The DOPE Roadmap: Stabilizing the Pediatric Trauma Airway and Beyond

Chris Prince, RRT-NPS

Disclosure

I do not have any conflicts of interest or financial relationships related to the content of this presentation.

Objectives

01 Apply the Pediatric Assessment Triangle and Primary Survey when assessing the pediatric patient.

02 Review differences in pediatric airway, thorax differences. Discuss cranial anatomy change trauma and the respiratory management plan.

03 Compare the indications for us of HFNC, NIV, and invasive mechanical ventilation in PARDS. Along with escalation pathways.

04 Apply the use of oxygenation classification in PARDS: OI, OSI, P/F, and S/F.

05 Discuss mechanical ventilation, including lung protection strategy. And use DOPE when the child suddenly deteriorates.

Maya, Pediatric MVA

Who	6 years old, 22 kg, back seat, restrained. T-boned at an intersection 20 minutes ago.
Now	Crying, then became sleepy. Blood at the mouth. Scalp laceration still bleeding through gauze. Open femur fracture.
Vitals	HR 146, BP 78/46, RR 36, SpO2 88% on a nonrebreather. GCS 9. Right pupil larger than the left.
Chest	Decreased sounds on the right. Trachea still midline. C-spine collar in place.
Ask	What do you do in the first minute?

Pediatric Assessment Triangle, then ABCDE

Appearance

Tone, interactiveness, consolability, gaze, cry. This is brain perfusion.

Work of breathing

Grunt, wheeze, stridor, tachypnea, retractions, nasal flaring.

Circulation to skin

Pallor, mottling, cyanosis. Shock can be present before the pressure falls.

Primary survey

A Airway: C-spine. Clear blood and vomit.

B Chest rise, breath-sound equality, rate, SpO2. Look for tension physiology.

C Central and peripheral pulses, capillary refill, skin, blood pressure.

D GCS, pupils, glucose. Airway decision often lives here.

E Exposure. Hypothermia worsens coagulopathy and ventilation.

Hypoxia and hypercarbia drive secondary injury

Respiratory priority

- Hypoxemia starves already injured brain and myocardium.
- Hypercarbia dilates cerebral vessels, raises blood flow and ICP, worsening acidosis.
- Together they extend the contusion and are a common path to secondary cardiac arrest.

Golden Hour

- The first 60 minutes from injury to surgical or critical-care stabilization. A delayed airway, or uncorrected hypoxemia and hypoventilation, raises mortality through secondary brain injury and shock.

Stop the Bleed

A child has about 80 mL/kg of blood. A scalp wound, an open fracture, or a junctional bleed can be life threatening before the pressure falls. Control compressible bleeding before the airway drugs.

Direct pressure

Gloved hands, then a firm dressing. Hold continuous pressure. Peeking restarts the bleed.

Pack the wound

Deep junctional or extremity wounds that pressure does not stop: pack gauze to the bleeding source, then press. Hemostatic gauze if it is on the cart.

Tourniquet the limb

Life-threatening arm or leg bleeding. Two to three inches above the wound, not over a joint. Tighten until bleeding stops and the distal pulse is gone. Write the time on the device.

Pediatric fit

A commercial windlass tourniquet may not occlude a very small limb. Apply a second one side by side if the first fails. Do not take it down until surgical control is ready.

The scalp is still bleeding. The femur is open.

1. Which injury gets treated first and with what?
2. Her pressure is 78/46. Is a 20 mL/kg crystalloid bolus the next move, or blood?
3. Who calls the tourniquet time out loud, and when is it allowed to come off?

