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Review Article

Primary and Secondary Survey in the Management of Pediatric Trauma

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Abstract

Trauma is the leading cause of death and acquired disability in children and adolescents.

The initial evaluation in ED has two main goals:

1. Identify and immediately treat potentially life threatening injuries.
2. Determine disposition after the trauma resuscitation on the basis of known or suspected injuries.

ATLS "Advance Trauma Life Support" consists of:

- First Phase: primary survey A, B, C, D, E "exposure environment"
- Second Phase: Secondary survey detailed head to toe examination with detailed evaluation that identifies other injuries with SAMPLE (Sign-Allergy-Medication-Past Medical History-**L**ast Meal-**E**vent).

Keywords: *Trauma; Primary Survey; Secondary Survey*

Introduction

Pre hospital care and trauma team activation: Which consists of a three main aspects:

1. Initial field care.
2. Appropriate triage: Most severely injures children are triaged to the trauma center where they will meet by a full team upon arrival including trauma surgeon, emergency department physicians, critical care physicians, anesthesiologists, nurses and radiology technicians.
3. Rapid transport: And minimally injured patients can be directed to non-trauma hospitals to avoid burdening pediatric trauma centers where they will meet by a smaller team with the option of summoning a larger team.

Trauma resuscitation

- Designating a specific team for trauma resuscitation and room will help ensure the needed resources are immediately available.
- Broselow measuring device: Warmed room to prevent hypothermia.
- Timeout: To allow for exchange of information between the pre hospital providers and trauma.

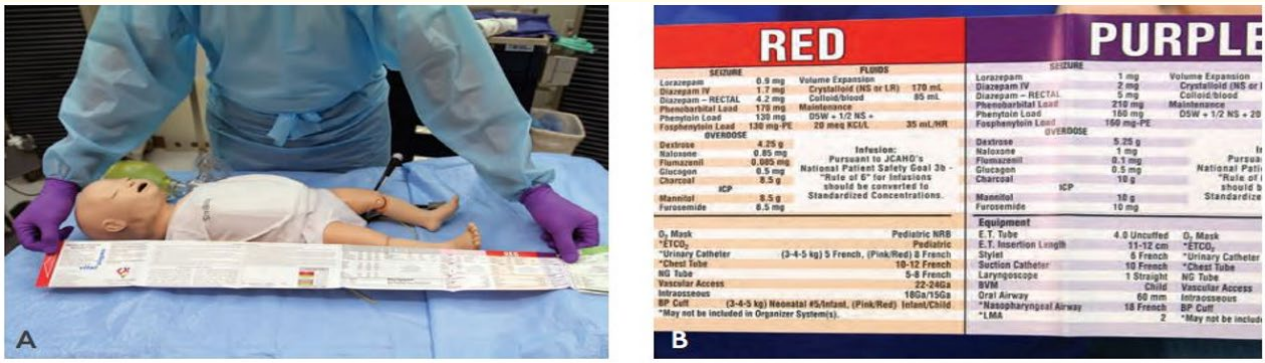


Figure 1

Discussion

Primary survey

Overview

Primary survey defined by ATLS as identifying and treating the most life-threatening injuries first and consists of A, B, C, D, E.

Establish an airway with cervical spine stabilization

a. Give O_2

b. Evaluate airway: And here we have three categories:

- **Category one:** Those with a patent airway requiring no manipulation. Accomplish most children, and evaluation consist of:
  - Asking the patient name.
  - Inspection for craniofacial injuries.
  - Assessment for voice changes.
  - Listening for obvious stridor.
- **Category two:** Those who have undergone intervention in the field or at another hospital to establish a patent airway "usually by ETT". Here evaluation consist of:
  - Appropriateness of tube size by age specific formula or by charts or by comparing tube with the child fifth little finger.
    - Uncuffed tube size age in year/4 + 4.
    - Cuffed tube size age in year/4 + 3, balloon inflated with usually.
    - 5 - 8 ml air to keep cuff pressure at 20 - 25 mmHg.
- **For newborns:**
  - BW < 1 kg: Tube size 2.5
  - BW 1 - 2 kg: Tube size 3

- BW 2 - 3 kg: Tube size 3.5
- BW > 3 kg: Tube size 3.5 - 4

- Evaluating tube depth by
- Formula (tube size x 3)
- Age specific formula:
  - Oral intubation: Age in year/2 + 12
  - Nasal Intubation: Age in year/2 + 15
- For Newborn: 6 + BW:kg or by doing a chest X-ray
- Assessing adequacy of ventilation by auscultation and inspection of the chest rise or measurement of $ETCO_2$.

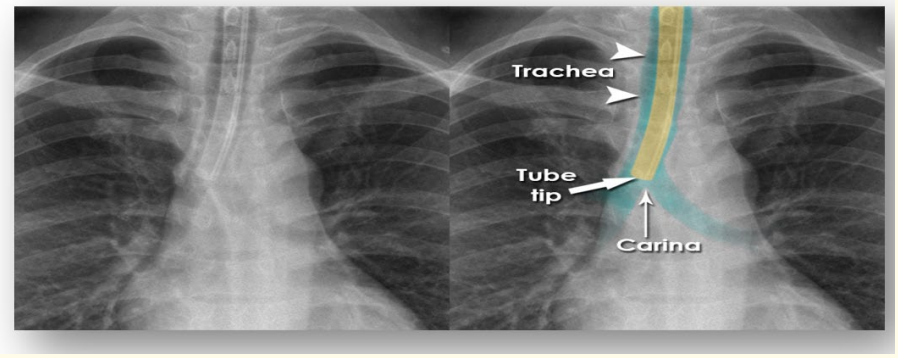


Figure 2

- **Category three:** Those who will need an intervention to establish a patent airway. It is the least category.

Figure 3

Indications for intubation:

1. Apnea
2. Inability to maintain a patent airway by other means
3. The need to protect the airway from aspiration
4. Impending compromise of the airway
5. GCS ≤ 8
6. Inability to maintain adequate oxygenation with supplemental face mask oxygen.

How to establish an airway?

1. Chin left and jaw thrust (alone in case of CS injury) to facilitate 2.

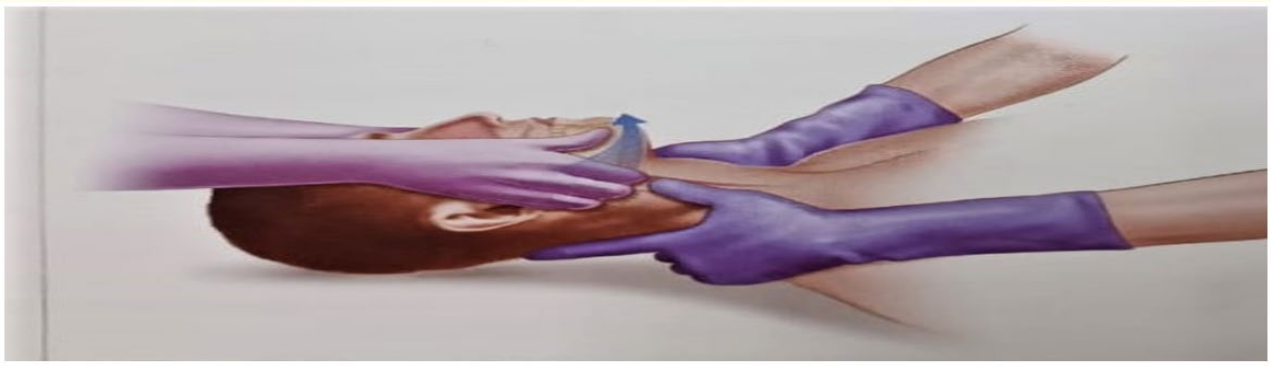


Figure 4

2. Bag, valve, mask ventilation.

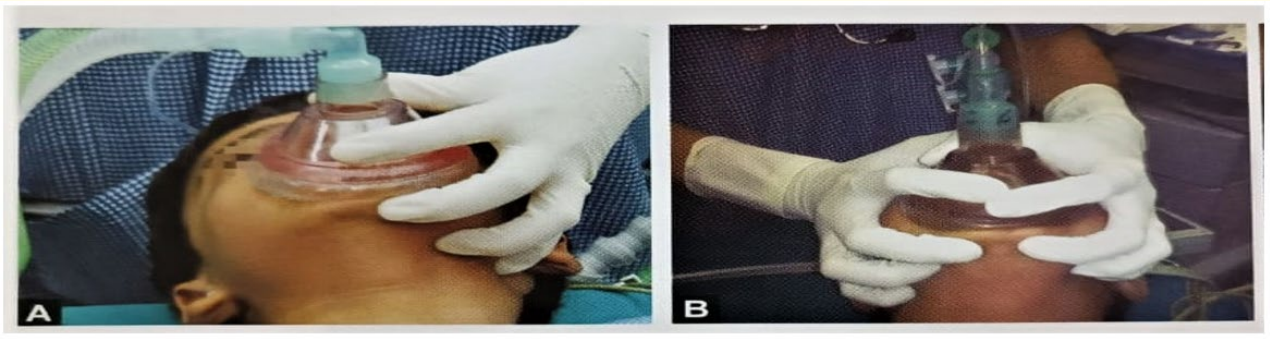


Figure 5

3. Young children: maintain the face plane parallel with spine board plane.

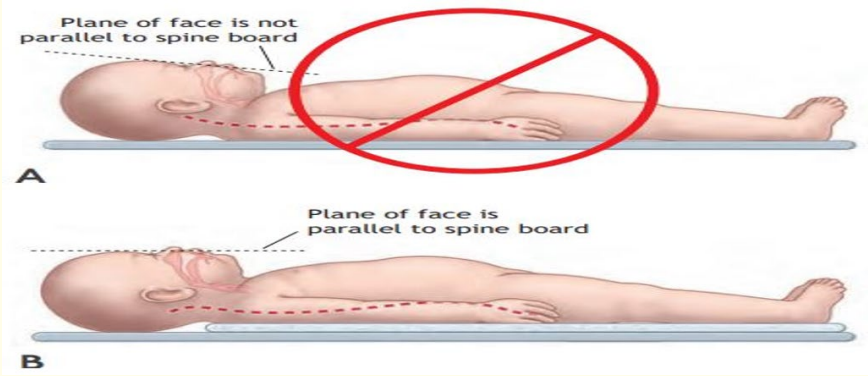


Figure 6

4. Orotracheal intubation: With rapid sequence technique.

- Nasotracheal intubation is contraindicated in:
  - Facial trauma
  - CSF leak
  - Suspicious of basilar skull fracture

} Due to possibility of disposition between cranial vault and nasopharynx

- NB1 evidence of basal skull fracture:
  - Blood or CSF leak from nose or ear
  - Haemotympanum
  - Panda or raccoon eyes

Figure 7

- Battle's sign "bruising behind the ear over the mastoid process".

