the perineum, vagina, and rectum should be considered as sites of open fractures until proven otherwise. Bladder injury is seen infrequently. In a review of 166 children with pelvic fractures, there was one urethral disruption and two bladder contusions. There is a strong association of these injuries with straddle-type mechanism.

Laboratory Investigations
At the time of IV insertion, blood should be taken for:
   - Venous Blood Gas (including lactate, pH, and ionised Calcium)
   - FBC
   - ELFTs (+lipase if appropriate)
   - Coagulation Profile
   - Group and hold (or Crossmatch if appropriate).

Imaging
All children with multiple injuries should have a trauma series of C-spine, CXR, AP Pelvis radiographs within the resuscitation room as part of the primary survey.
The AP pelvis should allow identification of serious and life-threatening pelvic fractures. Further imaging of the pelvis may be required prior to definitive management however the most appropriate imaging modality should be confirmed with the treating Orthopaedic team.

Computed tomography (CT) allows for greater certainty regarding the extent of pelvic bony injury. In the trauma setting CT of the abdomen should be considered when there is significant pelvic trauma because of the high likelihood of associated intra-abdominal injury. Therefore a CT of the Abdomen + Pelvis is performed in trauma.

Further specific imaging of the pelvis may also be required prior to definitive management. The most appropriate imaging modality should be confirmed with the treating orthopaedic team.

Consideration of vascular surgeon or interventional radiologist involvement may be required if vascular injury is suspected.

Below are some of the main pelvic fractures:

**Pelvic ring fractures**

**Pelvic avulsion**

**Acetabular fractures**
Management

Anteroposterior Compression-type Fractures may require the following to reduce / stabilise pelvic volume and stop bleeding:

- Wrapping the pelvis with a pelvic binder / bed sheet
- Taping the knees and ankles while flexing the hips
- External fixation and angiography with embolisation have both also been used successfully to control haemorrhage, particularly in adolescent children.
- Internal fixation and packing in O.T.

Generally, simple methods of wrapping the pelvis are sufficient to reduce the volume of the pelvis. However, they provide only temporary control and are only useful where the instability is rotational (opening up the pelvis anteroposterior compression) rather than vertical.

The haemodynamically unstable patient with radiological evidence of an unstable fracture of the pelvis:

- Vascular injury and exsanguination in children are rare, in contrast to in adults. This is thought to be due to the greater skeletal flexibility and the greater ability of paediatric arteries to constrict after injury.
- However if haemorrhage does occur it can be extensive. Up to 4L of blood can be accommodated in the retroperitoneal space until tamponade occurs as vascular pressure is overcome. It is thought that most pelvic bleeding is from the fractures themselves and from low-pressure sacral venous plexus. Both small and large vessels, especially the superior gluteal and internal pudendal branches of the internal iliac artery, can also be disrupted, with haemorrhage dissecting from the back to the buttocks.
- In those children in whom blood loss is significant, early involvement of an orthopaedic surgeon and radiologist is essential to optimise management.

 INITIAL RESUSCITATION WITH BOLUSES OF CRYSTALLOID +/- BLOOD PRODUCTS, GIVEN VIA WIDE-BORE CANNULA, ACCOMPANIED BY METHODS TO REDUCE AND STABILISE PELVIC VOLUME.

These include wrapping the pelvis with a pelvic binder / bed sheet and taping the knees and ankles while flexing the hips. External fixation and angiography have both also been used successfully to control haemorrhage, particularly in adolescent children.

NOTE: Generally, simple methods of wrapping the pelvis are sufficient to reduce the volume of the pelvis. However, they provide only temporary control and are only useful where the instability is rotational (opening up the pelvis from lateral or anteroposterior compression) rather than vertical.

T-POD Pelvic Binder

To Apply the T-POD Pelvic Binder –

1. Wrap the fabric belt around the supine patient
2. Fit the T-POD around the pelvis at the level of the greater trochanters (ideally the belt should cover the buttocks).
3. Cut excess belt (or fold) in front leaving a 15-20cm gap of exposed abdomen.
4. Apply pulley system to each side of the belt and slowly pull tension until snug. This provides simultaneous circumferential compression of the pelvic region. This should aid in both pain control and vital sign improvement.

In male patients make certain genitalia are elevated out of groin area.

5. You should be able to insert two fingers between the patient and the T-POD.

**Using a Sheet as a Pelvic Binder** –

1. Place folded bed sheet underneath the patient – between the iliac crests and greater trochanters.

2. Two team members should cross the sheet across the pubic symphysis and pull the sheet firmly so it tightly fits around and stabilises the pelvis.

3. A third person should clamp the sheet at the 4 points shown (away from laparotomy / angiograph access points).

**Role for Pelvic Angiography** at Lady Cilento Children’s Hospital

1. Pelvic angiography with embolisation can be both diagnostic and life-saving in appropriate adult cases, but has not been well studied in paediatric populations.

   Appropriate cases are those where external sources, long bones, intrathoracic injury and intra-abdominal injury don’t account for the hypotension in a haemodynamically unstable patient with a major pelvic fracture.

2. The decision to perform pelvic angiography should occur early after the patient’s arrival in the Emergency Department. With this in mind, early consultation with both the Orthopaedic Consultant on-call and Paediatric Radiologist on-call should occur.

   If it is deemed appropriate, the Paediatric Radiologist on-call will liaise with the on-call Interventional Radiologist at the Princess Alexandra Hospital.

**Double breaks through the pelvic ring:**

- Patients with this type of fracture and haemodynamically instability should be managed as described above.
- Initial treatment of the unstable pelvic fracture without haemodynamic instability is bed rest.

**Single fractures through the pelvic ring:**

- Fractures of the superior and inferior pubic rami – provided the sacroiliac joints and sacrum remain intact rarely require any specific treatment in children and adolescents. Analgesia is important.
- Diastasis of the pubic symphysis with associated anterior sacroiliac joint disruption / “open book” fracture – if significant displacement is present closed reduction with an external fixator or pubic plate is usually required.

**Avulsion Fractures:** These injuries are not life-threatening and their management is based on treatment of symptoms only. Often, crutches with partial or no weight bearing for 4-6 weeks with slow resumption of activities are all that is required even with significantly displaced fractures.

**References and Further reading**

3. T-POD Manufacturer website http://www.tpod.com
6. Heetveld M The management of haemodynamically unstable patients with a pelvic fracture *NSW Institute of Trauma and Injury Management* 2007.
Orthopaedic injury in children

Musculoskeletal injuries in children are essentially divided into two groups:
1. before fusion of growth plates
2. after fusion of growth plates.

The second group are essentially managed the same way as adults. The first group requires special attention.

Anatomy

Parts of the growing bone

The bone is divided into:
- Epiphysis – between the adjacent joint and the physis
- Physis – growth area at one or both ends of the bone
- Metaphysis – area between physis and diaphysis
- Diaphysis – midshaft of a long bone.

It may also have an apophysis which is a separate type of growth plate that occurs on the end of a bone with no bone either side.

Paediatric bones vs adult bones:
- Long bones – less dense/more porous in children
- Response to mechanical stress – bowing and buckling, less likely to fracture in children
- Periosteum is thicker and protects the less dense physis
- Ligaments are stronger/more compliant in children - epiphyseal injuries are seen more frequently than ligamentous injuries in children.

Crush injuries

Crush injuries are relatively uncommon in children. Minor crush injuries tend to form the majority of presentations. Major crush injuries are less common but have more devastating consequences.

Clinical concerns in crush injury vary and include:
- Limb viability
- Exsanguination
- Rhabdomyolysis secondary to muscle crush injury - the most important associated complication of rhabdomyolysis is acute renal failure secondary to myoglobin breakdown deposits in the renal tubules
- Infection - prophylactic antibiotics are given on a case by case basis
- Fracture/dislocation - plain film radiography will rule out underlying fracture
- Nail bed avulsion will require surgical correction
- Tendonous injury.

Traumatic Amputation

Major traumatic amputations are relatively uncommon in children.

Common mechanisms for a major traumatic amputation include:
- Lawn mower
- Caught between objects
- Machinery
- Motorized vehicle
- Power tools/other cutting instruments
- Bicycle
- Explosives/fireworks
- Firearms
- Not specified.

This data is taken from USA sources and it is unlikely we would see as high a percentage of firework and firearm crush injuries in Australia. Infants are more likely to have a traumatic amputation than adolescents. Most will present with an amputated finger or thumb, usually from being caught in a door. Adolescents are more likely to present with power tool/cutting instrument amputations.

**Management**

A, B, C support focussing on:
- Haemostasis of wound - with direct compression +/- tourniquet
- 2x large bore peripheral cannulae - send blood for urgent crossmatch.
- If the patient remains haemodynamically unstable or there is ongoing significant bleeding that is unable to be stopped with direct compression/tourniquet then necessary
- Arrange emergent surgical review and if necessary prepare theatres for imminent patient
- Vascular and orthopaedic surgeons need to be notified at the same time
- Splint limb if proximal fractures.

Other considerations include:
- further History - following the AMPLE acronym
- analgesia
- tetanus
- antibiotics

**Fracture types**

**Physis fractures**

The Salter-Harris Classification System is used to describe fractures in skeletally immature children in relation to the physis. The weakest area of the physis is the **hypertrophic cell zone**.

<table>
<thead>
<tr>
<th>S-H</th>
<th>Description</th>
<th>Clinical implication</th>
<th>Treatment</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Separation of the epiphysis from the metaphysis</td>
<td>Low incidence of growth disturbances</td>
<td>Immobilisation, elevation, ice. Ortho follow up</td>
</tr>
<tr>
<td>2</td>
<td>Fracture through hypertrophic cell zone which then extend out through the metaphysis</td>
<td>Growth is preserved</td>
<td>Closed reduction, immobilisation, elevation, ice. Ortho follow up</td>
</tr>
<tr>
<td>3</td>
<td>Intra-articular. Fracture line extends from epiphysis to physis then to periphery without fracturing the metaphysis</td>
<td>Generally good prognosis</td>
<td>Ortho referral. May require open reduction to align intra-articular surfaces</td>
</tr>
<tr>
<td>4</td>
<td>Intra-articular. Fracture line extends through epiphysis, physis and out through the metaphysis</td>
<td>High risk growth disturbance</td>
<td>Ortho referral. May require open reduction/internal fixation</td>
</tr>
<tr>
<td>5</td>
<td>Compression injury to physis with minimal displacement of epiphysis.</td>
<td>High risk growth disturbance pari with traumatic mechanism</td>
<td>Ortho referral. Immobilisation. Ortho follow up</td>
</tr>
</tbody>
</table>
Torus fractures
Also called a ‘buckle fracture’. These result from compression forces which cause the periosteum to buckle.

These fractures:
- Are not usually associated with severe angulation or displacement
- Rarely require reduction
- Are treated with immobilisation and orthopaedic follow up
Greenstick fractures
Greenstick fractures are characterised by:
- Cortical disruption and periosteal tearing on the **convex** side
- Intact periosteum on the **concave** side.
- They may require reduction. Treatment is usually reduction, immobilisation and orthopaedic follow up.

Plastic deformities
Also called ‘bowing fractures’ these injuries involve deformation that is usually found:
- in the forearm and long bones of the lower limb
- with another associated fracture.

Essentially it is an injury of the cortex with an intact periosteum. These injuries require orthopaedic consultation as reduction and realignment is essential. Completion of the fracture is usually necessary for reduction.

Upper extremity injuries
Clavicle fractures
Newborns may sustain clavicular fractures during childbirth. Assessment of a brachial plexus injury should be made.

Mobile children older than two years old may sustain clavicular fracture from a fall, commonly from landing onto an outstretched hand or onto the lateral side of their shoulder. Children less than two years old with a clavicular fracture should be a concern for non-accidental injury.

**Classification of clavicular fractures is anatomical. This is outlined below.**
1. **Middle third of clavicle fracture.** Most common clavicle fracture. Even if displaced, treatment is conservative with a broad arm sling and ortho follow-up.
2. **Medial clavicle fracture.** Uncommon in children. Disruption of the strong ligamentous attachments of the clavicle to the sternum usually result in epiphysyal disruption. Treatment depends on the angle of displacement. Anteriorly displaced fractures will require open reduction and fixation. Posteriorly displaced fractures may compress nearby structures e.g. oesophagus/airway leading to dysphagia/respiratory difficulty. Open reduction and fixation is also needed for posteriorly displaced fractures.
3. **Lateral clavicle fracture** Uncommon in children. Even if displaced, management is usually a broad arm sling with ortho follow-up.
Humeral fractures

**Humerus fractures are divided into three groups:**
1. Fractures of the proximal humerus
2. Fractures of the humeral diaphysis

**Fractures of the proximal humerus**
These tend to occur more commonly in adolescence. Essentially, fractures with greater than 20 degrees displacement will require closed reduction and immobilisation. If less than 20 degree displacement, treatment is conservative, with a sling and orthopaedic follow-up.
Fractures of the humeral diaphysis
Uncommon injury in children. Requires a great deal of force to produce this injury. Suspect non-accidental injury.