Pediatric airway differences

Feature	Child	What you do
Occiput	Large, positioning is important for airway patency.	Shoulder roll in infants; neutral if C-spine is not clear
Tongue	Large relative to the mouth	Jaw thrust, suction, consider a straight blade
Larynx	Higher and more anterior	Video laryngoscopy recommended first
Epiglottis	Floppy and omega shaped	Lift it with a Miller blade when the view fails
Subglottic	Cricoid ring, prone to edema	Cuffed tube, cuff pressure 20–25 cm H2O, avoid traumatic passes
Trachea	Short	Depth about 3 × internal diameter ETT at the lip; recheck after every move

Thoracic and cranial differences

Pliable chest wall

Cartilage absorbs energy and passes it into the lung. Severe contusion is common without rib fractures. No fracture does not mean no lung injury.

Mobile mediastinum

Tension pneumothorax shifts the mediastinum early and collapses venous return. Cardiovascular collapse can precede a dramatic tracheal deviation.

High head-to-body mass

Thin cranial vault and a heavy head raise the risk of acceleration injury and TBI. Hypoxia and hypotension are the secondary insults you can still prevent.

Oxygen reserve

High metabolic rates and a small FRC. Apnea time is seconds, shorter still in shock, anemia, and contusion.

Intubation Preparation

Cuffed ETT

(age ÷ 4) + 3.5. Always used cuffed ETT.

Lip depth

3 × internal diameter

SGA

Weight-based i-gel or LMA

Drugs

Ketamine 1–2 mg/kg in shock. Rocuronium 1.2 mg/kg if succinylcholine is unsafe.

Intubate now if

Apnea, or obstruction not fixed by position and suction

GCS ≤ 8 without a protected airway

Refractory hypoxemia or worsening inhalation injury

Cannot oxygenate on NIV, or the face will not take a mask

Failed airway: one good video look, then SGA

No nasal route in facial trauma.

SpO2 is 88%. GCS is 9. Blood is in the mouth.

1 Does she get HFNC, NIV, or a tube right now? What makes NIV the wrong interface?

2 How do you hold the neck — and what does manual inline stabilization prevent?

3 Name the tube size, the lip depth, and what is already out of the package if the look fails.

Create Contingency Plan for Airway Placement

Plan A

Best look

Video laryngoscope, sized cuffed tube, bougie. One deliberate change of blade or operator.

Plan B

Oxygenate

Two-hand mask and an oral airway. If that fails, use SGA. Do not keep looking while SpO2 falls.

Plan C

Bridge

If the SGA allows oxygenates continue to use. Should only be used for 4 hours. Call anesthesia for airway exchange.

Plan D

Neck

Cannot intubate, cannot oxygenate. Needle cricothyroidotomy in small children. Open surgical cricothyroidotomy once size and skill allow, often the older child.

TABLE 4.

Diagnosis of Pediatric Acute Respiratory Distress Syndrome (Definition Statement 1.1; Definition Statement 1.7.1)

Age (DS 1.1)	Exclude patients with perinatal lung disease		
Timing (DS 1.2)	Within 7 d of known clinical insult		
Origin of edema (DS 1.3)	Not fully explained by cardiac failure or fluid overload		
Chest imaging (DS 1.3)	New opacities (unilateral or bilateral) consistent with acute pulmonary parenchymal disease and which are not due primarily to atelectasis or pleural effusion[a]		
Oxygenation[b] (DS 1.4.1)	IMV: OI ≥ 4 or OSI ≥ 5 NIV[c]: $Pao_2/Fio_2 \leq 300$ or $Spo_2/Fio_2 \leq 250$ **Stratification of PARDS severity:** Apply ≥ 4 hr after initial diagnosis of PARDS (DS 1.4.4)		
	IMV-PARDS: (DS 1.4.1)	Mild/moderate: OI < 16 or OSI < 12 (DS 1.4.5)	Severe: OI ≥ 16 or OSI ≥ 12 (DS 1.4.5)
	NIV-PARDS[c] (DS 1.4.2; DS 1.4.3)	Mild/moderate NIV-PARDS: $Pao_2/Fio_2 > 100$ or $Spo_2/Fio_2 > 150$	Severe NIV-PARDS: $Pao_2/Fio_2 \leq 100$ or $Spo_2/Fio_2 \leq 150$
	Special populations[d]		
Cyanotic heart disease (DS 1.6.1; DS 1.6.2)	Above criteria, with acute deterioration in oxygenation not explained by cardiac disease		
Chronic lung disease (DS 1.6.3; DS 1.6.4)	Above criteria, with acute deterioration in oxygenation from baseline		

DS = definition statement, IMV = invasive mechanical ventilation, NIV = noninvasive ventilation, OI = oxygenation index, OSI = oxygenation saturation index, PARDS = pediatric acute respiratory distress syndrome, Spo_2 = pulse oximeter oxygen saturation.