Figure 8

- NB2 rapid-sequence intubation protocol "RSI"

1. Pre oxygenate by providing 100% O_2 by mask
2. Assemble the equipment required.
    a. Bag-valve-mask
    b. Yankeur suction
    c. ET tube cuffed ± uncuffed, stylet, syringe and tape
    d. Laryngoscope and blades
    e. Back up airway equipment
3. IV line "working"
4. Monitor cardiac and SpO_2
5. Premedication as appropriate:

- Fentanyl: 1 - 2 mcg/kg "slowly IV push" for analgesia in awake patients.
- Atropine: 0.02 mg/kg for children or adolescents "a minimum dose of 0.1 mg (0.2 ml) is recommended.
- Lidocaine: 1.5 - 2 mg/kg IV over a period of 30 - 60 seconds.

6. Induced anesthesia: With one of the following agents.

- Thiopental, fentanyl, ketamine, etomidate or propofol
- Thiopental: 3 - 5 mg/kg/IV preferred in ↑ICP and SE "Status Epilepticus"
- Fentanyl: 5 - 15 mcg/kg/IV
- Midazolam: 0.1 - 0.3 mg/kg/IV

- Ketamine: 1 - 2 mg/kg/IV preferred in children, shock and RAD: reactivate airway disease.
- Etomidate: 0.3 mg/kg/IV contraindicated in case of adrenal insufficiency and children less than 10-year-old.
- Propofol: 1 - 2 mg/kg/IV preferred in ↑ICP and SE.

7. Give succinylcholine 1.5 mg/kg/IV push and 2 mg/kg for infants and small children or rocuronium 0.8 - 1.2 mg/kg up to 1.4 mg/kg which associated for a more successful intubation. Use only when oxygenation before RSI cannot be optimized by spontaneous ventilation.

8. Perform ET intubation: If you cannot do this within 20 seconds, stop, ventilate the patient with BVM for 30 - 60 seconds monitor SpO_2.

9. Treat bradycardia during intubation with Atropine.

10. Once intubation is completed, do:

    a. Inflate the cuff.

    b. Confirm ET tube placement.

    c. Check SpO_2 and $ETCO_2$.

11. Secure the ETT.

5. LMA: Laryngeal mask airway: Doesn't protect against aspiration. Also cannot be used effectively to provide PPV in patient with altered respiratory compliance or resistance, and it should be used only as rescue technique.

Figure 9

- **Patient size:**

a. Neonate (< 5 kg): LMA size 1
b. Infant (5 - 10 kg): LMA size 1.5

c. Child (10 - 20 kg): LMA size 2
d. Child (20 - 30 kg): LMA size 2.5
e. Child (30 - 50 kg): LMA size 3

Figure 10

6. Surgical airway

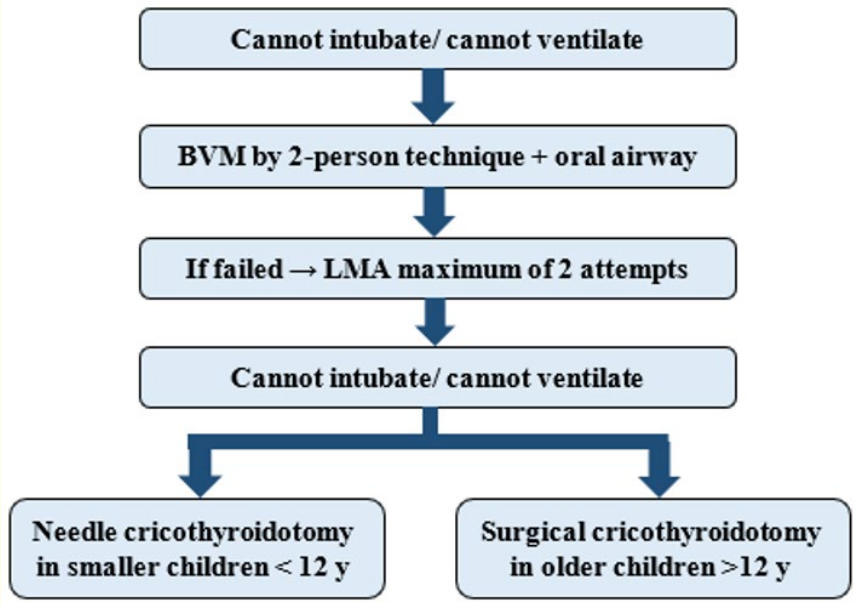
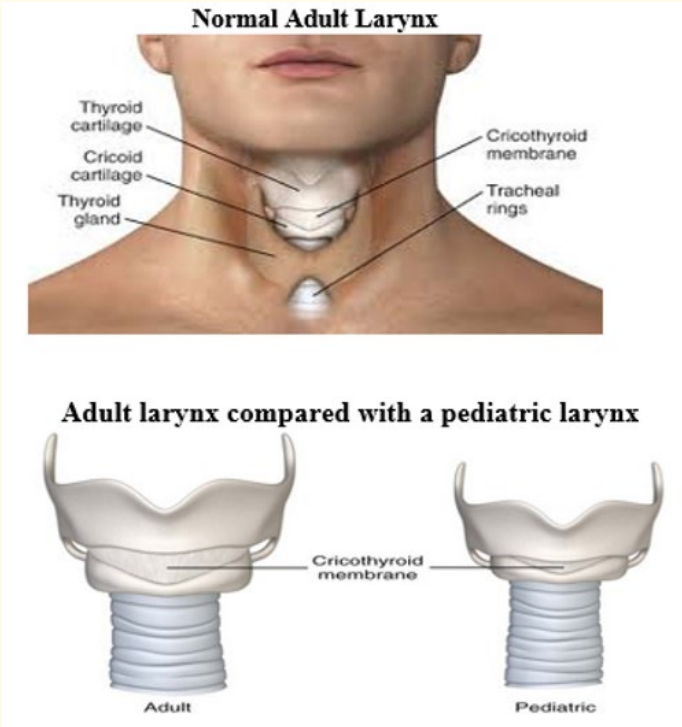
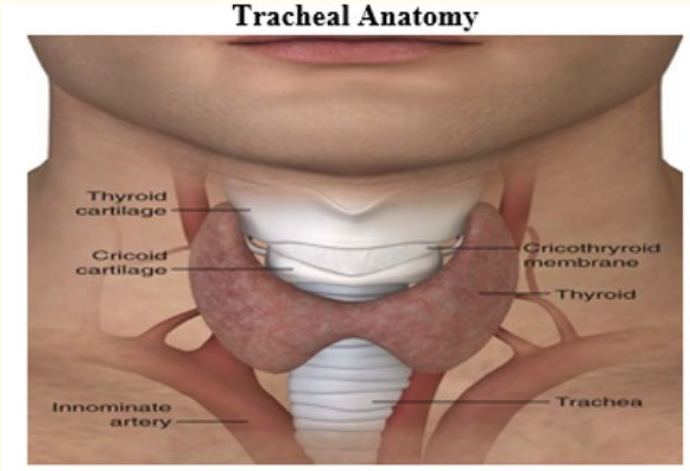


Figure 11

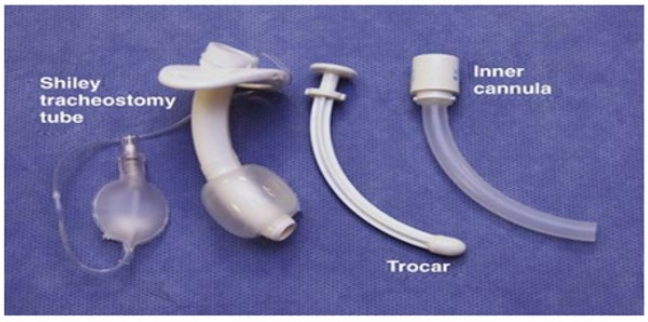
- **Surgical cricothyroidotomy:** 4 steps for surgical cricothyroidotomy

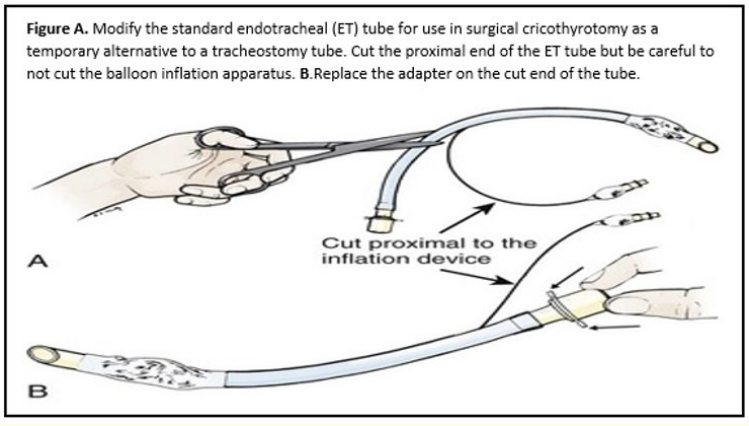
1. Identification of cricothyroid membrane.
2. Making an incision through the skin on cricothyroid membrane.
3. Stabilization of the larynx with a tracheal hook at the inferior aspect of the ostomy.
4. Placement of a tube in the trachea.