It is important to rule out a **radial nerve injury** and follow any reduction attempts.

Transverse fractures are more likely to be significantly displaced and require closed reduction. Spiral fractures can also occur at the humeral diaphysis.

Supracondylar fractures
The most common fracture in children < 8 years old. Classic mechanism is a fall onto an outstretched hand (FOOSH) with the elbow hyperextended.
There are three types of supracondylar fracture:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Clinical Complications</th>
<th>Fracture Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minimal/no displacement +/- anterior/posterior fat pad sign</td>
<td>Stable fracture</td>
<td>Immobilisation, long arm posterior splint, arm at 90 degrees, forearm neutral/pronation</td>
</tr>
<tr>
<td>2</td>
<td>Displaced with angulation but posterior cortex is intact</td>
<td>Unstable fracture</td>
<td>Immediate ortho review, likely operative management</td>
</tr>
<tr>
<td>3</td>
<td>Completely displaced with no cortical contact</td>
<td>Unstable fracture</td>
<td>If pulseless hand, emergent traction and reduction are needed. Otherwise immediate ortho review and likely operative management.</td>
</tr>
<tr>
<td>3a</td>
<td>Distal fragment displaced posteriomedially</td>
<td>Unstable fracture</td>
<td>If pulseless hand, emergent traction and reduction are needed. Otherwise immediate ortho review and likely operative management.</td>
</tr>
<tr>
<td>3b</td>
<td>Distal fragment displaced posterolaterally</td>
<td>Brachial artery + median nerve at risk of injury. Compartment syndrome risk</td>
<td>If pulseless hand, emergent traction and reduction are needed. Otherwise immediate ortho review and likely operative management.</td>
</tr>
</tbody>
</table>

**Elbow radiograph**

A true lateral and anterio-posterior radiograph of the elbow is required.

Two lines are usually assessed on elbow radiographs:

1. Anterior humeral line
2. Radiocapitellar line.

**Anterior humeral line** is drawn along the anterior cortex of the humeral shaft and should intersect the middle third of the capitellum. If the capitellum falls posterior to the line, consideration of an extension-type supracondylar fracture, lateral condylar fracture or transphyseal fracture should be considered.

**Radiocapitellar line** is drawn on a long axis through the radius and should bisect the capitellum on lateral and AP views. If it does not then consideration of a lateral condyle fracture, radial neck fracture, Monteggia fracture or elbow dislocation should be made.
Fat pads
Anterior fat pads can be normal particularly if teardrop shaped. If the fat pad appears more like a sail, also called ‘sail sign’ then this may be pathological for a fracture.

Posterior fat pads are always pathological and usually represent hemarthrosis from an intra-articular injury.

Elbow ossification centres
Ossification centres can be confused with fractures so it is important to identify these rather than incorrectly identify a fracture.

All ossification centres will be seen on an AP view of the elbow. These centres follow the acronym ‘CRITOE’ for order of appearance.

Only the shaded ossification centres can be seen on a Lateral XR, remembered by the acronym ‘CRIO’.

<table>
<thead>
<tr>
<th>CRITOE</th>
<th>Age (years old)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Capitellum</td>
</tr>
<tr>
<td>R</td>
<td>Radial head</td>
</tr>
<tr>
<td>I</td>
<td>Internal (medial) epicondyle</td>
</tr>
<tr>
<td>T</td>
<td>Trochlear</td>
</tr>
<tr>
<td>O</td>
<td>Olecranon</td>
</tr>
<tr>
<td>E</td>
<td>External (lateral) epicondyle</td>
</tr>
</tbody>
</table>

Other elbow fractures
Other elbow fractures to consider include:
1. **Lateral epicondyle fractures.** Usually Salter-Harris 4 following an injury with the extended arm in supination.
2. **Medial epicondyle fractures.** Not true Slater-Harris fractures as they involve the apophysis buthalf are associated with elbow dislocations.
3. **Distal humeral physeal fractures.** Difficult to identify, usually occur in under 3 year olds, can be a non-accidental injury.
4. **Olecranon fractures.** Result from a fall on the elbow. Can be conservatively managed if <5mm displacement. Be wary for Monteggia Fracture – assess radial head.
5. **Radial head and neck fractures.** Uncommon. Radial neck is fractured more than the radial head. Usually secondary to a fall. If angulation >60 degrees, displacement >50degrees then open reduction is indicated.
Elbow dislocation

Usually from a FOOSH, with posterior displacement being the most common dislocation. Associated fractures include medical epicondyle and radial neck. **Median nerve** injury occurs in 10% of presentations. Radial nerve/brachial artery injury is rare. If suspect neurovascular injury, immediate ortho review is necessary. If no neurovascular injury, relocation with sedation and immobilisation with ortho follow-up is appropriate.

Pulled elbow

Also called radial head subluxation. There may be a history of a ‘pulling’ movement of the upper limb. The annular ligament slides over the proximal end of the radius and ends up catching in the joint.

The patient will present not using the affected limb but will be comfortable at rest. The elbow is likely to be in extension and the forearm in pronation. Examination will reveal distress only on elbow movement, unlikely to have swelling, deformity, or bruising of the elbow or wrist. They will be unable to supinate the forearm. It is important to rule out fractures if manipulating pre-radiologically. If any suspicion of fracture, radiography is recommended. Often manipulation for films will reduce the pulled elbow.

**Reduction manoeuvres involve:**
- Applying pressure over the radial head
- Fully pronating the forearm
- Flexing the elbow

Post reduction, within 5-10 minutes the child should have normal function back in the affected limb.

Torus fractures

A torus fracture is a common injury yet often missed on radiography. Immobilisation and ortho follow-up one week later is appropriate management.

Radial physeal fractures

Salter-Harris fractures of the radial physis are very common. Essentially if there is pain assume there is a Salter-Harris 1 fracture. All Salter-Harris 3,4,5 fractures need immediate ortho review.
These can be divided into:
- **Proximal** radial shaft fractures. Can be very unstable and often require open reduction
- **Distal** radial shaft fractures. Stable fractures. If less than 10 degrees angulation and no rotation, immobilise and arrange ortho follow-up. If greater than 10 degrees angulation, immediate ortho review is required.

Ulnar fractures

Isolated ulnar fractures are rare.

There are two specific types of injury to look for with ulnar fractures:
- Monteggia. Ulnar fracture with dislocation of the radial head.
- Galeazzi. Radial fracture with dislocation of the distal radioulnar joint.

These injuries can be remembered by the acronym ‘GRUesome MURder’ where:

- **G**=Galeazzi with radial fracture, dislocated ulnar;
- **M**=Monteggia with ulnar fracture, dislocated radius.
Carpal bone injuries

Rare in children although adolescents will have carpal bone injuries with similar mechanisms to adults e.g. scaphoid fracture when falling onto an outstretched hand. Pain out of proportion to examination findings is a hallmark for carpal bone fracture.

Any suspicion of carpal bone injury should be immobilised in a thumb spica and referred for ortho follow-up.

Phalangeal fractures

Phalangeal crush injuries are the most common phalangeal injury. These should be immobilised with a splint. If there’s a nail bed injury the fracture should be treated as open with ortho follow up in a week. Prophylactic antibiotics may have some benefit although this is unclear. Significant displacement or tendinous disruption should be reviewed by ortho for consideration of reduction and repair.
Lower extremity injuries
(Pelvic injuries - This is covered in more detail in *Pelvic Trauma in Children Page 84*).

Hip fractures and dislocations
Hip fractures can be either a fracture of the head, neck, trochanteric/subtrochanteric region, or epiphyseal disruption. Fractures involving the head/neck of the femur may lead to *vascular necrosis* of the femoral head.

Hip dislocations are rare in children. If the hip is dislocated it is more likely to be posteriorly dislocated. Emergent closed reduction is essential.

![Hip dislocation posteriorly](image)

Femoral shaft fractures
In a child who isn’t walking, this may be a non-accidental injury. The femur is a strong bone; significant force is usually required to result in a femoral fracture.

**Classic signs of a femoral fracture include:**
- Unable to weight bear
- Externally rotated lower limb
- Shortened lower limb.

Slipped capital femoral epiphysis
Chronic slipping of the femoral epiphysis of the hip can result in chronic hip pain. Further, referred pain to the thigh/knee may be apparent. The presentation may be acute or acute-on-chronic or chronic slipped capital femoral epiphysis (SCFE).

All adolescents with chronic hip/groin/thigh/knee pain should be clinically and radiologically evaluated. AP and lateral bilateral hip films are a minimal requirement.

**Complications of a missed or late diagnosis of SCFE include:**
- Avascular necrosis of the hip
- Premature closure of the physis
- Disability.

The diagrams below show how to assess whether there has been any epiphyseal slippage.
Management principles are:
- Definitive operative management
- Non-weight bearing.

Knee fractures

Ligamentous injuries are much less common in children.

It is easiest to discuss knee injuries proximally to distally:
- **Fracture of Distal Femoral Physis.** Uncommon injury with significant associated injury risk (popliteal artery injury, physeal damage and growth arrestment). If displaced, urgent ortho evaluation is required.
- **Patellar Fracture.** Uncommon injury usually secondary to direct blunt force. Liaise with ortho.
- **Proximal Tibia Fracture.**

Three different types of fracture exist

1. **Tibial spine fractures.** Anterior cruciate ligament inserts onto the tibial spine. Ligaments are strong in children hence tibial spine fractures are more common than ligamentous injury. Undisplaced fractures can be immobilised with ortho follow up. Displaced fractures require urgent ortho evaluation.
2. **Tibial tuberosity fractures.** Type 1 (tip of tibial tuberosity fractured) and Type 2 (tip and epiphyseal fracture) fractures can be managed conservatively. Type 3 (fracture extends into the joint) are at risk of compartment syndrome. Displaced Type 2 and 3 fractures need urgent ortho review plus reduction and fixation.
3. **Proximal tibial physis fractures.** Uncommon.

Patellar dislocation

Mechanism of pivoting the knee on a fixed lower limb. A displaced patella lies laterally and the knee is usually flexed. Gentle extension of the knee (with intravenous sedation and analgesia if required) whilst pushing the patella medially should relocate the patella. Plain films post manipulation should be obtained. The patient can be given a knee immobiliser and orthopaedic follow up arranged.

Tibia and fibular fractures

Fractures of the tibia and fibular often occur at the shaft. These can be immobilised and ortho review arranged if there is less than 10 degrees displacement. If there’s more than 10 degrees displacement then urgent ortho review should be sought.
Spiral tibial fractures, also called ‘Toddler’s Fracture’ can be difficult to diagnose radiologically. A non-weight bearing toddler following relatively insignificant injury, immobilise the leg and bring back in one week’s time for repeat plain films.
Ankle fractures
Distal tibial fractures tend to be type 1 and 2 Salter-Harris fractures. These are managed by closed reduction and immobilisation with ortho follow up. Type 3 fractures, also called ‘Tillaux Fractures’ require surgical correction, as do type 4 fractures.

Distal fibular fractures also tend to be type 1 and 2 Salter-Harris fractures. Again these are managed by closed reduction and immobilisation. Ligamentous injuries occur more frequently in the ankle than the knee in children.

Foot and toe fractures
Foot and toe injuries are uncommon as the foot is relatively pliable and lacks ossification centres.

The three regions of the foot are:
- Hindfoot – calcaneus and talus
- Midfoot – navicular, cuboid, second and third cuneiforms
- Metatarsals and phalanges.

Fractures of the hindfoot and midfoot are extremely rare in children. Fractures of the metatarsals and phalanges are more common, usually resulting from a fallen object. Management of these fractures is with a short posterior short-leg splint and ortho follow-up

Compartment syndrome
Compartment syndrome has the potential to be limb-threatening so needs to be identified and treated rapidly. Any fracture or blunt trauma to a limb can cause a rise in compartment pressures. Tissues within the compartment are inadequately perfused due to this high pressure, causing a compartment syndrome.

Tissue hypoxia can lead to ischaemic injuries which in turn can become irreversible. These irreversible changes tend to occur about six to eight hours after the increase in compartment pressure has begun.

Any compartment can be affected. The forearm and lower leg compartments are the most likely to be affected by compartment syndrome due to the relatively inelastic borders of the compartments.

Normal compartment pressures are close to 0mmHg. It is unclear what level of pressure definitively causes a compartment syndrome; however, clinical signs can help determine whether there is a compartment syndrome present.

The 5 Ps of compartment syndrome.
- Pain out of proportion to the physical findings.
- Pallor.
- Poikilothermia.
- Parasthesia.
- Pulselessness.