Oxygenation Classification

Grade at least 4 hours after stabilization, not during a transient desaturation.
SpO2 metrics need SpO2 88-97%.

Support	Metric	Mild / moderate	Severe
Invasive	OI = FiO2 × MAP × 100 / PaO2	4 to < 16	≥ 16
Invasive	OSI = FiO2 × MAP × 100 / SpO2	5 to < 12	≥ 12
NIV	PaO2/FiO2 or SpO2/FiO2	> 100 or > 150	≤ 100 or ≤ 150
HFNC	Same ratios, on high flow	Possible PARDS	Not NIV-PARDS

TABLE 5.

Diagnosis of Possible Pediatric Acute Respiratory Distress Syndrome and At-Risk for Pediatric Acute Respiratory Distress Syndrome (Definition Statement 1.5.3; Definition Statement 1.7.2; Definition Statement 11.2)

Age	Exclude patients with perinatal lung disease
Timing	Within 7 d of known clinical insult
Origin of edema	Not fully explained by cardiac failure or fluid overload
Chest imaging (DS 1.5.2)	New opacities (unilateral or bilateral) consistent with acute pulmonary parenchymal disease and which are not due primarily to atelectasis or effusion[a]
Oxygenation[b] threshold to diagnose possible PARDS for children on nasal respiratory support[c] (DS 1.5.1)	
	Nasal continuous airway positive pressure/bilevel positive airway pressure or high-flow nasal cannula (≥ 1.5 L/kg/min or ≥ 30 L/min): $Pao_2/Fio_2 \leq 300$ or $Spo_2/Fio_2 \leq 250$
Oxygenation[b] threshold to diagnose at-risk for PARDS	
	Any interface: Oxygen supplementation[d] to maintain $Spo_2 \geq 88\%$ but not meeting definition for PARDS or possible PARDS
Special populations	
Cyanotic heart disease	Above criteria, with acute deterioration in oxygenation not explained by cardiac disease
Chronic lung disease	Above criteria, with acute deterioration in oxygenation from baseline

DS = definition statement, PARDS = pediatric acute respiratory distress syndrome, Spo_2 = pulse oximeter oxygen saturation.
[a]Children in resource-limited environments where imaging is not available who otherwise meet possible PARDS criteria are considered to have possible PARDS.

At Risk for PARDS

- Patients requiring supplemental oxygen to maintain SpO2 ≥ 88% exceeding specific flow/FiO2 thresholds without meeting PARDS criteria:
  - > 2 L/min (< 1 yr)
  - ≥ 4 L/min (1-5 yr)
  - ≥ 6 L/min (6-10 yr)
  - ≥ 8 L/min (> 10 yr)

High-flow nasal cannula in trauma

PaO2/FiO2 ≤ 300 or SpO2/FiO2 ≤ 250 on ≥ 1.5 L/kg/min or ≥ 30 L/min.

Reasonable use

Mild hypoxemia with increased work of breathing

Isolated mild contusion or chest-wall pain, airway protected

Titrate flow then FiO2

Post-extubation bridge if the face allows it

Do not use

Shock or hemodynamic instability

GCS < 8 or a tiring child

Apnea, vomiting, or high aspiration risk

Facial trauma, burns, or fixed obstruction

Severe hypoxemia or rising CO2

CPAP and bi-level NIV: TIME LIMITED TRIAL

Who's indicated

- Cooperative child, protected airway, mild to moderate failure. Useful to recruit contused lung. Full-face interface. Sedation only if it improves synchrony without losing the airway.