Standard Shiley tracheostomy tube with removable trocar and inner cannula





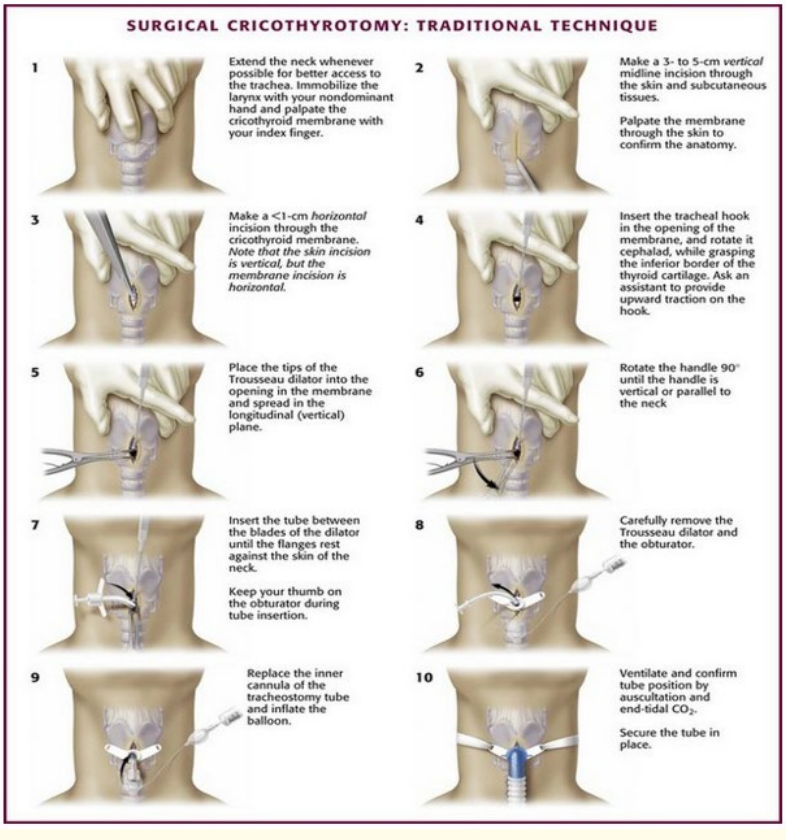
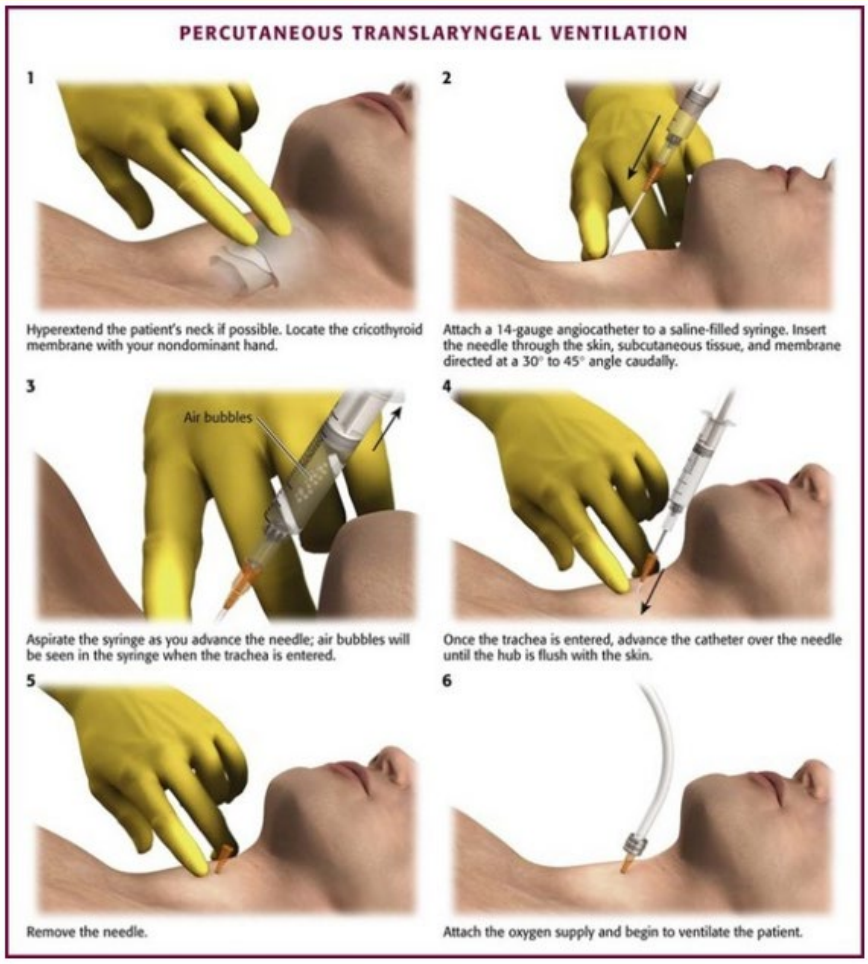
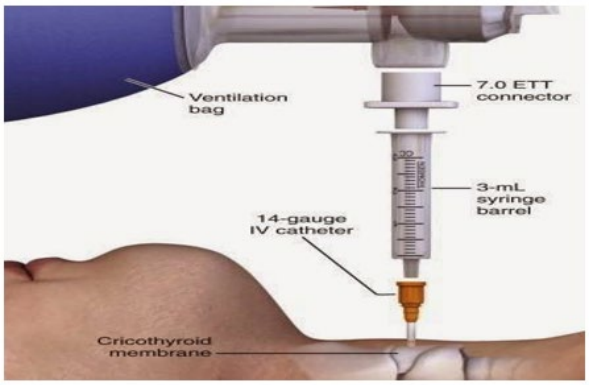


Figure 12

- **Needle cricothyrotomy**

- Is performed by: Inserting a large bore (12 - 18) gauge angiocatheter in caudal direction at 30 - 45° angle through the cricothyroid membrane. During needle advancement, constant negative pressure is applied to the plunger of the syringe to aspirate air and confirm its endotracheal position.
- After confirmation of endotracheal placement, the syringe and stylet are removed and the cannula is connected to O_2 source.
- Another option is to place a needle tracheostomy where the needle is placed at roughly the 2nd tracheal ring and by passing the small larynx in children.
- There are a numerous methods for delivering O_2 via the angiocatheter but CO_2 removal is limited, flow 10 - 12 L/min at 25 - 35 psi.
- Standard IV tubing can be connected to the cannula.
- Y connector can be placed between IV tubing and O_2 tubing intermittent occlusion for one second, and release of the Y connector for 4 to 5 seconds → provides some passive ventilation.
- Improvement of SpO_2 in the 1st minute confirm correct deployment
- Should be managed by single dedicated person.





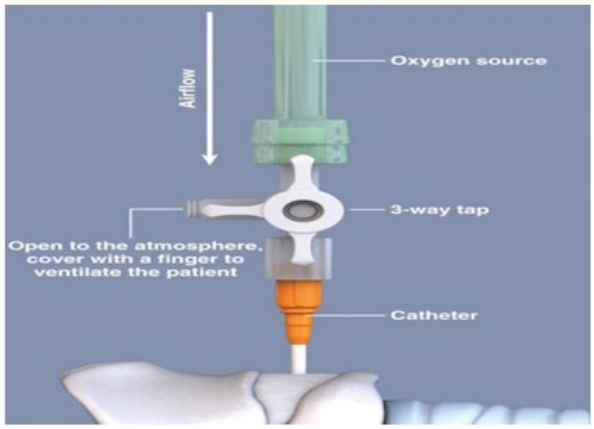


Figure 13

7. Cervical spine stabilization: Is needed in patients with any mechanism of injury that can be associated with CS trauma, so when ETT is required in-line cervical spine stabilization must be used, take care of ill-fitting collars, especially for mechanisms of injury in which spine injury is unlikely.

Breathing

Assessment consists of three important steps.

1. Chest auscultation, RR, adequacy and symmetry of chest wall movement.
2. Pulse oximeter (SpO_2).
3. ET CO_2.

What are the causes of breathing (ventilation) impairment?

1. Tension pneumothorax.
2. Open pneumothorax.
3. Flail chest with pulmonary contusion.
4. Massive hemothorax.

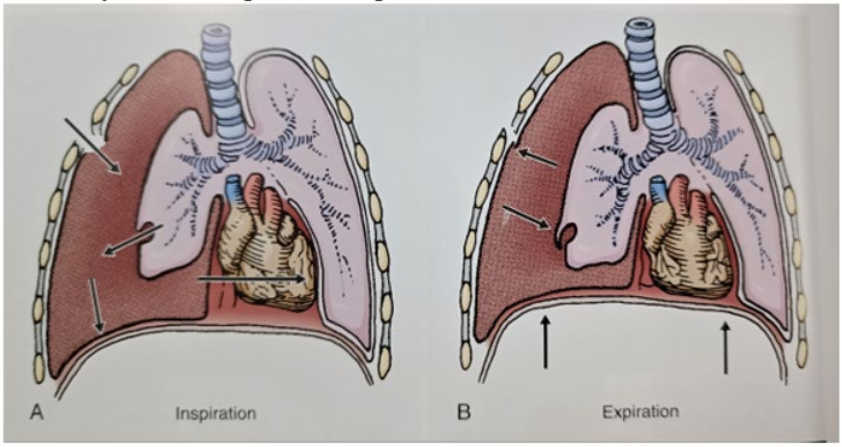
Tension pneumothorax

Clinically tracheal deviation, unilateral absence of breath sounds, neck vein distention, tachycardia, ↓BP and respiratory distress. Don't delay treatment till you obtain chest x-ray, due to delay in treatment can result in decompensation of clinical status. Put an angiocatheter 14 to 18 gauge needle into the 2nd intercostal space at the midclavicular line, and once the angiocatheter is in place (audible rush of air) the needle should be removed to prevent further trauma.

A minimum length of 5 cm is recommended in older children and adult, but shorter needle may suffice in infants and younger children.

The needle will convert a tension pneumothorax into simple one, a chest tube will be necessary regardless of the response for a definitive treatment.

Traumatic Tension Pneumothorax. Pathophysiology of a tension pneumothorax. During inspiration, air enters the pleural space through a one-way valve either from the outside or from the lung itself. On expiration, the injury/valve closes and traps increasing amounts of air in the pleural space Eventually, the mediastinum shifts and cardiac filling and ultimately cardiac output are compromised.