Generally, clinical diagnosis is of more importance than measuring compartment pressures. However, this is difficult in an intubated patient so measuring compartment pressures becomes more useful in this context.
circumstance. Pressures greater than 30mmHg have been quoted as being diagnostic of compartment syndrome yet it is usually at pressures of >40mmHg that surgical intervention is required. See compartment syndrome information chart page 102

References
Burn injury in children
(Early management)

Burns are a leading cause of unintentional injury in children of all ages. Scald injuries are the most common presentation. It is usually the case that most paediatric burns will eventually need review by the paediatric burns team. This can be in the form of a photograph emailed from a peripheral site, direct interhospital transfer or presentation to a tertiary centre.

70% of children who suffer burns are preschool age, most commonly 1-2 years old. Scald injuries account for 60-80% of burns and mostly occur in the under 4 age group. Boys are more likely to suffer burns than girls in a 2:1 ratio.

Most fatal burns occur from house fires, with smoke inhalation the usual cause of death. Although mortality from serious burn injuries has declined as the result of advances in burn care and the implementation of prevention strategies, children with moderate and severe burn injuries require intensive treatment and often experience scarring and long-term disability.

Inflicted injuries should also be considered when assessing burns injuries.

Pathophysiology

Local Injury

Thermal injury denatures and coagulates protein, resulting in irreversible tissue destruction. Surrounding this zone of coagulation is an area of decreased tissue perfusion. Tissue in this zone is potentially salvageable, provided that resuscitative efforts are successful in restoring perfusion to the area.

Two main factors determine the severity of burns and scalds

1. Temperature
2. Duration of contact

The time required for cellular destruction to occur decreases exponentially with temperature.

This relationship underlies the different patterns of injury seen with different types of burn:

- Scalds generally involve water at below boiling point. Scalds that occur with liquids at a higher temperature (such as hot fat or steam), or in children incapable of minimising the contact time (such as young), tend to result in more serious injuries.
- Flame burns involve high temperatures and consequently produce the most serious injuries of all.
- Chemical and Electrical Burns are discussed in Management.

Systemic Response

Immediately following the burn injury, vasoactive mediators are released from damaged tissue. Increased capillary permeability results in extravasation of fluid into the interstitial space around the burn. Patients with large burns (>10% for young children, and >15% for older children and adolescents) develop systemic responses to these mediators. Systemic capillary leak usually persists for 18-24 hours, after which vascular integrity improves.

Initial Assessment & Resuscitation

When faced with a seriously burned child it is easy to focus on the immediate problems of the burn, and forget the possibility of other injuries. When the victim of a burn injury is first seen by medical personnel, rapid assessment and treatment can be lifesaving. The approach to the child with burns is like any other patient with serious injury.

Preparation

Like any other major trauma, coordination between the pre-hospital personnel and the receiving hospital allows for the mobilisation of all necessary personnel and resources. For patients with moderate to severe burns, the burns registrar (or after-hours, the surgical registrar on-call) should be notified prior to the patient’s arrival.
During the initial assessment and resuscitation, burn care should be limited to preventing further injury by removing clothing that is hot, burned, or exposed to chemicals. Jewellery that may become constricting should also be removed.

Airway maintenance with cervical spine protection

All cases of burns should be examined with a view to excluding the diagnosis of inhalation injury. The airway can become compromised either through inhalational injury and oral scalds or because of severe burns to the face. The latter are usually obvious, whereas the former two may only be indicated more subtly. Indicators of inhalational injury are listed below:

- history of exposure to smoke in a confined space (e.g., house, car), or burns with an associated explosion (e.g., from a petrol or gas fire)
- burns to mouth, nose, and pharynx
- sputum containing soot
- change of voice
- hoarse, brassy cough
- inspiratory stridor
- tracheal tug.

Respiratory obstruction often develops as a result of soft tissue swelling at the time of maximal wound oedema (between 12 & 36 hours). Thus even suspicion of airway compromise, or the discovery of injuries that might be expected to cause problems with the airway at a later stage, should lead to immediate consideration of tracheal intubation. It is important to perform this as soon as possible, as it becomes more difficult as oedema progresses.

A burn to the neck skin may aggravate this obstruction by producing neck oedema. This is much more likely to occur in children as they have relatively narrow airways and short necks with soft tissues that are readily distorted by oedema.

As the clinical signs and symptoms may evolve over a period of time, as with all serious traumas, the patient must be repeatedly re-evaluated.

If there is any suspicion of cervical spine injury, or if the history is unobtainable, appropriate precautions should be taken until such injury is excluded.

Breathing and ventilation

All children who have suffered burns should be given high flow oxygen. If there are signs of breathing difficulties then intubation and ventilation should be commenced as soon as possible. Once the airway has been secured, the adequacy of breathing should be assessed.

Signs that should arouse suspicion of inadequate ventilation include:

- Abnormal rate
- Abnormal chest movements
- Cyanosis (a late sign)
- Circumferential burns to the chest or upper abdomen may cause breathing difficulty by mechanically restricting chest movement.

Always assume carbon monoxide (CO) exposure in patients burned in enclosed areas. Diagnosis is made primarily from a history of exposure.

Patients with a CO level of less than 20% usually have no physical symptoms. Higher levels may result in:

- Headache, and nausea 20-30%
- Confusion 30-40%
- Coma 40-60%
- Death >60%.

Cherry-red skin colour is rare. CO displaces oxygen from the haemoglobin molecule and shifts the oxyhaemoglobin curve to the left. CO dissociates very slowly, and its half-life is 250 minutes, compared with 40 minutes while breathing 100% oxygen.
Circulation
In the first few hours following injury, signs of hypovolaemic shock are rarely attributable to burns. Therefore any such signs should raise suspicion of bleeding from elsewhere, and the source should be actively sought. If the burn is extensive, 2 intravenous cannulas should be inserted during resuscitation and fluids started. If possible, IVs should be inserted in unburnt areas, but burned skin, eschar, can be perforated if necessary.

Remember that the intraosseous route can be used.

Disability - Neurologic status
Reduced conscious level following burns may be due to:
- Hypoxia (remember smoke filled rooms may contain little oxygen)
- Head injury
- Hypovolaemia

Exposure / Environmental control
Exposure should be complete. Because burned children lose heat especially rapidly, they should be kept in a warm environment (e.g. warmed room, overhead heaters) and be covered with blankets when not being examined.

Adjuncts to Initial Assessment and Resuscitation
- Give appropriate analgesia early - burns are painful
  - If parental analgesia is warranted, then this should be given either intranasally (fentanyl), or intravenously (morphine or fentanyl). Intramuscular analgesia should not be given.
- Insert an IDC in all patients requiring fluid resuscitation
- An NG or OG tube should be placed in all patients with large burns (gastroparesis is common)

Investigations
Laboratory
No laboratory tests are required in minor burns

Suggested laboratory tests in severe burns include:
- Full blood count - assess hemoglobin for ongoing losses elsewhere
- Coagulation studies - ensure platelet count appropriate for healing wounds
- Electrolytes, urea and creatinine - hyperkalemia from cell lysis - renal failure/Injury from hypovolemia
- Creatinine kinase - assess extent of muscle breakdown.
- Blood glucose
- Crossmatch

Assessing the Burn
History
The injury history often is extremely valuable in the management of the burn patient:
- Time of the burn injury
- Associated injuries may be sustained
  - When escaping the fire
  - Explosions may throw the patient some distance and may result in internal injuries or fractures, e.g., head, c-spine, thoracic, and abdominal injuries.
- Whether burn was sustained in an enclosed space
- Any past medical history
- Tetanus immunisation status
- Any allergies
Depth of burn

The depth of burn is important in:

- Evaluating the severity of the burn for communication with the burns team
- Planning for wound care and resuscitation fluids
- Predicting functional and cosmetic results

- **Superficial burns** *(involve only epidermis)*
  - Superficial burns are erythematous, have intact epithelium and blanch when touched.

- **Superficial partial thickness burns** *(involve only papillary dermis and epidermis)*
  - These have blistering as a common feature. They are typically painful as they have intact sensation with exposed nerves. Here the epidermis is raw where the blisters have broken and is erythematous and blanches to touch.

- **Deep dermal partial thickness burns** *(involve epidermis and dermis to reticular dermis)*
  - These are difficult to assess as the wound may change in characteristics over the first 48 hours. Here blistering is uncommon and discomfort less. Originally the raw wound surface may blanch but will not do so 24 to 48 hours later as these superficial vessels cease functioning, leaving a pale wound eschar of dead cells and exudate. Sometimes deep dermal partial thickness burns have a red appearance which does not blanch to touch. The reason for this phenomenon is that red blood cells have extravasated and lie in the eschar.

- **Full thickness burns** *(involvement of the whole thickness of the skin and possibly subcutaneous tissue)*
  - These are easier to identify with their thick, white, leathery layer of eschar and total loss of sensation.

Body Surface Area

The greater the surface area of the body injured, the greater the mortality rate.

The “Rule of Nines” divides the body surface into areas of 9% or multiples of 9% and is used with relative accuracy in adults. This rule however is inaccurate in small children. This is because children have different body surface area proportions than adults, e.g. Children have proportionately smaller hips and legs and larger shoulders and heads. Using the adult “Rule of Nines” may seriously under- or over-estimate the size of the burn wound of a child, and leads to inaccurate IV fluid resuscitation. A chart such as the Lund and Browder chart *(shown in figure 1 below)* is specifically designed for estimating the extent of the burn in children.
Rule of Nine’s (A) & Lund and Browder Chart (B) (Orgill D (2009))

Remember the palm (including the fingers) of the child’s hand represents approximately 1% of the patient’s body surface.

Specific burns management

Minor Burns

Partial thickness burns less than 10% total body surface area (TBSA) are ideally suited to outpatient management. With the advent of newer biologically compatible dressings (e.g. Acticoat), it is possible to treat these burns with dressings that protect the wound and facilitate normal healing.

Small burns when appropriately dressed are well suited to oral administration of ibuprofen or paracetamol. However, oral narcotic analgesia (e.g., Oxycodone 0.1mg/kg) allows for dressing of the burn to occur.

Moderate to Severe Burns

As burn wounds are sterilised at the time of burning, extensive initial burn wound care involving complicated dressings is unnecessary and causes unwarranted delays.

The appropriate initial treatment of the burn is to cover the wound with a clean sheet or plastic cling wrap.

This provides:
- moist wound environment
- A barrier that reduces the risk of infection
- Pain relief by preventing air contact with the wound

Arrangements for definitive burns management should follow the provision of resuscitation measures and pain relief.
Special burn requirements

Chemical burns
Resulting from exposure to acids or alkalis. Alkali burns are considered to be more serious than alkali burns.

The main approach with chemical burns is as follows.
- Removal of causative agent.
- Resuscitation - ABCDEs.
- Full history of length of exposure to causative agent, any irrigation thus far.
- Irrigation with large volumes of water - consider shower if able.
- Discuss burn with Toxicology Helpline 131126 for specific advice.

Electrical burns
Electrical burns can be deceptive. Internal injuries are likely to be more extensive than the external injuries. Specific injuries to look for include arrhythmias and rhabdomyolysis from muscle damage.

Intravenous Fluid Resuscitation

When considering fluid resuscitation - compared to adults, children have:
- Greater surface area to mass ratio
- Lower threshold at which fluid resuscitation is required
- Tend to need a higher volume per kilogram, and this increased need for fluids equates with the volume of maintenance over that calculated by the fluid resuscitation formula.

Inhalation injury further increases fluid requirements. Oedema formation ceases between 18 and 30 hours post-burn. So the duration of fluid resuscitation is variable but can be recognised when the volume needed to maintain adequate urine output is equal to maintenance requirements.

Fluid resuscitation is required for

| any burn > 10% in an infant 0 – 18 months |
| any burn > 15% in a child over 18 months |

The modified Parklands Hospital Formula for burns resuscitation used at the Royal Children’s Hospital is shown below.

Fluid Resuscitation Formula:

4ml Compound Sodium Lactate (Hartmann’s Soln) x Body Weight (Kg) x Area of Burn (%) (excluding erythema)
Plus
Maintenance fluid given as Compound Sodium Lactate (Hartmann’s Soln) + 5% Dextrose

Maintenance fluids are usually calculated as
- 4ml/kg/hr for the first 10kg
- 2ml/kg/hr for the next 10kg
- 1ml/kg/hr thereafter

E.g. 24kg child would have (10x4) + (10x2) + (4x1) = 64ml/hr.
In 24 hours this would equal 24x64 = 1536ml.

Give half of total amount in first 8hrs and half over next 16hrs
Note:
The replacement of fluid commences from the time of the burn, not from the time of presentation.

The best, easiest and most reliable method of monitoring fluid resuscitation is by following urine output:

<table>
<thead>
<tr>
<th>Children up to 12mths</th>
<th>1.0 - 2.0ml/kg/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other children</td>
<td>1.0ml/kg/hr</td>
</tr>
</tbody>
</table>

A urinary catheter is vital for accurate monitoring and should be inserted for all burns requiring fluid resuscitation.