Starting point

- CPAP 5–8 cm H2O, or bi-level with PEEP 5–8 and a pressure support that moves the chest. Backup rate on. Watch the mask leak and the stomach.

Stop using

- No improvement in work of breathing, rate, or SpO2/FiO2 within about 1–2 hours in the ED.
- **Max 6-hour** rule is an ICU ceiling, not for ER.

Never use

- Active facial trauma, severe burns, fixed upper-airway obstruction, shock, vomiting. Severe NIV-PARDS: PaO2/FiO2 ≤ 100 or SpO2/FiO2 ≤ 150 → intubate.

X-Ray Findings

Cor

Most important occult lung injury. Hypoxemia can worsen over 24–48 h. Analgesia, lung-protective support,

Ten

nd

Her

Air

Maya gets intubated, suddenly her right chest is silent and BP falls

D

Displacement

Lip mark changed, ETCO2 gone or squared off, sounds unequal. Look with the laryngoscope before you assume the lung.

O

Obstruction

Blood, vomit, kink, bite. Suction through the tube with a measured catheter. Do not instill saline as a routine.

P

Pneumothorax

Especially after positive pressure in chest trauma. Unilateral sounds, rising peak pressure, falling pressure. Decompress.

E

Equipment

Disconnect, failed oxygen supply, cuff leak, vent circuit, exhausted battery. Bag the child with the tube still in while you find it.

Lung Protective Ventilation

Target	Guideline	Why it matters
Tidal volume	6–8 mL/kg IBW; 4–6 if pressures climb	Volutrauma. Use ideal, not actual, weight.
Plateau pressure	≤ 28 cm H2O; ≤ 32 if the chest wall is stiff or restrictive anatomy	Overdistention. Contused lung is not uniform.
Driving pressure	Limit to ≤ 15 cm H2O (Pplat − PEEP)	Reduces strain injury risk.
PEEP	At or above the lower ARDSNet PEEP/FiO2 table	Protect FRC. Do not let the lung derecruit between turns and suction.
SpO2	93–97% in mild–moderate; never chase 100%	Avoid < 88% and > 97%. Severe PARDS may accept < 92% after PEEP is optimized.
CO2	Permissive hypercapnia to pH 7.20 if needed	Not in uncontrolled TBI. No routine bicarbonate.

Executive Summary of the Second International Guidelines for the Diagnosis and Management of Pediatric Acute Respiratory Distress Syndrome (PALICC-2)

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

https://www.ardsnet.org/files/ventilator_protocol_2008-07.pdf

Initial ventilator Setup

Mode	Volume-targeted with a pressure limit, or pressure control if the leak is large. Either is fine if the targets are met.
Volume and rate	6–8 mL/kg IBW. Infant 25–30, toddler 20–25, child 16–20, teen 12–16, correlate ETCO2.
Pressures	PEEP 5 to start; 8–10 if contused and hypoxic. Set tight pressure limit alarms. Check plateau.
Oxygen	FiO2 1.0 for intubation, then wean to SpO2 93–97%.
Time	Inspiratory time by age, I:E near 1:2 or 1:3. Longer I-time only if hypoxia persists after PEEP.
Ongoing Care	Cuff 20–25 cm H2O, gastric decompression, sedation, lip depth written down, CXR.

Cranial Injury: $PaCO_2$ and $EtCO_2$

Carbon dioxide is a potent cerebral vasodilator. $PaCO_2$ directly changes cerebral blood flow and intracranial pressure. The target is normocarbia, not a lower number.

Do not hyperventilate routinely

- $PaCO_2$ below 30 mm Hg was once used to lower ICP.
- Severe hypocapnia constricts cerebral vessels, causes focal ischemia, and worsens neurologic outcome.
- Prophylactic hyperventilation is a pitfall, not a plan.