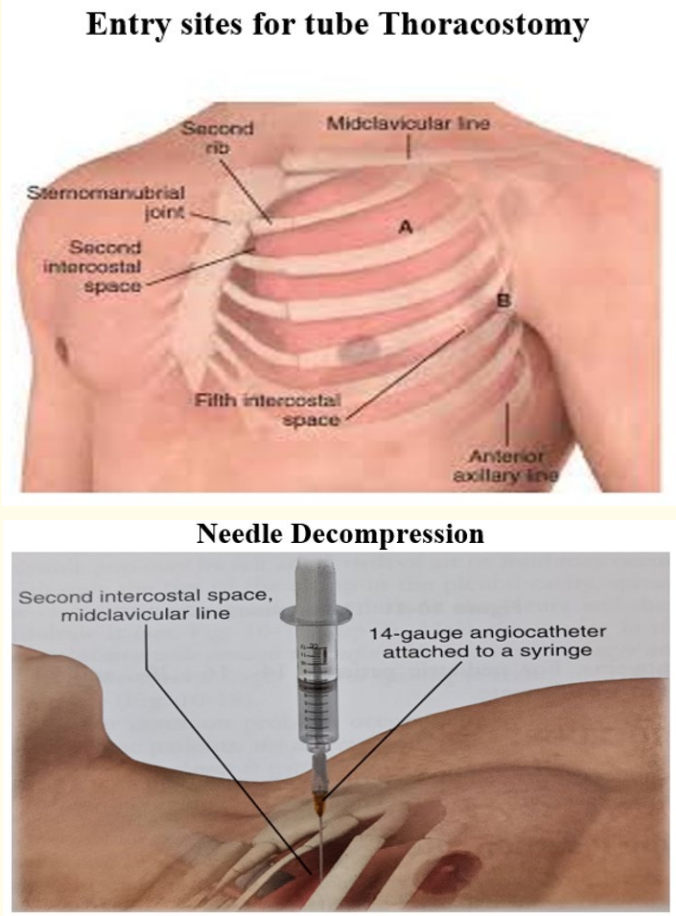


Figure 14

Open pneumothorax

Or sucking chest wound

Occur when the size of a chest wall injury approaches 2/3 of the area of the tracheal lumen, causing a preferential pull of air into the pleural space, through the wound and can cause:

1. Mediastinal shift, ↓ venous return and cardiopulmonary collapse.
2. Air flow through the wound, will be audible or can be visualized by bubbling of blood at the wound.
3. Treatment is by semi occlusive rectangular petroleum jelly/ gauze dressing that is occlusive on 3 sides beyond the wound edge will produce a one-way valve effect that will allow air to escape on expiration but inhibit air from entering the thoracic cavity on inspiration.

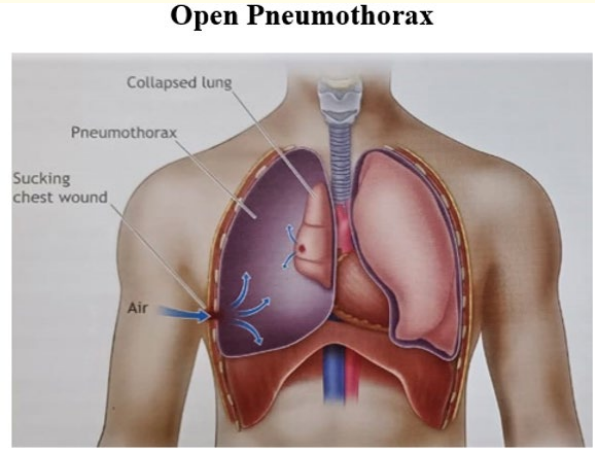
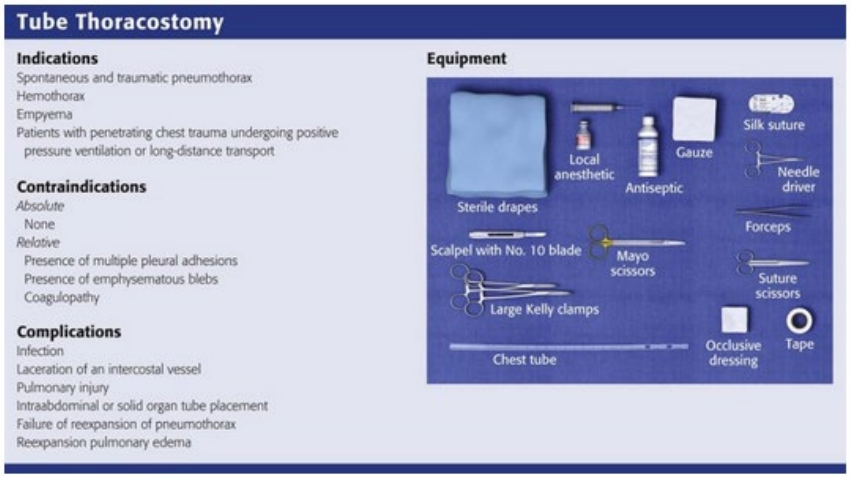
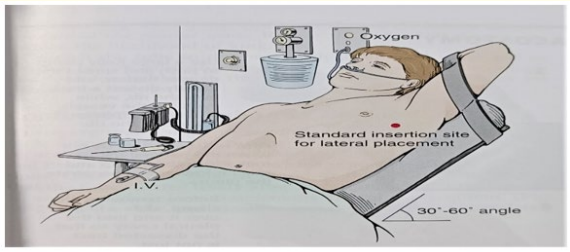
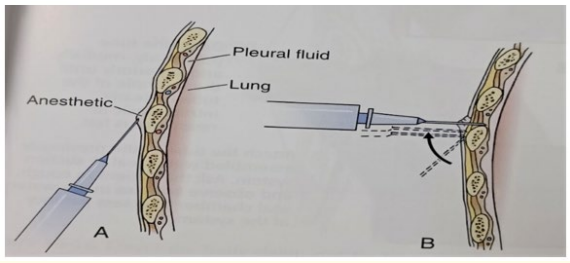


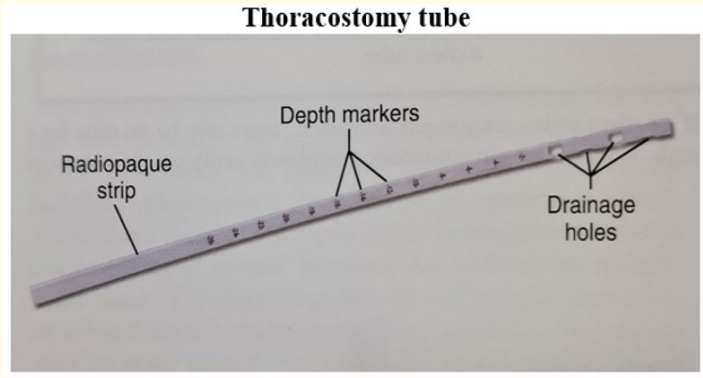
Figure 15

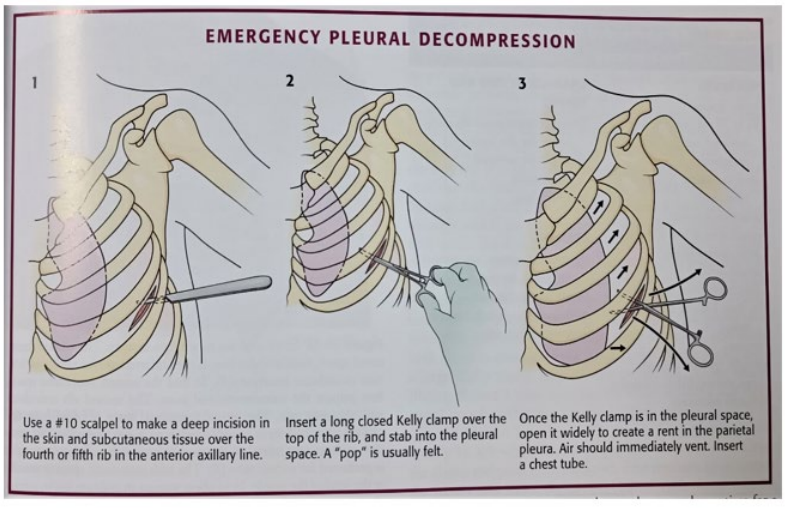
Or sucking chest wound which app 2/3 the tracheal diameter (during inspiration) treated with three sides occlusive dressing "petrolatum gauze".

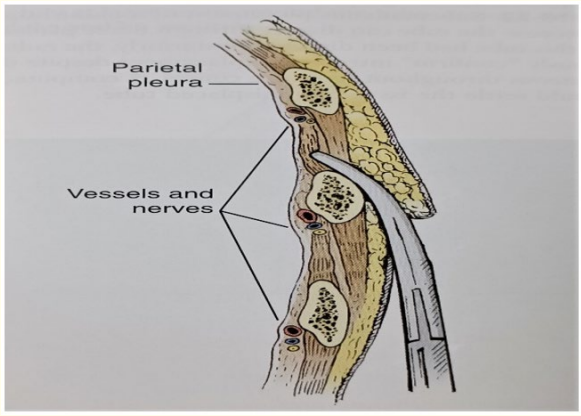


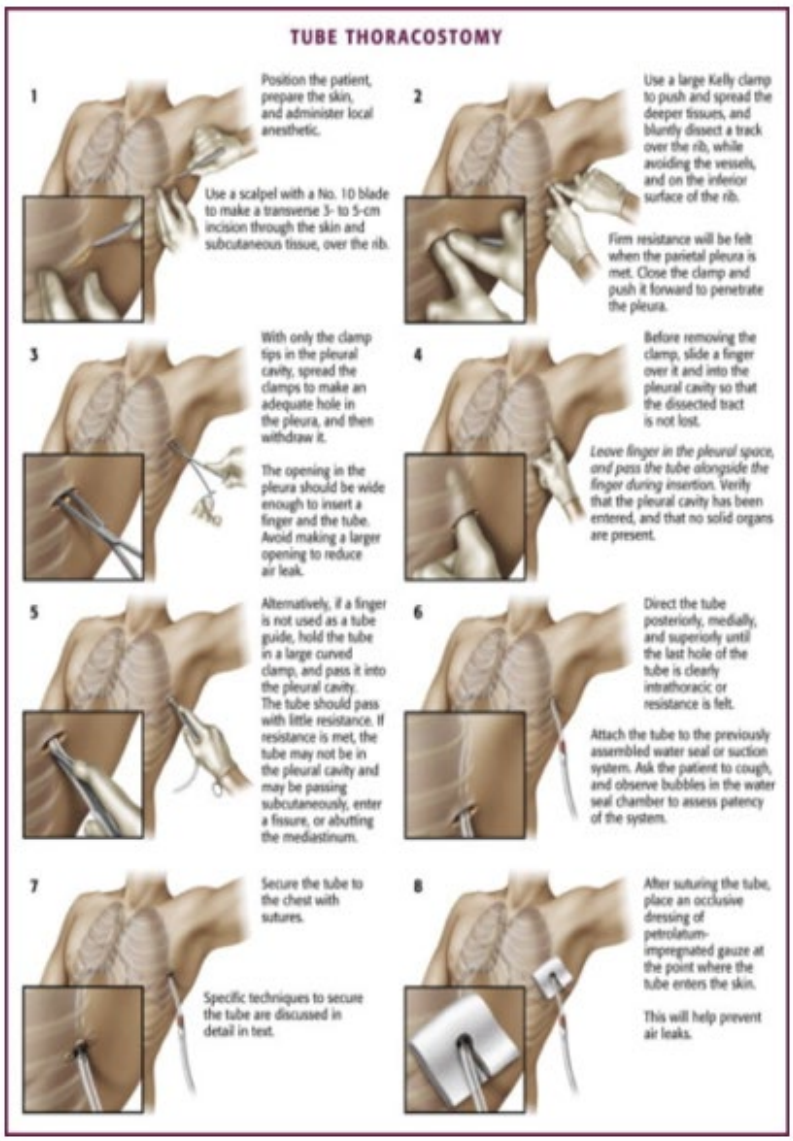

Oxygen
Standard insertion site for lateral placement
I.V.
30°-60° angle


Pleural fluid
Lung
Anesthetic
A
B


Thoracostomy tube
Depth markers
Radiopaque strip
Drainage holes


EMERGENCY PLEURAL DECOMPRESSION
1
2
3
Use a #10 scalpel to make a deep incision in the skin and subcutaneous tissue over the fourth or fifth rib in the anterior axillary line.
Insert a long closed Kelly clamp over the top of the rib, and stab into the pleural space. A "pop" is usually felt.
Once the Kelly clamp is in the pleural space, open it widely to create a rent in the parietal pleura. Air should immediately vent. Insert a chest tube.