If urine output is not adequate
- Give a fluid bolus (compound sodium lactate (Hartmann’s Soln) or normal saline) of 5 – 10 ml/kg
- and/or increase the next hour’s fluid to 150% of planned volume for that hour.

Escharotomy
Circumferential partial-thickness and full-thickness burns may lead to functional impairment as oedema increases over the first 24 hours following a burn injury. An emergency escharotomy (which involves making an incision completely through the depth of the burn eschar) may be required to relieve restriction (as with chest burns) or reduce pressure (as with a compartment syndrome). The need for emergency escharotomy should be discussed with the paediatric burns surgeon on-call.

The equipment needed is a scalpel or cutting diathermy and some means of haemostasis. Artery forceps and ties, diathermy or topical haemostatics such as calcium alginate are useful. Anaesthesia is usually not necessary. Sometimes local anaesthesia is necessary at the edge of the burn to extend up into normal tissue adequately.

Trunk
When the trunk is extensively burned rigidity of the chest wall decreases compliance, and this may reduce ventilation. In adults this problem is seen with circumferential burns of the chest with or without involvement of the abdomen. In children whose breathing is principally diaphragmatic, the problem can be seen when the anterior aspect of the chest and abdomen are burned without the injury extending to the posterior aspect. The incisions to be made run longitudinally along the anterior axillary lines to the costal margin or to the upper abdomen if this is burnt, and are connected by a cross incision which crosses at approximately the level of the xiphisternum.

Extremities
When a limb is burned circumferentially the increase in pressure due to the accumulation of oedema under the rigid burned skin may interfere with circulation and cause death of tissue in the distal part of the extremity. The onset of circulatory embarrassment is slowly progressive and subtle if not sought. The increase in pressure may be detected by the appearance of one or more of the following:

- Loss of distal circulation
  - Pallor
  - Loss of capillary return
  - Coolness
  - Decrease in pulse pressure
  - Loss of palpable pulses
- Deep pain at rest
- Pain on passive movement of distal joints
- Numbness
- Decreased SpO₂

The incisions should extend by a few millimetres onto normal skin above and below. The incisions are in the mid-axial lines between flexor and extensor surfaces. Avoid incisions across the flexural creases of joints. They should be carried down to the fat sufficiently to see obvious separation of the wound edges. Running a finger along the incision will detect residual restrictive areas. Sometimes one incision is enough but often incisions on both sides are necessary to restore circulation. The palpable softness of the limb is a useful guide.
The escharotomy incisions should avoid important superficial structures such as:
- the ulnar nerve as it runs behind the medial epicondyle at the elbow
- the neuro-vascular bundle as it runs behind the medial malleolous at the ankle
- the long saphenous vein as it runs down the lower limb.

Further reading
Exsanguination injury in children

Exsanguination injuries remain rare in the Australian paediatric trauma patient.

Assessment of these patients follows the usual trauma assessment, with a focus on the following:

- mechanism of injury: blunt vs. penetrating
- pre-hospital hypotension
- fluids given so far and response
- estimated blood loss so far, difficult in blunt injury
- expected blood loss given present rate of loss
- any history of coagulopathy disorder/unusual blood type/reaction to blood transfusion
- any reasons to expect that consent for blood products will be an issue e.g. patient is a Jehovah's Witness (JW)
- availability of blood products (including fresh frozen plasma, platelets, cryoprecipitate) in the hospital
- availability of clotting factors e.g. Factor Seven in the hospital
- appropriate definitive care is available and being arranged e.g. general surgery or cardithoracic surgery depending on the nature of the injury.

Child specific issues
Child specific issues in exsanguination injury include blood volume, temperature, and blood product consent, which will be explored further below.

Blood volume
Normal blood volume for a child is 80 – 85mls/kg

Temperature
Children have a higher body to surface area so are at increased risk of hypothermia. This is a controversial topic. Adult data shows a decreased mortality if the patient's core temperature is less than 34 degrees, however, a reduced period of hypothermia to temperatures that do not decrease lower than 34 degrees has been shown to have an improved survival. Fortunately in Queensland, this is not usually a problem.

Controlled hypothermia has been proven to improve morbidity and mortality in adults in out-of-hospital arrests and severe head injuries.

Aiming for a low-normal temperature greater than 34 degrees would be appropriate in paediatric trauma patients

Crystalloids
Crystalloids are often the first administered fluids given intra-venously in a trauma patient. Normal saline is commonly administered pre-hospital. Normal saline is not without complications though.

The key complications are:

- dilution of haemoglobin - and therefore oxygen delivery
- dilution of coagulation factors - and therefore ability to clot bleeding site.

However, the aim in children is to not exceed 40ml/kg of saline in any patient before changing to blood products. In exsanguinating patients it is ideal to initiate fluid replacement with O negative blood until the blood group and type has been correctly identified for that patient.

Colloids
There is no evidence that resuscitation with colloids reduces the risk of death, compared to resuscitation with crystalloids in trauma patients.

Further, colloids are:

- not associated with an improvement in survival
- more expensive than crystalloids.
Blood products - Resuscitation of the trauma patient with uncontrolled bleeding requires:

- early identification of potential bleeding sources
- prompt action to minimise blood loss
- prompt action to restore tissue perfusion and achieve haemodynamic stability.

Haemorrhage is the second leading cause of death after injury, accounting for 40% of trauma-related mortality. Hemorrhagic shock and exsanguination are responsible for 80% of deaths in the operating room and nearly 50% of deaths in the first 24 hours after injury.

Massive blood transfusion

Massive blood transfusion is rare in paediatric trauma as most injuries sustained are blunt not penetrating trauma.

Massive blood loss in adults usually refers to:

- the loss of one or more circulating blood volume in 24 hours or
- the expected loss of one circulating blood volume in 24 hours or
- loss of 50% blood volume in 3 hours.

A useful way to monitor blood loss and transfusion requirement is to sum the total volume of blood products given and divide by the estimated blood volume. This gives the fraction of blood volume replaced. Transfusion of more than 1 blood volume of RBCs in 24 hours is considered a Massive Transfusion.

Data gathered from the U.S. Military has demonstrated success with whole fresh blood transfusion in exsanguinating trauma patients. The main aim of blood replacement in this situation is to give products in a 1:1:1 (Packed Cells:FFP:Platelets) ratio otherwise a lethal triad, which is outlined in the numbered list below, may result.

1. **acidosis**
2. **hypothermia**
3. **progressive coagulopathy**

Furthermore, identification and surgical correction of the bleeding source will also help prevent this lethal triad from developing.

See Massive Transfusion Protocol

Damage control resuscitation

More recent evidence has described another approach called damage control resuscitation (DCR) which encompasses:

- permissive hypotension to avoid thrombus disruption
- rapid control of surgical bleeding
- prevention of acidosis
- hypocalcemia
- hypothermia
- limitation of crystalloid products to avoid hemodilution.

We presently advocate not giving more than 40ml/kg crystalloid in a haemodynamically unstable trauma patient. Blood products should be used after this limit is reached. It has also been suggested that in children<30kg the ratio should be 3:2:2 (packed cells:FFP:platelets), although this is a novel idea.

Packed cells

Red blood cells (RBCs) can be stored for up to 40 days, however the longer they are stored, the more potentially harmful changes occur. Following storage of 5–7 days hyperkalemia may become an issue; greater than 14–28 days hyper-inflammatory reactions, immune dysfunction, impaired vasoregulation, and perfusion can become an issue. Older RBCs can be depleted in 2,3 DPG and ATP, which may lead to poor oxygen delivery. Stored RBC also will show an increase in aggregation, adhesion, and inflammatory mediators.

Fresh RBCs will decrease these associated risks. However, it should also be remembered that the usual risks associated with blood product transfusion will still exist.
Fresh frozen plasma

Trauma requiring massive transfusion is complicated by:
- insensible losses of whole blood into body compartments
- greater proportional losses of clotting factors and platelets because of low blood volume
- clotting factor consumption at the site of injury
- inhibitory effects of colloid resuscitation fluids and inactive coagulation factors
- hypothermia and acidosis worsening coagulopathy

Earlier supplementation of fresh frozen plasma may decrease the likelihood of coagulopathy. Most bleeding trauma patients will need fresh frozen plasma well before losing one blood volume.

Fresh frozen plasma contains:
- citrate
- approximately 0.5 g of fibrinogen per unit of FFP
- all the pro and anti-coagulant proteins within normal range

Platelets

A decreased platelet count usually requires hasty replacement in a bleeding trauma patient. However, it is not just platelet count but platelet function that we have to consider. Platelet function is a great deal more difficult to assess. Assays exist for platelet function but lack accuracy and can take a long time to process. Thromboelastograph (TEG) studies perhaps being the exception.

Platelet count post transfusion can be misleading as the platelet function is often compromised.

Factors that can impair platelet function include:
- blunt trauma more than penetrating injury
- hypothermia - above 33 degrees, platelet adhesion is not compromised, below 33 degrees platelet adhesion and enzyme activity is compromised
- administration through a small bore cannula

Factor seven

Exsanguinating trauma patients are not yet formally an indication for the use of Factor Seven yet it is commonly used in tertiary centres as part of their massive transfusion protocols. There is a paucity of evidence in demonstrating that administration of Factor Seven leads to decreased mortality.

Cryoprecipitate

Initially used for Haemophilia A and Von Willebrand Disease, i unit of Cryoprecipitate contains:
- 0.25gm fibrinogen
- von Willebrand-factor/VIII complex
- fibrin stabilizing factor/XIII.

Used initially for replacing Factor VIII then for replacing von Willebrand factor it may also be the case that cryoprecipitate promotes adhesion and aggregation of platelets. It is administered in 10ml aliquots

Tranexamic acid

Tranexamic acid is a synthetic derivative of the aminoacid lysine. It inhibits fibrinolysis by blocking the lysine binding sites on plasminogen.

Tranexamic acid use in traumatic haemorrhage has just recently been studied in adults (CRASH-2 Study). It was found that ‘early administration of tranexamic acid to trauma patients with, or at risk of, significant bleeding reduces the risk of death from haemorrhage with no apparent increase in fatal or nonfatal vascular occlusive events’. A bolus dose was given 8 hours after the initial injury and then a maintenance infusion given for the next 8 hours. Suggested doses are 5-10mg/kg bolus dose followed by 1-5mg/kg infusion dose based on coagulation laboratory results and clinical picture. 1g bolus over 10 minutes followed by 1g over 8 hours was used in the CRASH-2 Study.

TXA is now part of the LCCH MTP/DCR guideline.
Laboratory
If the patient is ‘bleeding out’ it is prudent to obtain bloods on insertion of a large bore IV cannula. If possible:

- urgent crossmatch
- venous blood gas can provide initial information on haemoglobin, pH and lactate providing some information on the extent of blood loss at that point.

Waiting for formal blood test results to direct further transfusion therapy should not hinder definitive surgical management of a hemodynamically unstable patient. 

**Laboratory tests that should also be performed include:**

- full blood count
- coagulation studies
- urea/electrolytes - elevated urea
- calcium - may decrease as more packed cells are given as citrate in the packed cells chelates calcium
- creatinine kinase - from muscle breakdown
- thromboelastograph (TEG).

Remembering that the laboratory results depict the clinical situation 30 minutes previously when the blood samples were sent.

**Repeat blood tests** should be sent but remembering that the smaller the child the more this will impact on blood loss. However, given the physiological changes associated with massive transfusion, it is safer to continue to monitor and treat coagulation, pH and electrolyte changes as soon as possible to limit their clinical consequences.

Radiology
Radiology for exsanguination injury is focused on locating the source of the bleeding but should not delay emergent transfer of a patient to theatre for explorative laparotomy. Radiological investigations in an exsanguinating patient will be at the surgeon’s discretion.

References
2. 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 CRASH-2 trial collaborators www.thelancet.com Published online June 15, 2010 DOI:10.1016/S0140-6736(10)60835-5
3. Eisenhut M. Adverse effects of rapid isotonic saline infusion Arch Dis Child 2006;91:797.
8. Skellet, Mayer, Durward et al. Chasing the base deficit: hyperchloraemic acidosis following 0.9% saline fluid resuscitation Arch Dis Child 2000 83: 514-516

Further reading
1. Advanced Trauma Life Support for Doctors 8th Edition. American College of Surgeons Committee on Trauma
Massive transfusion protocol

RESUSCITATION TEAM ACTIONS:
Damage Control Resuscitation in the critically bleeding/trauma patient

- Activate MTP with Blood Bank when sustained massive bleeding (>100mL/kg) is occurring or anticipated.

Blood Bank Actions:
Blood Bank—Expected critically bleeding/trauma patient

- Activation of MTP may occur when sustained massive bleeding (>100mL/kg) is occurring or anticipated.