Parietal pleura
Vessels and nerves


TUBE THORACOSTOMY
1
Position the patient, prepare the skin, and administer local anesthetic.
Use a scalpel with a No. 10 blade to make a transverse 3- to 5-cm incision through the skin and subcutaneous tissue, over the rib.
2
Use a large Kelly clamp to push and spread the deeper tissues, and bluntly dissect a track over the rib, while avoiding the vessels, and on the inferior surface of the rib.
Firm resistance will be felt when the parietal pleura is met. Close the clamp and push it forward to penetrate the pleura.
3
With only the clamp tips in the pleural cavity, spread the clamps to make an adequate hole in the pleura, and then withdraw it.
The opening in the pleura should be wide enough to insert a finger and the tube. Avoid making a larger opening to reduce air leak.
4
Before removing the clamp, slide a finger over it and into the pleural cavity so that the dissected tract is not lost.
Leave finger in the pleural space, and pass the tube alongside the finger during insertion. Verify that the pleural cavity has been entered, and that no solid organs are present.
5
Alternatively, if a finger is not used as a tube guide, hold the tube in a large curved clamp, and pass it into the pleural cavity. The tube should pass with little resistance. If resistance is met, the tube may not be in the pleural cavity and may be passing subcutaneously, enter a fissure, or abutting the mediastinum.
6
Direct the tube posteriorly, medially, and superiorly until the last hole of the tube is clearly intrathoracic or resistance is felt.
Attach the tube to the previously assembled water seal or suction system. Ask the patient to cough, and observe bubbles in the water seal chamber to assess patency of the system.
7
Secure the tube to the chest with sutures.
Specific techniques to secure the tube are discussed in detail in text.
8
After suturing the tube, place an occlusive dressing of petrolatum-impregnated gauze at the point where the tube enters the skin.
This will help prevent air leaks.

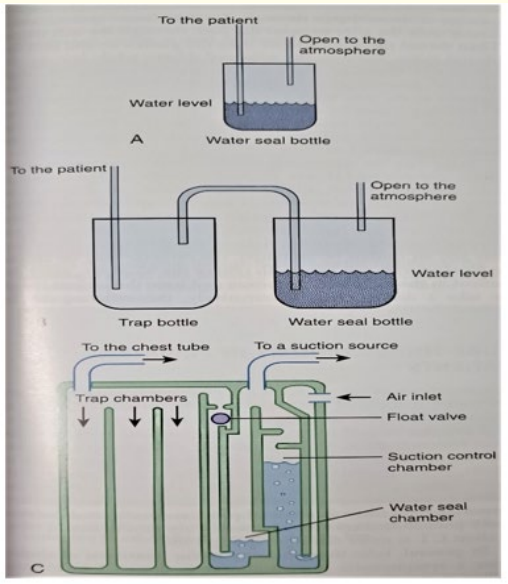


Figure 16

How to place a chest tube in an injured child?

1. Direct the tube posteriorly.
2. Use Fr 20 to Fr 22 chest tube size.
3. Best place 5th intercostal space "nipple level" in mid axillary line.
4. Confirmation of correct tube place by observing a fluid movement in the water-seal chamber in the time with the patient respiration when connected to a pressure-regulated collection device.
5. Chest x-ray.

Flail chest

When a segment of the chest wall has lost continuity with the movement of the thoracic cage, occur when two or more adjacent ribs are fractured in two or more places. Due to the high compliance of chest in infants→ rib fracture suggests a significant amount of blunt force to the chest and the possibility of an underlying pulmonary contusion as well as hepatic or splenic injury.

Need for providing temporary ventilatory support until the injury heals.

Surgical Fixation of multiple displaced rib fractures has been shown to reduce the hospital length of stay, and also reduce the need for ICU admission and decrease the overall mortality in adult trauma patients, thus it should be considered after patient stabilization.

Massive hemothorax

Blood come from intercostal vessels-intermammary vessels-lung parenchyma-cardiopulmonary vessels.

Clinically ↓ breath sounds and dullness on the affected side.

Insert a chest tube even without chest X-ray:

1. If the blood volume which came through the chest tube exceeds 20-25% of estimated blood volume, or
2. Bleeding continue at a rate exceeding 2-4 ml/kg/hr, or
3. The bleeding rate is increasing, or
4. The pleural space cannot be drained of blood and clots

Need for thoracotomy for controlling bleeding from chest wall, lung or heart.

Also don't forget the need for resuscitation with IV fluid or blood.

Circulation

For shock identification

Assessment by

- **HR:** Tachycardia could be due to shock, pain, fear or other stress.
- **BP:** Shock index HR/S.BP
  - 4→6 y > 1.22
  - 7→12 y > 1
  - 13 → 16 y > 0.9
  - Adult > 0.7.

Also, hypotension is a late sign of shock and considered as an ominous sign of impending circulatory collapse palpation of central and peripheral pulses is a rapid method for detection of hypotension.

Lost from wrist or feet → groin → neck.

In teen ages but not so accurate in younger children.

Pulse volume

Capillary refill time "CRT" and skin color.

Temperature: Core/peripheral > 3.

The main management of shock

1. Controlling external hemorrhage
2. Restoration of intravascular volume

Restoration of intravascular volume

For this purpose, we need to establish an adequate IV access.

- 2 peripheral IV lines
- Or IO
- Or PCCV: Percutaneous central venous access, and the best is femoral placement which isn't preferred in case of abdominal or pelvic injuries.
- Or venous cut down.

Figure 17

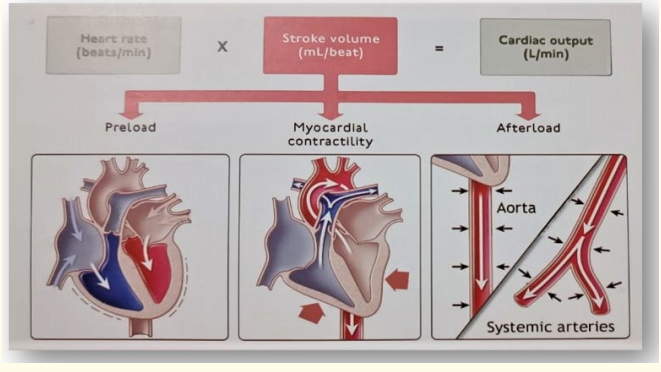


Figure 18

Intraosseus Infusion

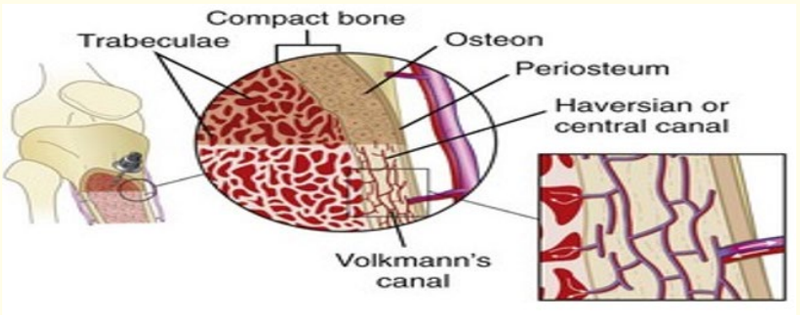
Indications
Emergency intravascular access when other methods have failed
Cardiac arrest in infants and young children
Military applications
Obtaining blood for laboratory evaluation

Contraindications
Osteoporosis and osteogenesis imperfecta
Fractured bone
Prior use of same bone for IO infusion
Cellulitis or burn overlaying insertion site

Complications

Technical difficulties	*Soft tissue and bony complications*
Over-penetration	Infection
Incomplete penetration	Bony inflammatory reaction
Needle obstruction	Skin sloughing
Fluid extravasation	Compartment syndrome
	Epiphyseal injury
	Fat embolism
	Pain with infusion

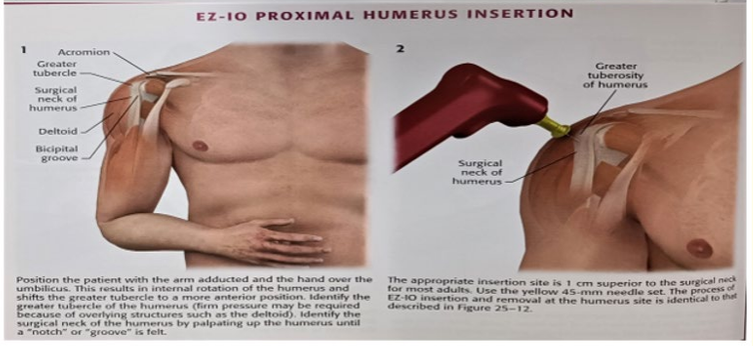
Equipment



Bone Injection Gun

Intraosseous (IO) Insertion Sites

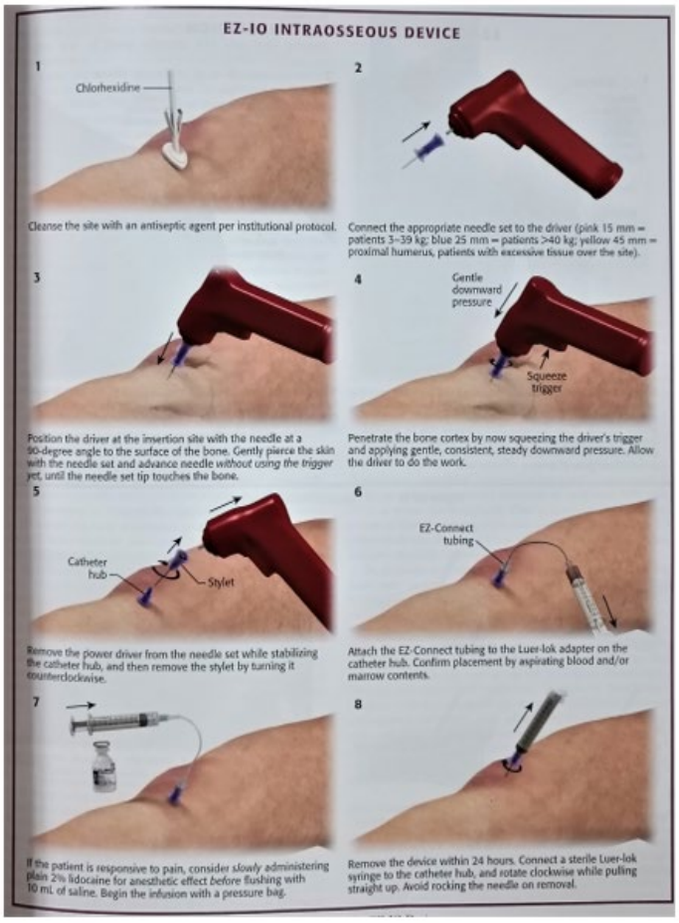
EZ-IO PROXIMAL HUMERUS INSERTION



Position the patient with the arm adducted and the hand over the umbilicus. This results in internal rotation of the humerus and shifts the greater tubercle to a more anterior position. Identify the greater tubercle of the humerus (firm pressure may be required because of overlying structures such as the deltoid). Identify the surgical neck of the humerus by palpating up the humerus until a "notch" or "groove" is felt.

The appropriate insertion site is 1 cm superior to the surgical neck for most adults. Use the yellow 45-mm needle set. The process of EZ-IO insertion and removal at the humerus site is identical to that described in Figure 25–12.


THE BONE INJECTION GUN (BIG)
1
Hold the bottom part of the device firmly, perpendicular to the leg.
2
Squeeze and pull out the safety latch.
3
While holding firmly at the bottom part, press down with the palm of your hand.
4
Pull up the Bone Injection Gun (BIG) slowly.
5
Remove the trocar needle.
6
Secure with the safety latch.
7
Flush with 10–20 mL of normal saline.


EZ-IO INTRAOSSEOUS DEVICE
1
Chlorhexidine
Cleanse the site with an antiseptic agent per institutional protocol.
2
Connect the appropriate needle set to the driver (pink 15 mm = patients 3–39 kg; blue 25 mm = patients >40 kg; yellow 45 mm = proximal humerus, patients with excessive tissue over the site).
3
Position the driver at the insertion site with the needle at a 90-degree angle to the surface of the bone. Gently pierce the skin with the needle set and advance needle without using the trigger yet, until the needle set tip touches the bone.
4
Gentle downward pressure
Squeeze trigger
Penetrate the bone cortex by now squeezing the driver's trigger and applying gentle, consistent, steady downward pressure. Allow the driver to do the work.
5
Catheter hub
Stylet
Remove the power driver from the needle set while stabilizing the catheter hub, and then remove the stylet by turning it counterclockwise.
6
EZ-Connect tubing
Attach the EZ-Connect tubing to the Luer-lok adapter on the catheter hub. Confirm placement by aspirating blood and/or marrow contents.
7
If the patient is responsive to pain, consider slowly administering plain 2% lidocaine for anesthetic effect before flushing with 10 mL of saline. Begin the infusion with a pressure bag.
8
Remove the device within 24 hours. Connect a sterile Luer-lok syringe to the catheter hub, and rotate clockwise while pulling straight up. Avoid rocking the needle on removal.

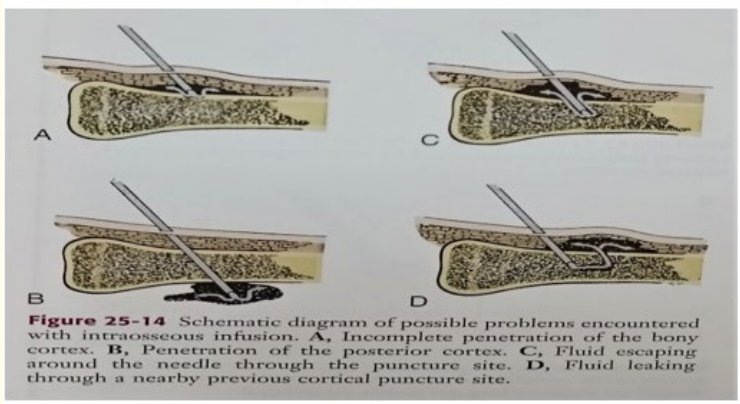


Figure 25-14 Schematic diagram of possible problems encountered with intraosseous infusion. **A,** Incomplete penetration of the bony cortex. **B,** Penetration of the posterior cortex. **C,** Fluid escaping around the needle through the puncture site. **D,** Fluid leaking through a nearby previous cortical puncture site.

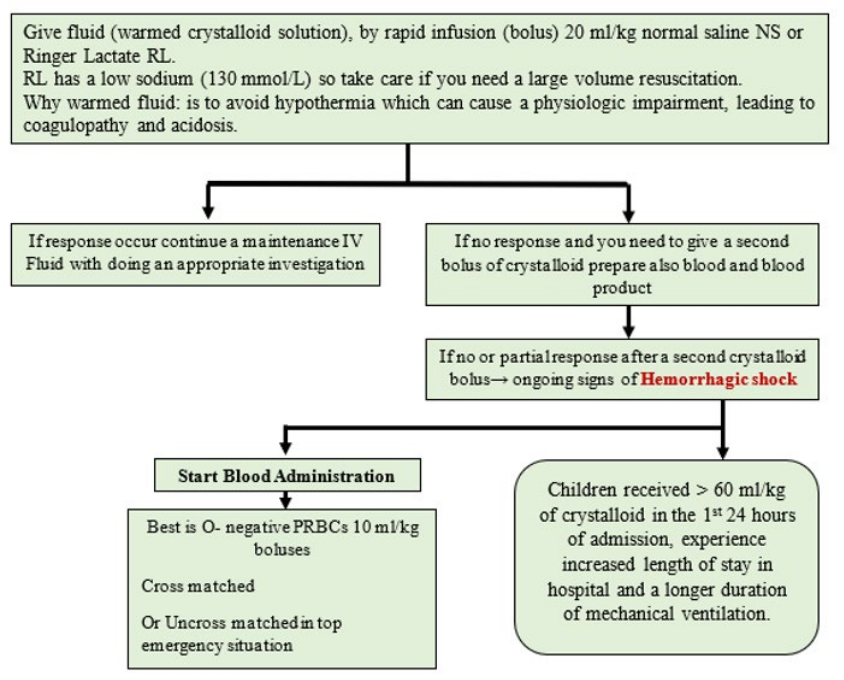


Figure 19

Also:

- Activate a massive transfusion protocol and give PRBCs and FFP with a ratio 1:1.
- Trauma induce coagulopathy.

Note: The top six sites of potential major blood loss after injury include:

1. External scalp laceration
2. Intrathoracic
3. Intra-abdominal
4. Pelvic Injury
5. Extremity
6. Retro peritoneum.

Systemic responses to blood loss in pediatric patients

Mild blood volume loss < 30%:

- CVS: ↑ HR, weak thread pulse, normal S.BP (80 - 90+2x age in year), with normal pulse pressure (S-D).
- CNS: Anxious, irritable, confused.
- Skin: Cool, mottled, prolonged CRT.
- UO: Urine Output: Low to very low.

Low normal infant 2 ml/kg/hr

- Young child 1.5 ml/kg/hr
- Older child 1 ml/kg/hr
- Adolescent 0.5 ml/kg/hr
- "IV contrast can falsely elevate UO".

Moderate blood volume loss 30 - 45%:

- CVS: ↑↑ HR, weak thread pulse, low normal S. BP (70 - 80 + 2x age in year), with narrow pulse pressure S-D < 25% of systolic.
- CNS: Lethargic, with a dull response to pain "↓ response to IV catheter insertion".
- Skin: Cyanotic, ↑↑ CRT.
- UO: Minimal.

Severe blood volume loss > 45%:

- CVS: ↓ HR, absent peripheral pulse, ↓ BP (<70+2x age in year) with undetectable diastolic BP→ very narrow pulse pressure.
- CNS: Comatose.
- Skin: Pale and cold.
- UO: None.

D: Disability

Includes a 2 main components:

1. GCS
2. Pupillary response.

GCS: Three components:

1. Best eye opening
2. Best verbal response
3. Best motor response: which is the best predictor of outcome after injury.

Infant:

Best eye opening:

- 4: Spontaneous
- 3: Open to verbal stimulation
- 2: Open to painful stimulation
- 1: No response

Best verbal response

- 5: Coos and babbles
- 4: Irritable cry
- 3: Cries to pain
- 2: Moans to pain
- 1: No response.

Best motor response

- 6: Spontaneous purposeful movement
- 5: Localizes to pain
- 4: Withdraws to pain
- 3: Flexion “decorticate response”
- 2: Extension “decerebrate response”
- 1: No response.

Children:

Best eye opening:

- 4: Spontaneous
- 3: Open to verbal stimulation
- 2: Open to painful stimulation
- 1: No response.

Best verbal response:

- 5: Oriented “person, place, time, converse”
- 4: Disoriented “confused”
- 3: Inappropriate words
- 2: Incomprehensive words
- 1: No response.

Best motor response:

6: Obeys command

5: Localizes to pain

4: Withdraws to pain

3: Flexion “decortication”

2: Extension “decerebration”

1: No response.

Pupillary assessment

- Pupil size
- Symmetry
- Response to light.

Unilateral, dilated, non-reactive pupil indicates a third nerve dysfunction due to an ipsilateral intracranial hematoma until proven otherwise.