Blood Bank Responsibilities:
- Blood Bank to notify Trauma Team if CSM specimen does not arrive within 30 mins of MTP activation.
- Once MTP activated:
  - Identify team leader (Critical Care Consultant)
  - Notify all ED/ICU Laboratory staff for CSM/CAIM specimen reception and start.
  - Start thawing up to 4 UFF/EPL and up to 4U Oryo
  - Source supply of platelets.
  - Continue to supply number MTP packs every 20-30 minutes as they are used per protocol.

MTP Pack 1
- 0-10mL: 1 RBC, 1 FFP/EPL, 1U Oryo
- 11-20mL: 2 RBC, 2 FFP/EPL, 1U Oryo
- 21-40mL: 3 RBC, 3 FFP/EPL, 1U Oryo
- 41mL: 4 RBC, 4 FFP/EPL, 1U Oryo

MTP Pack 2
- 0-10mL: 1 RBC, 1 FFP/EPL, 3 Platelet
- 11-20mL: 2 RBC, 2 FFP/EPL, 2 Platelet
- 21-40mL: 3 RBC, 3 FFP/EPL, 3 Platelet
- 41mL: 4 RBC, 4 FFP/EPL, 1 Platelet

Triggers – in response to hourly blood loss:
- If <8.5-10.5 g/dL give additional 300mL/kg FFP
- If Hb remains <7g/dL give 1 UFF/EPL
- If platelets <60 x 10^9/L give 1 U PFP/EPL
- If GFR <50mL/min give 1/2 dose of RBC
- If GFR < 20mL/min give 1/4 dose of RBC

Paediatric Trauma Service | Children’s Health Queensland
Drowning injury in children

To standardize reporting worldwide, a new definition of drowning was developed. Drowning is now defined as a process resulting in respiratory impairment from submersion /immersion in a liquid. Terms such as ‘near-drowning, dry or wet drowning’ should not be used.

A more accurate description maybe’ fatal drowning’ or ‘non-fatal drowning’. This is the terminology preferred at LCCH.

Three age groups are at risk of drowning:
- toddlers and young children
- adolescents
- the elderly.

Pathological associations with drowning

With regards to children, pathology associated with drowning can be split into two groups, pre-drowning and post-drowning pathology.

Pre-drowning pathology

These are conditions that may have contributed to the episode of drowning and include:
- epilepsy/seizures
- cardiac arrhythmia e.g. long QT
- panicking
- syncope
- ethanol in adolescents
- non-accidental injury

Post-drowning pathology

These are conditions that may result from the initial drowning episode:
- spinal cord injury
- head injury
- hypoxic ischemic encephalopathy
- aspiration and pneumonia
- haemolysis and hyponatremia post freshwater drowning are possible but rare

Primary survey

The basis of resuscitation is the prevention of secondary brain injury. Most paediatric hospital deaths following drowning are secondary to hypoxic brain injury. Optimisation of oxygenation and stabilisation of concomitant injuries is key.

Airway

This may already have been secured at the scene. If there is a concern with patency, maintenance, or ongoing laryngospasm, then a definitive airway must be placed. Also, if there is a likelihood that the patient will require CT scans for concomitant injuries then intubation may be prudent early on.

Cervical spine injuries need to be considered based on mechanism, and need to be managed appropriately.

Breathing

Oxygen should be given to all drowning patients during initial assessment. If unable to maintain saturations above 92% with high flow oxygen, intubation is necessary followed by positive pressure ventilation.

Acute Respiratory Distress Syndrome can result from aspiration of water. Pulmonary injury can also result in non-cardiogenic pulmonary oedema, impaired alveolar gas exchange, and increased intrapulmonary shunting. Profound hypoxia can result from any of these conditions.
Circulation
Arrhythmias need to be treated promptly. Asystole is associated with a poor outcome in children. Inotropic support may be required.

Warmed fluids, warmed blankets, and judicious fluid boluses are the mainstay of treatment. It is important to aim for euvolemia as the patient may have cerebral oedema.

A 12 lead ECG will help rule out precipitating or resulting arrhythmias.

Disability
GCS pre-intubation can be important for predicting secondary brain injury.

Severe hypothermia needs to be identified if the patient is bradycardic/asystole as this can be reversed and the patient has no sequelae.

Exposure/environment
Exposure of the patient is necessary to rule out other injuries but consideration must be given to keeping a cold patient as warm as possible. However, wet clothes should be removed from the patient. Bair Huggers, warm blankets, warm fluids can all increase hypothermic core temperatures.

Secondary survey
History
In the case of a drowning injury, a secondary survey is targeted at:

- identifying precipitating causes
- clinical status of patient immediately following rescue
- eliciting an increased risk for new injury - analysis of the mechanism of submersion e.g. diving would increase the risk for spinal cord/head
- identifying the type of water – dirty vs clean, cold vs warm - cold water submersion injuries have been reported as having a more favourable outcome due to potential cerebral protection of ice cool water
- time of submersion injury
- identifying non-accidental injury.

Factors associated with poor prognosis include:

- bystander CPR at the scene
- CPR in emergency department
- asystole at the scene or emergency department after drowning.

Essentially an understanding of the risk of hypoxic injury is important to identify in history.

Head-to-toe, back-to-front
A thorough secondary survey for a submersion injury is necessary. It is important to be particularly aware of the possibility of:

- head Injury
- spinal Injury
- long bone injury.

Investigations - Bedside tests
The following bedside tests may need to be performed for a paediatric patient with a drowning injury:

- blood sugar level is important as the patient may be hypoglycaemic and require emergent glucose replacement
- urinalysis may show haemoglobin in haemolysis or myoglobin in rhabdomyolysis
- ECG may identify underlying arrhythmia.

Although not an investigation it is useful to remember to assess temperature as the patient maybe hypothermic even if the submersion was in warm water in a warm climate.
Laboratory tests

- Blood tests rarely reveal anything abnormal. Haemolysis, coagulopathy, and transient changes in sodium maybe seen.
- Creatinine Kinase maybe elevated due to rhabdomyolysis.
- Venous or arterial blood gas will provide more information regarding oxygen saturation, carbon dioxide, pH, lactate.

Radiology

- CXR is essential. Aspiration is likely in this group of patients. If fever later develops, a baseline CXR can be useful.
- Cervical spine XRs may also be necessary.
- CT head if there is a possibility of head trauma or any suspicion of non-accidental injury.

Management

Patients with an oxygen requirement or other significant injury need admission.

Observation for 4-6 hours of an otherwise well looking patient with:

- GCS>13/15
- no oxygen requirement
- no chest signs
- no signs of aspiration/collapse/pneumothorax on CXR
- normothermia.

Consider intubation & ventilation if the patient is unconscious, hypoxic on high flow oxygen, severe respiratory distress or poor respiratory effort. Intubated & ventilated patients will need intensive care for at least the next 24 hours.
Hypothermia in children

**Hypothermia is defined as being a core temperature less than 35 degrees Celsius.** Core temperature is measured via:
- rectal
- oesophageal
- tympanum
- bladder.

Hypothermia is less frequently seen in Australia compared with hyperthermia. However, it should be considered in the following scenarios:
- environmental - can occur any season in any setting but more likely in the colder seasons
- trauma - multi trauma/head injury/entrapment, minor trauma and irritability, major burns
- drugs - alcohol intoxication/sedative overdose
- neuro - decreased mobility/paraplegia
- endocrine - hypoglycemia/hypothyroid/hypoadrenalism
- systemic illness - sepsis/malnutrition.

Children have an increased surface area to body ratio so are at increased risk of hypothermia.

### Signs and symptoms
The key signs and symptoms are summarised in the below table according to the classification of hypothermia:

<table>
<thead>
<tr>
<th></th>
<th>CNS</th>
<th>CVS</th>
<th>Renal</th>
<th>Resp</th>
<th>GI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>32-35°C</td>
<td>Shivering Apathy</td>
<td>Tachycardia</td>
<td>Cold induced diuresis</td>
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<td></td>
<td>Ataxia</td>
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<td></td>
<td>Dysarthria</td>
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<tr>
<td>Moderate</td>
<td>28-32°C</td>
<td>Loss of shivering,</td>
<td>Bradycardia</td>
<td>Cold induced diuresis</td>
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<td></td>
<td>Altered mental state,</td>
<td>Hypotension</td>
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<td></td>
<td>Muscle rigidity</td>
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<tr>
<td>Severe</td>
<td>&lt;32°C</td>
<td>Undetectable life signs</td>
<td>Profound Bradycardia</td>
<td>Acute renal failure</td>
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<tr>
<td></td>
<td>Coma</td>
<td>Fixed dilated pupils</td>
<td>Hypotension</td>
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<td></td>
<td>Areflexia</td>
<td>Loss of cardiac output</td>
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<td>Apnoea</td>
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<td>Respiratory depression</td>
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<td>Respiratory arrest</td>
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<td>Ileus Stasis</td>
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</tbody>
</table>

### Investigations
There are specific bedside, laboratory, and radiological investigations that may be needed with a paediatric submersion injury. These are outlined below.

#### Bedside investigations
- **Urinalysis** - for signs of rhabdomyolysis - myoglobinuria.
- **12 Lead ECG** - Looking for bradycardia, slow atrial fibrillation, J/Osborn waves Leads II V3-V6, interval prolongation, asystole (check not fine ventricular fibrillation).
- **Blood sugar level** - hypoglycemia likely as glycolysis occurs following shivering.

#### Radiological investigations
- **CXR** - impaired respiratory secretions likely.
- **CT Head** - if concerned about head injury as precipitant.
Laboratory investigations

- Electrolytes/urea/creatinine - evidence of renal impairment/failure.
- Calcium/magnesium/phosphate.
- Amylase.
- Ethanol - intoxication.
- Coagulation studies - disseminated intravascular coagulation, platelet dysfunction likely.
- Arterial blood gas - decreased pH, metabolic acidosis likely. Hypercapnoea from respiratory depression.
- Lactate - assess degree of anaerobic ventilation.

Management

1. Supportive Therapies.

Airway/breathing: consider endotracheal intubation and ventilation if poor respiratory effort and to manipulate acid/base status.

Circulation: intravenous fluids (more detail in rewarming therapies). Disrhythmias:

- Bradycardia - should improve with rewarming and is likely to be refractory to pacing.
- Atrial fibrillation - requires no chemical/electrical cardioversion if patient otherwise stable, should improve with rewarming.
- Ventricular tachycardia/fibrillation - usual management but bearing in mind:
  - CPR necessary until core temperature >35 degrees.
  - Adrenaline and lignocaine tend to be beneficial only above 35 degrees.
  - Magnesium is often the antiarrhythmic medication of choice.
  - Repeat shocks with each increase in degree of temperature not necessarily after every three cycles as the damage to the myocardium would be significant in a prolonged rewarming.
  - If the initial DC shock is unsuccessful, other shocks are also less likely to be successful.

2. Rewarming therapies

There are reports of good outcome following drowning and prolonged cardiac arrest where the patient was severely hypothermic at presentation. However, for hypothermia to be neuroprotective, the environment needs to be such that there is rapid cooling following submersion (for example a child falling through ice). In temperate climates children rarely drown in water where there is rapid loss of core body temperature. Therefore, rewarming a hypothermic child in prolonged cardiac arrest before discontinuing CPR is usually not appropriate in our setting.

Endogenous rewarming therapies

- Used in all hypothermic patients. May be the only therapy needed in mild hypothermia patients (32-35 degrees).
- Remove wet clothes.
- Warm, dry patient.
- Place blanket over patient.
- Expected rise of 0.75 degrees/hour.

External exogenous rewarming therapies

- Used in moderate and severe hypothermia patients (less than 32 degrees).
- Heat packs - pre-hospital therapy.
- Body-to-body contact - pre-hospital therapy.
- Both heat packs and body-to-body contact would achieve an expected rise of 1.5 degrees/hour.

External exogenous rewarming therapies – cont

- Hot bath immersion - difficult in acutely ill patients, only suitable in local injuries, can vasodilate and worsen hypothermia. Expected rise of 2.5 degrees/hour.
- Forced air blankets - blankets filled with air at 43 degrees. Expected rise of 1.5 degrees/hour.
Core exogenous rewarming therapies

- Used in moderate and severe hypothermia patients (less than 32 degrees).
- Warmed, humidified inhalation - prevents ongoing loss.
- Warmed, intravenous fluids.
- Both of the above techniques are occasionally also used in mild hypothermia patients as they are relatively minimally invasive and a temperature rise of 1.5-2.5 degrees would be expected.
- Body cavity lavage - peritoneal, pleural, colonic, bladder. Pleural lavage would raise core temperature 4.5-7.5 degrees.
- Extra corporeal life support - expected rise of 7.5 - 10 degrees.

Disposition

Most patients following a drowning injury or hypothermic episode would be admitted. Those suitable for discharge are those who present with mild hypothermia, have been observed for a few hours, and have not had any complications.

Otherwise, patients for admission would be any moderate/severe hypothermia patients, or mild hypothermia patients with complications/co-existing pathology.

ANZICS guidelines recommend that a patient has to be above 35 degrees before being declared dead. Further if there is no circulating rhythm post 30 minutes of resuscitation with a core temp>32 degrees then the patient is unlikely to survive.

References

1. Advanced Trauma Life Support for Doctors 8th Edition. American College of Surgeons Committee on Trauma

Further reading

Frostbite

Frostbite is ice crystal formation in the interstitial/cellular spaces secondary to prolonged exposure to freezing temperatures.

The frostbite injury cascade is:
1. Pre Freeze Phase - superficial tissue cooling.
2. Freeze Phase - ice crystals form.
3. Vascular Stasis - AV shunting in damaged tissue leads to stasis coagulopathy and thrombus formation.
4. Late Progressive Ischemic Phase - inflammation results from thrombus formation. Tissue hypoxia and distal necrosis can result.

Signs and symptoms
- cold skin
- shivering
- anaesthesia
- loss of motor function
- severe joint pain

It is useful to attempt to classify the injury as either a:
1. superficial Injury - localised to skin and subcutaneous tissue, clear blisters, better prognosis
2. deep Injury - involves bones/joints/tendons, blood filled blisters, poor prognosis.

Management
The following are guidelines for the management of frostbite:
- remove patient from the cold
- do not rub the limb - it will worsen the injury
- analgesia pre rapid immersion rewarming
- rapid immersion rewarming - ideally a 40 degree whirlpool superficial injuries for 20 minutes, deep injuries for an hour, remove limb when soft and pliable
- don't drain blisters - discuss with burns team
- tetanus
- antibiotic prophylaxis considered

Disposition
All frostbite injuries should be admitted. Superficial injuries have a better prognosis and are less likely to result in loss of digits/amputations.
Hyperthermia

Hyperthermia differs physiologically from fever. Hyperthermia results from:

- prolonged exposure to high ambient temperatures, e.g. child locked in back of a car
- increased heat production - metabolic (hyperthyroidism), drugs (anticholinergics, aspirin, sympathomimetics), seizures
- decreased heat loss - overwrapped babies, excess clothing on hot/humid days, heart disease, drugs.

Hyperthermia is described as being either:

- heat syncope
- heat cramps
- heat exhaustion
- heat stroke

Heat syncope is the more benign of the four syndromes, heat stroke is a medical emergency. The identifying features and management of these syndromes will be discussed separately.

Investigations

The extent of investigations will depend on the severity of the hyperthermia. Investigations to consider when treating heat-related illnesses are listed below.

- Blood sugar level - hypoglycemia likely.
- 12 lead ECG - to assess any myocardial damage.
- Urea, electrolytes, creatinine - hypernatremia, acute renal injury/failure.
- Creatinine kinase - assess extent of muscle breakdown.
- Arterial blood gas - metabolic acidosis possible, lactate may be elevated.
- Coagulation studies - assess for disseminated intravascular coagulation.
- Liver function tests - assess for liver damage.

Heat syncope/cramps

Heat syncope occurs after standing for prolonged periods or post exercise. Heat cramps occur following strenuous exercise, usually in hot/humid conditions.

Management principles

- Simple external cooling: removing clothing, light water spray and fan or cold shower.
- Oral fluids are generally used for rehydration. Gastrolyte if the patient has cramps as these are usually the result of a depletion of salt.

Heat exhaustion

Heat exhaustion presents with:

- normal mental status
- hyperpyrexia (not usually greater than 40 degrees)
- vomiting
- headache
- lethargy
- weakness

Commonly, heat exhaustion follows exercise and can present with the patient having experienced an 'exercise associated collapse'.
Management principles

- **Rest**
- **Cool** down by external cooling: remove clothing, spray with water, fan, ice packs to areas of the body where the vessels lie close to the skin - groin/axillae/neck.
- **Fluids** - oral/nasogastric or intravenous. IV fluids can be given cooled or run the tubing through an ice bucket if cooling pumps aren't available. Ready cooled bags should be available in the refrigerator.

Heat stroke

As mentioned earlier, heat stroke is a medical emergency.

**The classic triad of symptoms**

- Neurological dysfunction - coma is a common presentation, as is altered mental status, irritability, confusion, ataxia and seizures.
- Core temperature > 40.5 degrees.
- Hot and dry skin.

**There are two types of heat stroke**

- Classic - usually resulting from being exposed to high ambient temperatures. Patients have impaired thermostatic mechanisms.
- Exertional - results from exercise in a thermally stressful environment.

Management principles

- Support ABCs. Intubate patient if unable to maintain/protect airway.
- Aggressive cooling - exogenously and endogenously. Remove patient's clothing. Spray with fine mist and use fans. Apply ice packs to areas of skin where vessels are closely sited: axillae, groin, neck. Cool intravenous fluids. Avoid shivering as this will result in thermogenesis. Aim to decrease temperature 0.1 degrees per minute.
- Rehydrate.
- Support organ function. Be mindful that rhabdomyolysis is likely. Early discussions with intensive care would be useful as this patient will eventually become an intensive care admission.

Complications of heat related illnesses are listed below.

- Rhabdomyolysis
- Shock
- Non-cardiogenic pulmonary oedema
- Cerebral oedema
- Consumptive coagulopathy (disseminated intravascular coagulopathy)
- Renal failure
- Hepatic failure
- Persistent coma

Disposition

Patients with minor heat-related illnesses like heat syncope and cramps can be safely discharged once their physiology has returned to normal parameters only if it is felt that it would be a safe discharge and the child is not at risk of the same exposure again.

All other heat-related injuries usually require admission for at least 24 hours observation. Heat stroke patients will usually require admission to intensive care.
Snake bite envenomation

General overview
Approximately 3000 real or suspect snake bites per annum (due to ↑ bushland recreation).
Approximately 300 snake bites/year require anti-venom.
Approximately 2-3 deaths/year from snake bite in 1990's (15 – 20/year in 1960's)
Impressive reduction due to:
  - Usage of effective anti-venoms
  - +/- Intensive Care Unit impact

Note, however, that venom potency (e.g. number of mice killed by 1mg of dry weight venom) is only one measure of how dangerous a snake is. Volume of venom injected is obviously also very important and average venom yields obtained by “milking” of snakes give some idea of what may occur in the field – see following table.

### Comparison of venom yields and toxicity of some Australian snakes
(Sutherland SK 1990 – Aust. Family Physician 19 (1), 1-13)

<table>
<thead>
<tr>
<th>Species</th>
<th>Average venom yield (dry weight) mg</th>
<th>LD50 mice (mg/kg)</th>
<th>Maximum recorded venom yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-scaled Snake</td>
<td>44</td>
<td>0.025</td>
<td>110</td>
</tr>
<tr>
<td>Common or Eastern Brown Snake</td>
<td>4</td>
<td>0.053</td>
<td>67</td>
</tr>
<tr>
<td>Taipan</td>
<td>120</td>
<td>0.099</td>
<td>400</td>
</tr>
<tr>
<td>Mainland Tiger Snake</td>
<td>35</td>
<td>0.118</td>
<td>189</td>
</tr>
<tr>
<td>Death Adder</td>
<td>78</td>
<td>0.450</td>
<td>236</td>
</tr>
<tr>
<td>Copperhead Snake</td>
<td>26</td>
<td>0.560</td>
<td>84</td>
</tr>
<tr>
<td>Mulga or King Brown Snake</td>
<td>180</td>
<td>2.380</td>
<td>1350</td>
</tr>
<tr>
<td>Red Bellied Black Snake</td>
<td>37</td>
<td>2.520</td>
<td>94</td>
</tr>
</tbody>
</table>

Taking into account the size of the snake, fang length, amount of venom injected (venom yield), potency of venom and aggressiveness/temper, the Taipan is undoubtedly Australia’s, and therefore the world’s, most dangerous snake. What the Mulga or King Brown Snake concedes in venom potency is made up for by the very large amount of venom it delivers and its aggressiveness, making it probably Australia’s second most dangerous snake. However, the Common or Eastern Brown Snake is responsible for most deaths in Australia, due to its frequency along the more densely populated Eastern coastal strip, its highly potent venom (fortunately venom yield is relatively small), and its aggressiveness/temper.

Contents of snake venom
Snake venom is a complex mixture of enzymes and other proteins comprising:
  - Neurotoxins – some act pre-synaptically (slow acting) and some post-synaptically (fast acting)
  - Procoagulants
  - Anticoagulants
  - Haemolysins
  - Rhabdomyolysins
  - Renal toxins
  - Cardiac toxins

E.g. Tiger Snake Venom
  - Notexin
  - Neurotoxin
  - Prothrombin Activator
  - Haemolysins
  - Myotoxin
  - Phospholipase 1 & 2
  - Hyaluronidase 1 & 2
Clinical envenomation

There are 3 possible clinical scenarios at time of presentation:
1. queried snake bite
2. definite snake bite but queried envenomated
3. clinical signs of envenomation present

Common clinical features are listed below but, note that the presentation can be quite variable, with some features present in some patients and absent in others.

The time course, pattern and severity of snake envenomation is determined by:
- Type of snake (and hence venom composition)
- Amount of venom injected (sometimes none – dry bite)
- Age, size and health of victim

Additionally, the symptoms can vary – a patient appearing to spontaneously improve may subsequently collapse (irregular movement of venom through the lymphatics into the circulation may partly contribute to this).

Early evidence of envenomation (e.g. within 1 hour)
- Headache
- Nausea/Vomiting
- Abdominal Pain
- Feeling faint

Within several hours
- Cranial nerve abnormalities/bulbar palsy
- Limb weakness
- Respiratory failure
- Haemorrhage

Effects seen in delayed presentation/diagnosis
- Prolonged paralysis (may last weeks despite eventually getting Antivenom)
- Uncontrolled haemorrhage
- Renal failure
CLINICAL PRESENTATION Versus TYPE OF SNAKE

<table>
<thead>
<tr>
<th>SNAKE GROUP</th>
<th>LOCAL EFFECTS</th>
<th>GENERAL EFFECTS</th>
<th>PARALYSIS</th>
<th>MYOLYSIS</th>
<th>COAGULOPATHY</th>
<th>RENAL DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Brown (Pseudonaja)</td>
<td>Often minimal, little pain, redness, fang marks hard to see.</td>
<td>Only 25% of bites serious; may present with collapse, convulsions, headache, vomiting.</td>
<td>Possible, but only rarely seen.</td>
<td>Not seen.</td>
<td>Most prominent features; defibrination type.</td>
<td>Moderately common.</td>
</tr>
<tr>
<td>2 Tiger (Notechis) Copper Heads (Austrelaps) Rough Scaled (Tropidechis)</td>
<td>Often painful with redness, swelling, bruising.</td>
<td>75% of bites serious; may present with collapse, convulsions, headache, vomiting.</td>
<td>Common, presynaptic.</td>
<td>Common, severe (not in Copper-head bites).</td>
<td>Common; defibrination type (not in Copper-head bites).</td>
<td>Moderately common.</td>
</tr>
<tr>
<td>3a King Brown Collett’s Spotted Black (Pseudechis)</td>
<td>Often painful with marked swelling, redness.</td>
<td>&gt;50% of bites serious; may present with collapse, convulsions.</td>
<td>Not seen.</td>
<td>Common, severe, may mimic minor paralysis.</td>
<td>Uncommon, anticoagulant, not defibrination type.</td>
<td>Uncommon.</td>
</tr>
<tr>
<td>4 Death Adders (Acanthophis)</td>
<td>Often painful, mild swelling.</td>
<td>&gt;50% of bites serious; headache, vomiting.</td>
<td>Major feature, severe, post-synaptic</td>
<td>Not seen.</td>
<td>Not seen.</td>
<td>Not seen.</td>
</tr>
<tr>
<td>5 Taipans (Oxyuranus)</td>
<td>Variable, may be minor.</td>
<td>&gt;80% of bites serious; headache, vomiting.</td>
<td>Major feature, severe, post-synaptic</td>
<td>Moderate.</td>
<td>Major feature; defibrination type.</td>
<td>Possible; not common.</td>
</tr>
</tbody>
</table>

First aid treatment of a snake bite
1. 70% of bites are to legs; 25% to arms; and only 5% to head, neck or trunk.
2. Venom is mostly deposited subcutaneously and spreads via absorption into the lymphatic system or small blood vessels.
   - Keep patient calm and lying still and reassure
   - Do not wash the bitten area - will be ideal for subsequent Venom Detection Tests; venom is not absorbed through the skin.
   - Do not incise or bite/suck the bitten area, this is not effective, and do not apply a tourniquet as they can’t stay on indefinitely.
Pressure immobilisation technique

- Apply pressure bandage (if necessary cut/tear strips of clothing) starting below the bite site and then up the limb to the groin or axilla (bind as firmly as you would bind a sprained ankle). Then immobilise limb with a splint, including both the joint above and the joint below; do not elevate the limb.
- Transport the patient immediately and consult early with hospital personnel.