Note 1: A rapid assessment of conscious level known as AVPU:

- A: Alert
- V: Response to voice
- P: Response to pain
- U: Unresponsive to all stimuli

} Immediate interaction is required

Note 2: Neurological assessments are used to plan for:

1. ETT
2. Requirement for additional imaging
3. Final disposition after leaving the emergency department.

Exposure/Environment

To assess this, you need for cloth removal

- Look for the spine with full spine stabilization.
- Take care of hypothermia: cover the patient warm, warm the room, or use an overhead warmer or a Bair Hugger.
- Core temperature check.
- Any skin bruise, petechial or laceration.

Secondary survey

History:

- Focused
- Done while performing a physical examination
- AMPLE acronym
- A: Allergy
- M: Medication
- P: Past medical history
- L: Last meal
- E: Environment/Event: related to injury.

Physical examination:

- Take care for posterior scalp laceration
- Should be modified to include steps to identify common and important injuries (face, chest, abdomen, mouth, ear, back) also perineum, rectum and vagina.
- A more detailed neurological exam.
- Tetanus administration.
- Antibiotic administration.

Tetanus prophylaxis

- Serum antibody titer of ≥ 0.01 unites 1 ml is considered protective.
- Active immunization DTaP 2, 4, 6, 15 - 18 months + poster at 4-6 years and another poster at 11 - 12 year Tdap.
- Then a poster dose every 10 year intervals with Td vaccine.
- d: Reduce diphtheria toxoid.
- A pregnant woman should receive a dose of Tdap vaccine during each pregnancy: preferably at 27 - 36 weeks' gestation.

First: For a clean, minor wounds

History of vaccination	(Tdap, Td) or DTap	TIG
Uncertain or less than 3 doses	Yes	No
3 or more doses	*No	No

Table 1

Note 1*: Become yes if 10 years or longer since the last tetanus toxoid, containing vaccine.

Note 2: TIG in HIV, infected patient should be given regardless of history of tetanus immunization.

Note 3:

- DTap for children < 7 year old.
- Tdap or Td for patients ≥ 7 year old.

Second: All other wounds

Such as:

1. Wounds contaminated with dirt, feces, and saliva'
2. Puncture wounds
3. Avulsions
4. Wounds resulting from missiles
5. Crushing
6. Burns
7. Frostbite.

History of vaccination	(Tdap, Td) or DTap	TIG
Uncertain or less than 3 doses	Yes	Yes
≥ 3 doses (three or more)	°No	No

Table 2

Note 1°: Become yes if 5 year or longer since the last tetanus toxoid containing vaccine.

Missed injuries

- Prevention of this can reduce morbidity during the patient hospital stay.
- The risk of missed injuries is higher in children with a more severe injuries including:
- Those transported by air
- Those who undergo ETT intubation in ED.
- Those with low GCS
- Those with an injury severity score > 15

Pediatric trauma severity score

Score	+2	+1	-1
Size	≥ 20 kg	10-20 kg	< 10 kg
Airway	Normal	Maintainable	Unmaintainable
S. BP	≥ 90 mmHg	50-90 mmHg	< 50 mmHg
CNS	Awake	Obtunded/LOC	Coma/Decerebrate
Open Wound	None	Minor	Major/Penetrating
Skeletal	None	Close Fracture	Open/Multiple Fractures

Table 3

Sum total points: Score ≤ 6 →the child is at increased risk of morbidity and mortality.

Diagnostic assessment

- ABG is the most important laboratory test in an injured child including hemoglobin and electrolyte.
- ± Lactate.

Laboratory studies:

- CBC: Initial Hb, however will not be indicative of acute hemorrhage.
- Screen for most intra-abdominal injuries:
- Screening for major TBI, penetrating trauma, multiple extremity fractures, and significant mechanisms of injury.

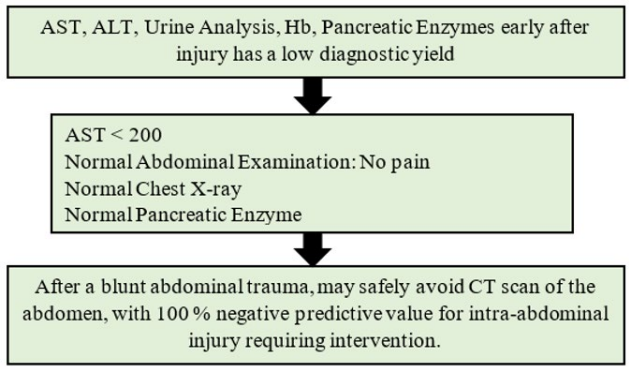


Figure 20

- Expand the laboratory panel to include:
- Coagulation studies: By thromboelastography TEG or Rotational thromboelastometry ROTEM both allow for comprehensive characterization of the coagulation process with point of care availability. Also better than INR for identifying the bleeding risk of the patient.
- Electrolyte: early detection usually normal and serve as baseline.
- Blood for cross matching
- Screening test for alcohol and drug use may be appropriate in older children and adolescent patients.

Radiographic imaging

Cervical spine radiograph

- Are suspected in sustaining a significant head injury or injured by a major or blunt mechanism.
- Clinically you can clear the CS injury without a radiographic imaging these clinical criteria are:
- Patient is alert and oriented.
- No posterior midline cervical tenderness.
- No evidence of intoxication.
- No focal neurological deficit.
- No painful distracting injuries.

CS series are:

- Cross table lateral: the most important one
- AP View
- Open-mouth view: To assess the dens process of C1
- High sensitivity 89%.
- High NPV ≈ 99.9.

Sciwora: A spinal cord injury without radiographic abnormality when there is a neurological deficit in the setting of Normal plain X-ray or Ct scan imaging and necessitating an urgent MRI.

Chest radiograph

No need if clinical examination of the patient is normal and no significant mechanism of injury like a major blunt mechanism.

Pelvic radiograph

No need if the child is alert and have no physical examination finding or a proximity injuries "like proximal femur fracture".

Extremities or other areas radiograph

A recent study demonstrated that using a more restrictive protocol for obtaining CT imaging reduced the number of CT scans obtained in a cohort of trauma patients without increasing missed injuries or mortality.

Pan-CT:

- A more radiation exposure
- A more finding unsuspected injuries requiring treatment also carcinogenic.

CT scan: The most two body regions imaged by CT are:

1. Head
2. Abdomen, pelvis "in Pediatric Trauma".

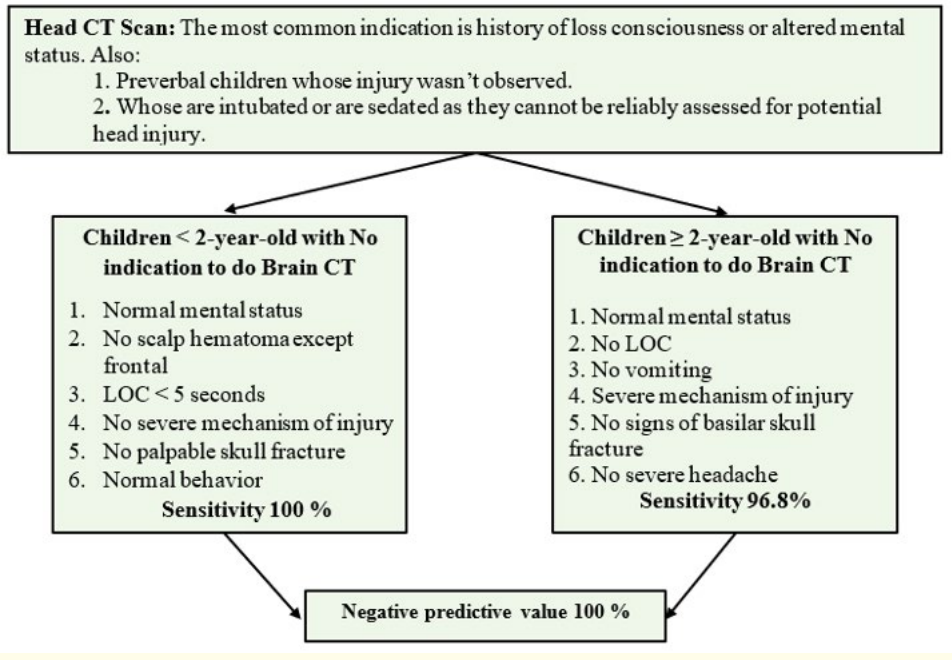


Figure 21

Abdominal pelvic CT scan

Indications:

1. Major abdominal wall ecchymosis.
2. Abdominal tenderness.

FAST "Focused abdominal sonogram for trauma"

Its value in pediatric trauma is less certain, sensitivity 28% and performed better in pediatric requiring interventions with 44% sensitivity.

FAST: Is focused on identifying fluid in 4 areas:

1. Pericardial sac
2. Hepatorenal fossa
3. Splenorenal fossa
4. Pouch of Douglas.

So, the presence of which is suggestive of hemopericardium or intra-abdominal injury.

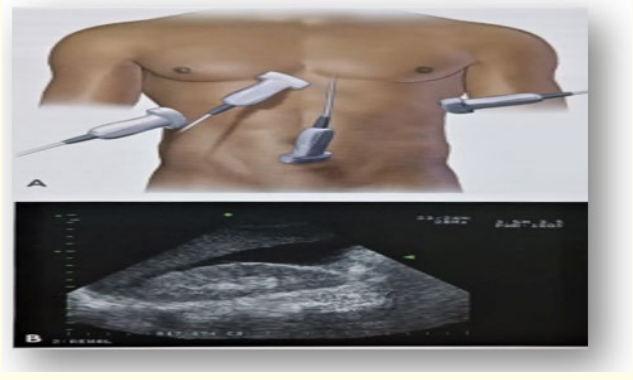


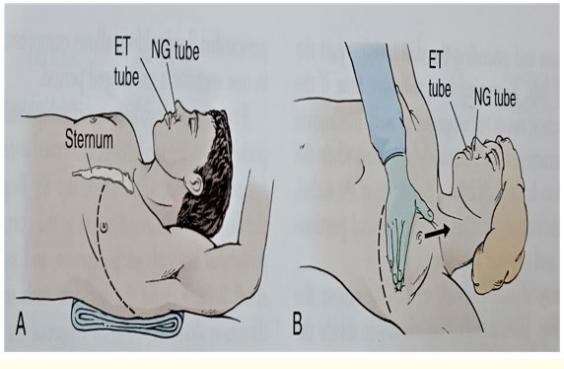
Figure 22

Emergency department thoracotomy

Has a benefit in some patients like:

1. Those who have received a brief period CPR after sustaining a blunt injury or witnessed penetrating injury due to higher potential for identifying injuries that can be treated after thoracotomy.
2. Detectable vital signs and deteriorate despite maximal resuscitation.
3. To be done by surgeon with appropriate training in this technique.