Diagnosis

**Note:** If a bite occurs by a snake less than a finger breadth thick, serious envenomation is highly unlikely. For patients presenting directly to DEM with serious snake envenomation, the most likely culprit is *Eastern Brown Snake*.

Other possibilities, especially if the patient came from an adjacent rural/urban area e.g. Samford Valley, Brookfield etc, include:

- Rough Scaled Snake, Red Bellied Black Snake, Taipan, Death Adder, Small Eyed Snake and Tiger Snake.

*As always, diagnosis is based on history, examination and investigations.*

History

- Time and circumstance of bite
- Was the snake definitely seen and, if so, was it identified and by whom (genuine expert)
- What first aid measures were applied and when

Symptoms of envenomation:

- Headache
- Feeling faint
- Cranial nerve abnormalities/bulbar palsy
- Nausea/Vomiting
- Haemorrhage
- Abdominal pain
- Limb weakness
• Previous administration of anti-venom or other horse-based product.

Examination
• **Site of bite** - ? scratches or punctures. The fangs of Australian elapids are fine and sharp and there are usually little local reaction (unlike many overseas snakes whose venom causes major local necrosis due to high procoytic enzyme content).
• **Regional lymph nodes** – Tender/painful regional lymph nodes may occur after bites from only slightly venomous snakes – hence in isolation, this is insufficient reason to give anti-venom.
• **Full clinical examination** – (1) Early evidence of neurological effects may be very subtle (e.g. mild ptosis, dysarthria or dysphagia). (2) Persistent oozing from venipuncture site is significant.

Investigations
(a) Coagulation tests:
  • PT
  • APPT
  • Fibrinogen
  • FDP’s / INR
  • Bleeding time

Note: Not all types of snake venom cause a coagulation problem, so a negative test doesn’t exclude envenomation.
(b) Creatinine kinase
(c) Venom detection tests (ELIZA methodology)
  • Wound site swab – use swabs and diluent supplied with kit
  • Swab fangs if dead snake has been brought in
  • Fresh urine – void and discard then collect subsequent urine
(d) Check urine for haematuria or myoglobinuria, especially if urine is dark

Before management decisions can be made, the following 3 questions need to be answered:
1. Has the snake bite actually occurred?
2. If so, has envenomation occurred – the bite may have been from a non-venomous snake or may have been a dry bite from a venomous snake?
3. If envenomation has occurred, what snake was it and hence, what specific anti-venom should be used?

Management
Refer to - Management Algorithm for Snake Envenomation (following page)

Snake anitvenoms
**General comments**
• Snake Anti-venoms are immunoglobulins made in horses. Anti-venoms available include:
  Tiger snake, Brown snake, Taipan, Death Adder, Black snake, Polyvalent (all previous) and Sea snake.
• Some specific anti-venoms cross-react with other snake venoms (e.g. Tiger snake) while others do not (e.g. Death Adder).
• Incidence of anaphylaxis (because they are made in horses) is approximately 1% for specific anti-venoms and 5% for polyvent.
• Whenever possible, **specific anti-venom** should be used.
Removal of pressure immobilisation

- If no symptoms/signs on arrival in Emergency Department – maintain it until IV access has been established and coagulation tests return as normal.
- If symptoms/signs are present on arrival – leave it on until Anti-venom has been given and you are in control. May need to release remaining venom in stages in a severe envenomation situation.

Traps for the clinical novice

To help clinicians avoid mistakes when dealing with snake bite victims, Sutherland (1990) has drawn attention to 9 dangers:

1. Fang marks may not be visible to the naked eye. Lack of them does not exclude snake bite.
2. Release of restrictive bandage may result in sudden systemic envenomation – leave in situ until patient reaches full medical facilities (and even then do not take off until you are in control).
3. If there is any doubt whatsoever regarding the identity of the snake, treat as for an unidentified snake.
4. Early paralysis may be missed, especially if patient is asleep (awaken and examine at least hourly).
5. Never give anti-venom unless there is evidence of envenomation or the victim has received an effective bite of an identified highly venomous snake.
6. Never give anti-venom without appropriate precautions.
7. Failure to respond may be due to insufficient anti-venom (or the wrong anti-venom).
8. Without adequate circulating anti-venom, it is useless trying to correct coagulation defects.
9. Renal failure is not uncommon and should be prepared for.
Management of emergency child abuse/neglect presentations


Procedure

Management of Emergency Child Abuse/Neglect Presentations

Child Protection and Forensic Medical Service

<table>
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<tr>
<th>Document ID</th>
<th>Version no.</th>
<th>Approval date</th>
<th>Effective date</th>
<th>Review date</th>
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<td>02681</td>
<td>1.2</td>
<td>18/11/2014</td>
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Purpose

This procedure describes the processes for promoting the protection, safety, health and well-being of children and young people who are at risk of harm or have experienced harm from child abuse and neglect.

This procedure outlines the processes involved in the coordination and management of significant harm to children and young people from inflicted injury or neglect.

These are child protection cases that may require the involvement of statutory agencies, possible hospital admission and/or criminal prosecution.

- To facilitate the expeditious identification of significant physical harm to children and young people from inflicted injury including the appropriate collection of pertinent information and evidence relevant to the assessment of harm.
- To promote a coordinated multidisciplinary and multi-agency response to children who have experienced significant harm from physical abuse.
- To ensure that a relevant and comprehensive assessment of harm is completed.
- To ensure decision-making and case plans are informed and remain current.
- To ensure all children and parents/carers are treated with respect, dignity and privacy.
Scope
This procedure relates to all Children's Health Queensland Hospital and Health Service (CHQ) staff and all clinicians with whom must respond and comply with the prescribed guidelines for the management of significant physical harm from inflicted injury and medico-legal requirements with mandatory reporting.

Procedure

- Refer and comply with the Guidelines for the Management of Emergency Child Abuse and Neglect Presentations (see Appendix 1).
- For situations requiring emergency management, engagement by the treating Consultant with the CPFMS Consultant on call is required. This is a 24/7 day a week service which will ensure appropriate consultation and activation of formal and available systems are in place for example instituting a Care and Treatment Order or providing advice and guidance in the management of emergency presentations is activated.

**ALERT**
Medical Officers and Registered Nurses are mandated by law (Public Health Act 2005) to report a reasonable suspicion of physical and sexual abuse and may report neglect and emotional harm or neglect.
All other health professionals have a duty of care to report.

Supporting documents

**Authorising policy and standard(s)**
- CHQ Proc 44100: Documentation in Medical Records

**Legislation**
- Child Protection Act 1999
- Public Health Act 2005

Consultation

Key stakeholders who reviewed this version:
- Child Protection and Forensic Medical Service
- Department of Communities – Child Safety and Disability Services
- Qld Police Service
- Qld Health Child Safety Unit
Definition of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Source</th>
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<tr>
<td>Emergency Child Abuse / Neglect</td>
<td>All children with injuries highly suggestive of inflicted injury or neglect will be assessed and managed in a timely, efficient and effective manner according to the guidelines for the Management of Emergency Child Abuse and Neglect Presentations.</td>
<td>Child Safety Unit&lt;br&gt;Protecting Queensland’s Children: Procedure Statement and Guidelines on the Management of Abuse and Neglect in Children and Young People (0-18 Years)</td>
</tr>
</tbody>
</table>

References and suggested reading

1. Child Safety Unit
2. Protecting Queensland’s Children: Procedure Statement and Guidelines on the Management of Abuse and Neglect in Children and Young People (0-18 Years)

Audit/evaluation strategy

| Level of risk | High                                                                                                                                                                                                                                                                                                                                                                    |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Strategy      | Director, Child Protection & Forensic Medical Service will monitor intake reports                                                                                                                                                                                                                           | Director, Child Protection & Forensic Medical Service                  |
| Audit/Review date | As required                                                                                                                                                                                                                                                         | Director, Child Protection & Forensic Medical Service                  |
| Key elements / Indicators / Outcomes | An acceptable and appropriate standard of assessment, documentation and response by team members<br>Compliance with established processes and procedures by clinicians with child protection intake responsibilities.                                                                                                                 | Director, Child Protection & Forensic Medical Service                  |

Procedure revision and approval history

<table>
<thead>
<tr>
<th>Version No.</th>
<th>Modified by</th>
<th>Amendments authorised by</th>
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<tr>
<td>1.0</td>
<td>CHS Patient Safety and Quality Unit</td>
<td>Patient Safety and Quality Committee</td>
<td>Chief Operating Officer</td>
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<td>1.2</td>
<td>Director, Child Protection and Forensic Medical Service</td>
<td>Divisional &amp; Medical Director, Medical Services</td>
<td>General Manager Operations</td>
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Keywords
Parent education, group, toolkit seminars

Accreditation references
EQuIPNational Standards: 1.7, 11.2, 11.4, 11.6

Proc 02881 – Management of Emergency Child Abuse/Neglect Presentations

Children's Health Queensland Hospital and Health Service
Appendix 1: Guidelines for the Management of Emergency Child Abuse and Neglect Presentations

Child Protection Service Intake that requires the involvement of statutory agencies, possible hospital admission and/or criminal prosecution.

Injuries highly suggestive of physical or sexual abuse in children

The injuries / circumstances listed below are highly suggestive of inflicted injury. If child protection concerns are identified by the presence of any of the listed injuries or concerns below, please be directed by the flowchart on the following pages.

- Parent’s history of injury is inconsistent with child’s developmental stage and/or medical findings
- Physical signs of injury in a non-ambulant child
- Injury or suspected injury within the context of family violence
- Any disclosure of abuse or neglect by a child or parent
- Any observation of abuse or neglect witnessed by staff
- Concerns about factitious illness

<table>
<thead>
<tr>
<th>Bruising</th>
<th>Burns</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Child aged less than 6 months</td>
<td>• Burns with a ‘forced immersion’ pattern (linear edge, spared flexures)</td>
</tr>
<tr>
<td>• Bite marks &gt;3cm in length</td>
<td>• Instrumental outlines (e.g. cigarette, iron) especially on dorsum of hands, backs, buttocks</td>
</tr>
<tr>
<td>• Instrumental outlines or slap marks</td>
<td></td>
</tr>
<tr>
<td>• Bruising behind or of the pinnae</td>
<td></td>
</tr>
<tr>
<td>• Grab marks on the child’s chest/shoulder</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skeletal Injuries</th>
<th>Head Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Any fracture in a child less than 12 months of age</td>
<td>• Head injury under the age of 6 months</td>
</tr>
<tr>
<td>• Rib fractures</td>
<td>• Depressed, basilar or bilateral skull fractures in a fall &lt; 1.2m</td>
</tr>
<tr>
<td>• Metaphyseal/epiphyseal fractures</td>
<td>• Intracranial haemorrhage with a history of minor injury</td>
</tr>
<tr>
<td>• Multiple or bilateral fractures</td>
<td>• Retinal haemorrhages except in setting of MVA</td>
</tr>
<tr>
<td>• Fractures of varying ages</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Genital Injury</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Evidence of vaginal/hymenal trauma without accompanying external damage (e.g. Labial/perineal contusions)</td>
<td></td>
</tr>
<tr>
<td>• Penile bruising or abrasion (unexplained)</td>
<td></td>
</tr>
<tr>
<td>• Sexually transmitted disease</td>
<td></td>
</tr>
</tbody>
</table>
Injuries or concerns suggestive of abuse and/or neglect

The injuries / circumstances below have been associated with inflicted injury or neglect. If there are any concerns that the following circumstances may be present, or the injuries listed may be caused by abuse or neglect, please be directed by the flowchart on the following pages.

- Parental care of child significantly compromised by parental substance abuse
- Parental care of child significantly compromised by parental mental illness
- Reluctance or inability to explain child's injury
- Delay in presentation
- Inappropriate response of parent/s to severity of child's injury
- Unexplained coma, seizures, neurological signs
- Accidental injury due to lack of appropriate supervision or secondary to carer's actions.

<table>
<thead>
<tr>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Failure to thrive</td>
</tr>
<tr>
<td>• Hyper vigilance</td>
</tr>
<tr>
<td>• Child excessively fearful/withdrawn</td>
</tr>
<tr>
<td>• Ingestion in child &gt; 3 years</td>
</tr>
<tr>
<td>• Recurrent ingestion where lack of parental supervision may be the concern</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bruising</th>
<th>Abdominal Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Facial/head bruising (other than forehead)</td>
<td></td>
</tr>
<tr>
<td>• Bruising with multiple sites/ages/planes</td>
<td></td>
</tr>
<tr>
<td>• Bruises found in places other than bony prominences (or expected sites for child's level of activity)</td>
<td></td>
</tr>
<tr>
<td>• Unexplained rupture of solid or hollow viscus</td>
<td></td>
</tr>
<tr>
<td>• Unexplained blunt or penetrating injuries of solid or hollow viscus</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 1 | Endotracheal Intubation

Introduction
Orotracheal intubation is indicated in any situation that requires definitive control of the airway. Management of airway and breathing has priority in the resuscitation of patients of all ages; however the rate at which respiratory function can deteriorate in children is particularly high. Young infants have relatively less oxygen reserve (greater oxygen consumption), so hypoxaemia occurs relatively more rapidly. The differences between adults and children must be realised and familiarity with equipment assured. Techniques for obtaining a patent and protected airway, and for achieving adequate ventilation and oxygenation, must be learned and practised. Rapid sequence induction will be mentioned in the teaching session, however the details of this procedure are beyond the scope of this session.

Paediatric Airway Anatomy & Physiology
There are differences between the infant and the adult upper airway:

1. The infant larynx is more superior in the neck
2. The epiglottis is shorter, and angled more over the glottis
3. The vocal cords are slanted – with the anterior commissure more inferior
4. The larynx is cone-shaped (being narrowest at the subglottic cricoid ring) and also softer, and more pliable, which allows it to be gently flexed or rotated anteriorly
5. Infant tongue is relatively larger.
6. Infant head is also relatively larger (it is naturally flexed in the supine position). Extension of the head may result in tracheal extubation, while flexion may lead to main stem intubation.
7. Resistance to air flow is inversely proportional to the fourth power of the radius of the airway. One mm of concentric oedema in a newborn trachea (radius approximately 2 mm) increases resistance about 16 times.
8. Young infants (less than approximately 2-3 months) are obligate nose breathers.

Equipment Required

Endotracheal tube (sized as per the formulas shown above)
Uncuffed ETT size may be determined by the following formula (age in years):
Size = (Age/4) + 4

Note: Subtract 0.5 for the appropriate size cuffed ETT

Depth of ETT insertion (Lau et al, 2006):
Over one year of age:
Length (oral): (Age/2) + 13 cm
Length (nasal): (Age/2) + 15 cm
Infants (weight in kg):
Length (oral): 0.5 x weight (kg) + 8 cm
Length (nasal): 0.5 x weight (kg) + 9 cm

Laryngoscope
- A laryngoscope blade should be chosen appropriate for age. It is possible to intubate with a blade which is too long but not one which is too short.
- The curved-bladed laryngoscope is designed to move the epiglottis forward by lifting it from in front. The tip of the blade is inserted into the mucosal pocket, known as the vallecula, anterior to the epiglottis and the epiglottis is then moved forward by pressure in the vallecula. (Shown to right in Figure A)
- The straight-bladed laryngoscope is usually employed to directly lift the epiglottis, thereby uncovering the vocal folds. (Shown to right in Figure B)

Tracheal tube introducer
- Intubation can be facilitated by the use of a stylet or introducer placed through the lumen of the ETT. It is used to alter the ETT shape, but can easily damage the tissues if allowed to protrude from the end of the ETT.

Magill’s forceps
Suction
Lubricant
Tapes to secure endotracheal tube.
End-tidal CO2 device
Ventilation device
Procedure

1. **Holding the laryngoscope**
   a. Hold laryngoscope using your thumb and index finger of your left hand
   b. Balance the laryngoscope body on the edge of your hand
   c. Fan out your middle, ring and little fingers as much as possible
   d. Do not hold the laryngoscope using all your fingers.

2. **Positioning the Baby’s head**
   a. Have the baby supine the their head partially extended and neck slightly flexed
   b. Hold the head of the baby using the index finger and thumb of your right hand
   c. Do not hyperextend the neck

3. **Viewing the cords**
   a. Ensure all equipment is present and that the assistance is briefed
   b. Apply pressure on the cricoid using your little finger (or ask your assistant to help you).
   c. Insert blade of the laryngoscope gently into the baby’s mouth sweeping the tongue to the left.
   d. Slowly progress laryngoscope identifying anatomy as you go
   e. Use suction catheter to clear the airway as needed
   f. Insert the tip of the blade into the vallecula (curved blade) or under the epiglottis (straight blade) and lift upwards (not tilt) to lift the epiglottis up, bringing the cords into view.

4. **Inserting the Endotracheal tube**
   a. Clear the airway, whilst holding the head firmly in position
   b. Make sure that you have a clear view of the cords
   c. Seek your assistant’s help to hold the head of the baby in the correct position
   d. Now quickly pick the ETT up in your right hand
   e. Holding the proximal end of the ETT, gently insert the tip of the ETT under direct vision through the vocal cords

5. **Check the placement of the tube by:**
   a. inspecting the chest for movement
   b. auscultating the chest in both axilla
   c. monitoring End-Tidal CO₂
   d. checking the tube position on a confirmatory chest x-ray

**Troubleshooting**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngoscope blade is too far in the pharynx</td>
<td>Slowly withdraw the blade</td>
</tr>
<tr>
<td>The Neck is hyper-extended</td>
<td>Place baby supine but make sure the neck is slightly flexed, and head is partially extended.</td>
</tr>
<tr>
<td>Baby’s tongue is in your visual field</td>
<td>Pass the blade over the infants tongue (right to left side or left to right) and firmly depress the tongue.</td>
</tr>
</tbody>
</table>

**Further Reading**

Appendix 2 | Intercostal Catheter Insertion

Indications
Insertion of an intercostal catheter (chest tube) may be indicated for several emergency and non-emergency situations in children.

- Pneumothorax
  - If it is large
  - If the patient is requiring mechanical ventilation
  - For tension pneumothorax after needle decompression
  - If it is recurrent or persistent
  - If it is secondary to chest trauma
- Massive or recurrent benign pleural effusions not responding to thoracentesis
- Empyema
- Haemothorax / haemopneumothorax
- Chylothorax

Contraindications
- Previous pleurodesis
- Bleeding diathesis (relative) – should be corrected if time permits
- Local infection (relative)

Equipment
In general emergency chest drain placement should be performed using an open technique. For non-emergency indications a Seldinger technique is available. It however uses a much smaller chest tube so is not appropriate for all patients.

Chest Tube Size:
In general, the largest size drain that will pass between the ribs should be used:

<table>
<thead>
<tr>
<th>Age</th>
<th>Chest Tube Size (Trauma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate</td>
<td>10-14Fr</td>
</tr>
<tr>
<td>0-6 months</td>
<td>12-18Fr</td>
</tr>
<tr>
<td>6-12 months</td>
<td>14-20Fr</td>
</tr>
<tr>
<td>1-3 years</td>
<td>14-24Fr</td>
</tr>
<tr>
<td>4-7 years</td>
<td>20-32Fr</td>
</tr>
<tr>
<td>8-10 years</td>
<td>28-38Fr</td>
</tr>
</tbody>
</table>

Other equipment:
- Gown, sterile gloves, surgical drapes
- Skin prep (Chlorhexidine 0.5% in 70% Alcohol)
- Local anaesthetic (1% Lignocaine with 1:100,000 Adrenaline)
- Consideration of conscious sedation
- Scalpel handle and blade
- Gauze squares
- Artery forceps or larger (eg Kelly clamps)
- Scissors
- Wide impermeable tape (eg Tegaderm / Sleek)
- Suture material (1-0, 0)
- Underwater drain
- Suction device

Intercostal Catheter Insertion

Procedure
- Position the patient in a supine, or semi-recumbent position. Maximally abduct the arm on the side of the procedure or place it behind the patient’s head.
- Decide on the insertion site (usually the 5th intercostal space in the anterior- to mid-axillary line) on the side with the pneumothorax / fluid collection.
- Ensure that all equipment is prepared. Remove the trocar from the chest tube.
- Swab the chest wall with skin prep. Apply surgical drapes to ensure that this remains a sterile procedure.
- If the patient is haemodynamically stable and conscious, consider sedation with an agent such as Ketamine.
- Infiltrate local anaesthetic, both subcutaneously and deeper through the intercostals muscles to the pleural space (you should get a flash of pleural fluid, or bubbles of air in the syringe).
- Make a 2-3cm skin incision at the site of insertion. Some people make the incision lower than the intended site (over the rib below the space) and make an angular tract through the chest wall to facilitate closure when the tube is removed.
- Blunt dissect through the subcutaneous tissues to the pleural space. You should feel a pop as you enter the pleural space. The tract should be immediately superior to the rib border, avoiding the neurovascular bundle on the inferior aspect of the rib.
- Put a gloved finger into the incision and clear the path into the pleura. This may not be possible in small children.
- Avoid losing the tract by keeping your finger in place and then inserting the tube alongside the finger.
- Direct the tube either superiorly for a pneumothorax, or posteriorly and inferiorly if draining fluid.
- Ensure the tube is far enough in so that all of the side holes are within the pleural space. This should be confirmed after the end of the procedure with a CXR.
- Connect the tube to an underwater drain.
- Suture the drain in place, with mattress or interrupted sutures on both sides of the incision.
- Use the loose ends of the sutures to wrap around the tube and tie them off. Tape the tube to the side of the patient, with either tegaderm or sleek.

Complications
The most important complications include:
- bleeding and haemothorax due to intercostal artery perforation
- perforation of visceral organs (lung, heart, diaphragm, or intra-abdominal organs)
- perforation of major vascular structures (aorta or subclavian vessels)
- intercostal neuralgia due to trauma of neurovascular bundles
- subcutaneous emphysema
- re-expansion pulmonary oedema
- infection of the drainage site
- pneumonia, and empyema

Chest Tube Removal
For a pneumothorax, bubbling must have ceased and the lung must be fully expanded on CXR before the tube is removed. If placement was for any pleural fluid drainage, once the drainage volume has reduced dramatically (eg less than 200ml in a 24 hour period in an adult), the fluid is serous, the lung has re-expanded on CXR, and the patient’s clinical status has improved, the chest tube can be removed.

The major concern with removal of a chest tube is the risk of pneumothorax. It should be removed at either end-inspiration of end-expiration.

Further reading
Appendix 3 | Needle thoracocentesis

Indications
- Tension pneumothorax
  - Clinical signs
    - Hypoxia and there may be shock
    - Unless deeply unconscious, there will be signs of respiratory distress
    - Decreased air-entry and hyper-resonance to percussion on the side of the pneumothorax
    - Distended neck veins may be present (not if hypovolaemic)
    - Tracheal deviation away from the side of the pneumothorax
  - Should be followed by chest drain placement to prevent recurrence
- Also used for drainage of benign pleural effusions

Contraindications
- This procedure can be life-saving and should be performed in any patient who clinically has evidence of a tension pneumothorax.

Equipment
- Alcohol swabs / Chlorhexidine 0.5% in 70% Alcohol
- Intravenous cannula (16-gauge or larger)
- 20-ml syringe

Procedure
- Identify the 2nd intercostal space in the mid-clavicular line on the side of the pneumothorax (the opposite side to the direction of tracheal deviation)
- Swab the chest wall with skin prep
- Attach the syringe to the cannula. Fluid in the cannula will assist in the identification of air bubbles.
- Insert the cannula vertically into the chest wall, just above the rib below, aspiration all the time.
- If air is aspirated remove the needle, leaving the plastic cannula in place.
- Tape the cannula in place and proceed to chest drain insertion as soon as possible.

Complications
If needle thoracocentesis is attempted, and the patient doesn’t have a tension pneumothorax, the chance of causing a pneumothorax is 10-20%. Patients who have had this procedure must have a CXR, and will require chest-tube drainage if ventilated.

Further reading
Appendix 4 | Needle pericardiocentesis

Indications
- Cardiac tamponade
  - Clinical signs
    - The child will be in shock
    - Heart sounds may be muffled
    - The neck veins may be distended (not if hypovolaemic)

Removal of a small amount of fluid from the pericardial sac can be life-saving

Equipment
- ECG Monitor
- Local anaesthetic
- 20-ml Syringe
- Skin prep and surgical drapes
- Spinal needle (22 Gauge, 9cm)

Procedure
- Swab the xiphoid and subxiphoid areas with skin prep.
- Use local anaesthesia if necessary
- Assess the patient for any significant mediastinal shift
- Attach the syringe to the needle
- Puncture the skin 1-2 cm inferior to the left side of the xiphoid junction, advancing the needle towards the tip of the left scapula, aspirating all the time.
- Watch the ECG monitor for signs of myocardial injury (ST segment changes or a widened QRS)
- Once fluid is withdrawn, aspirate as much as possible (unless it is possible to withdraw limitless amounts of blood, in which case a ventricle has probably been entered)

Complications
The ECG should be closely monitored throughout the procedure to ensure that arrhythmia doesn’t occur.

Further Reading
Appendix 5 | Useful links

The Trauma in pregnancy guideline has now been published on the QCG website

QHEPS/ CHS paediatric trauma

NSW Institute of Trauma and Injury Management
www.itim.nsw.gov.au

Blood Safe e-Learning Program
www.bloodsafelearning.org.au

Clinicians Knowledge Network
https://sp.ckn.dotsec.com

Emergo Train System
www.emergotrain.com

The Joanna Briggs Institute
www.joannabriggs.edu.au