Left lateral thoracotomy



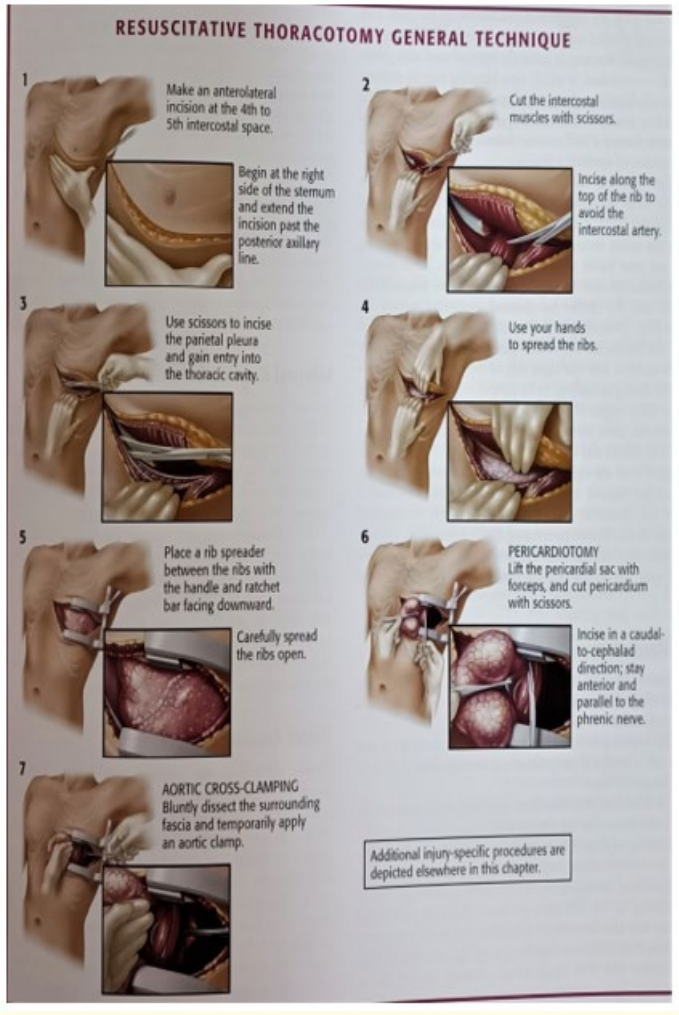


Figure 23

Two-handed method of cardiac massage

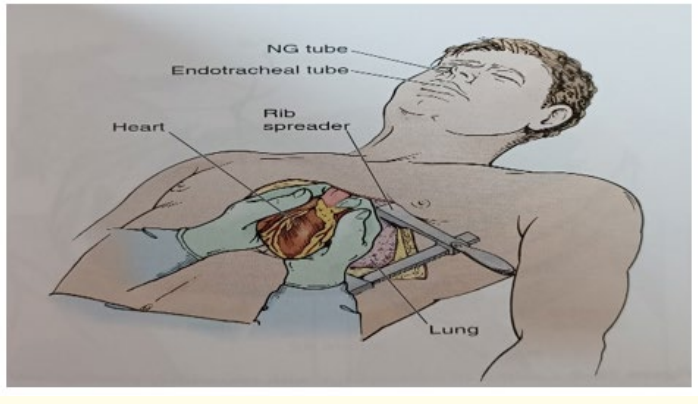


Figure 24

Sauerbruch Maneuver method

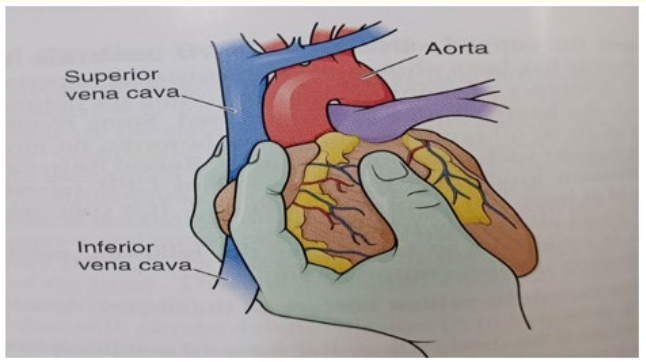


Figure 25

1. Left anterolateral incision: From "L" sternum in the 5th intercostal space to the table.
2. May be extended across the "R" side of chest clamshell incision "if needed".
3. Digital compression to control hemorrhage suture control or clamping of bleeding blood vessels.
4. You can do pericardiotomy.
5. We can do an open cardiac massage.
6. Cross-clamping the descending thoracic aorta will stop blood loss below the diaphragm and allow cardiac filling to maintain cardiac and brain perfusion.
7. Pulmonary hilum can be clamped or manually compressed to control bleeding from the lung and pulmonary vessels.

Stabilization and definitive care

It is important to promptly call the next higher level of care for transfer (If the ER and Pediatric doctor determines from the primary and secondary survey that the child will not be able to be treated at their hospital).

And don't waste time obtaining CT scans or other studies that will not be acted on at the sending facility.

To take a special care to the importance of TBI and not cause a second hit injury to the brain:

- Liberal Cranial CT
- Normothermia
- Euvolemia
- Head of bed elevation to 30°
- Appropriate Sedation
- Mechanical ventilation as needed to maintain a normal oxygenation and ventilation.
- Normoglycemia
- Bolus hypertonic saline NaCl 3% 5 ml/kg in patient with ↑ICP to keep it below 20 mmHg.
- Keep CPP > 40 mmHg
- Barbiturate Coma, if indicated
- Decompressive Craniotomy, if indicated.

Some important notes

Note one

Weight estimation

Newborn 3-12 months = $\frac{\text{age in month} + 9}{2}$

After that = (age in year x 2) + 8 (from 1-6 years)

= $\frac{(\text{age} \times 7) - 5}{2}$ (from 7-12 years)

Height estimation

At birth 50 cm

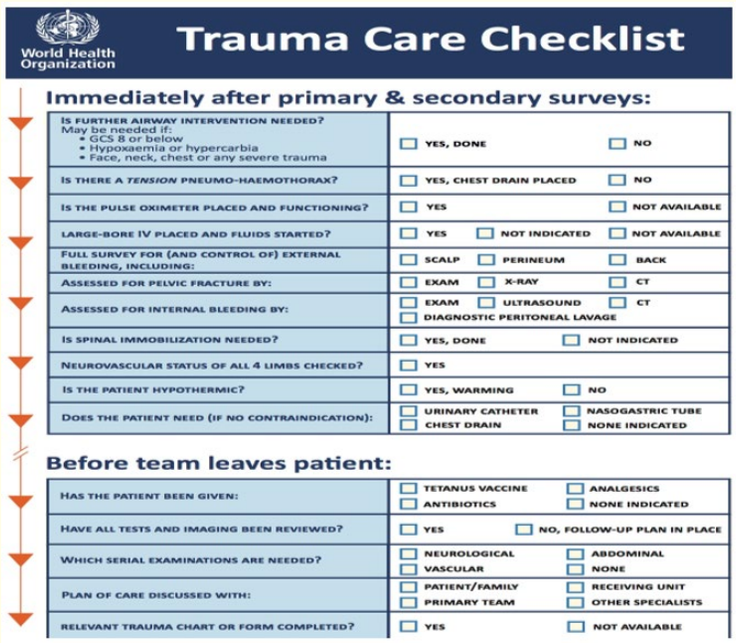
One year 75 cm

(2-12 year)=[age x 6] + 77

Note two

The most common mistakes when managing multisystem trauma

1. Not working as a team.
2. No checklist in order not to miss any step in patient estimation and management primary survey, secondary survey, laboratory, radiology…
3. Failure to avoid hypothermia.
4. Failure to treat hemorrhage and stop bleeding.
5. Missed diagnosis of important injuries intra-abdominal, intracranial, spinal…



World Health Organization

Trauma Care Checklist

Immediately after primary & secondary surveys:

Is further airway intervention needed? May be needed if: • GCS 8 or below • Hypoxaemia or hypercarbia • Face, neck, chest or any severe trauma	☐ YES, DONE ☐ NO
Is there a *tension* pneumo-haemothorax?	☐ YES, CHEST DRAIN PLACED ☐ NO
Is the pulse oximeter placed and functioning?	☐ YES ☐ NOT AVAILABLE
Large-bore IV placed and fluids started?	☐ YES ☐ NOT INDICATED ☐ NOT AVAILABLE
Full survey for (and control of) external bleeding, including:	☐ SCALP ☐ PERINEUM ☐ BACK
Assessed for pelvic fracture by:	☐ EXAM ☐ X-RAY ☐ CT
Assessed for internal bleeding by:	☐ EXAM ☐ ULTRASOUND ☐ CT ☐ DIAGNOSTIC PERITONEAL LAVAGE
Is spinal immobilization needed?	☐ YES, DONE ☐ NOT INDICATED
Neurovascular status of all 4 limbs checked?	☐ YES
Is the patient hypothermic?	☐ YES, WARMING ☐ NO
Does the patient need (if no contraindication):	☐ URINARY CATHETER ☐ NASOGASTRIC TUBE ☐ CHEST DRAIN ☐ NONE INDICATED

Before team leaves patient:

Has the patient been given:	☐ TETANUS VACCINE ☐ ANALGESICS ☐ ANTIBIOTICS ☐ NONE INDICATED
Have all tests and imaging been reviewed?	☐ YES ☐ NO, FOLLOW-UP PLAN IN PLACE
Which serial examinations are needed?	☐ NEUROLOGICAL ☐ ABDOMINAL ☐ VASCULAR ☐ NONE
Plan of care discussed with:	☐ PATIENT/FAMILY ☐ RECEIVING UNIT ☐ PRIMARY TEAM ☐ OTHER SPECIALISTS
Relevant trauma chart or form completed?	☐ YES ☐ NOT AVAILABLE

Figure 26

Conclusion

Multidisciplinary team work is the best for caring a trauma patient, started from pre hospital setting to discharge [1-5].

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