Maintain normal $PaCO_2$

- Keep $PaCO_2$ 35–45 mm Hg.
- Transient hyperventilation is only a bridge for active herniation: blown pupil, posturing, or sudden neurologic collapse. ***Only until the next intervention***.

$EtCO_2$ is mandatory

- Waveform capnography for every intubated pediatric patient.
- Pulmonary contusion widens the $PaCO_2$–$EtCO_2$ gap, so $EtCO_2$ can read falsely low.
- Check an arterial gas before you trust the capnograph alone.

What you change on the ventilator

- Rate and tidal volume are the CO_2 controllers.
- Fix hypoxia and hypotension first.
- If $EtCO_2$ falls after a contusion, get a gas before you drop the minute ventilation.
- Monitor the $PaCO_2$-$ETCO_2$ gradient.

Troubleshooting checklist

A rising PaCO2–EtCO2 gap is not one problem.

Gap + hypotension

Dead space. Pulmonary blood flow is down, ETCO2 reads much lower than PaCO2. Treat the shock before you chase the ventilator.

Gap + a small baby

Mechanical dead space. Remove filters and adapters that increase dead space. Ask what the tidal volume actually is?

High CO2 + white-out film

Shunt. Alveoli are perfused and not ventilated. Recruit with PEEP, optimize position. Adjusting RR is not always the answer.

Sudden change

DOPE first. Displaced tube, obstruction, pneumothorax, equipment failure.

The pupil is still larger on the right. EtCO2 reads 28.

1. Do you leave the rate where it is because the capnograph looks helpful?

2. What PaCO2 do you want, and when is hyperventilation actually allowed?

3. She has a contusion. Why might an EtCO2 of 28 not mean a PaCO2 of 28?

Her S/F is falling and her OSI is becoming severe

	Just after the tube	Now, still hypoxic
FiO2 / SpO2 / MAP	**0.50 / 96% / 11**	**0.80 / 91% / 14**
S/F ratio	192 · moderate	114 · severe
OSI	5.7 · mild/moderate	12 · severe
Ventilator	VT 150 mL, PEEP 5, rate 20	Same settings. FiO2 was the only change.

SpO2 is under 97%, so both ratios are usable. Score the steady value, not a brief desaturation

What caused the change? Tube, the chest, or the lung

What change can we make? Raise PEEP before more FiO2. At FiO2 0.80 the lower PEEP/FiO2 table is about 12–14.

What are my volumes and pressures? VT 6 mL/kg (about 130 mL), lower if plateau exceeds 28. Driving pressure ≤ 15. Recheck S/F and OSI after the change.

Different plans for different injuries

Facial blood	Suction to ensure patient airway, video laryngoscopy, early SGA. No nasal tube or nasal airway if midface or basilar skull injury is possible.
Inhalation injury	Stridor, soot, enclosed space. Intubate early with a smaller tube. Edema progresses. Do not cut the tube so short it cannot be secured after swelling.
TBI	No hypoxia, no hypotension. $PaCO_2$ 35–45 mm Hg. Hyperventilate only for active herniation, and only as a bridge. $EtCO_2$ will not correlate with $PaCO_2$ if the lung is contused or low perfusion.
Neck hematoma	Voice change is a threatened airway. Most experienced operator. Ensure surgical airway kit present.
Foreign body	If they are moving air, keep spontaneous breathing. Do not paralyze a partial tracheal obstruction until you can see and retrieve foreign body.

What to take back to the next activation

01

Assess before you treat

PAT from the doorway. ABCDE with C-spine control. Hypoxia and hypercarbia are the emergencies

02

Match support to the airway

HFNC and NIV only if the airway is protected and the face will take the interface. Severe scores from oxygenation classification means intubate.

03

Know your chest injuries

Contusion hides. Tension physiology does not wait for imaging. Positive pressure can create the emergency.

04

Ventilate gently

6–8 mL/kg, plateau ≤ 28, driving pressure ≤ 15, SpO2 not 93-97%.

05

Maya on the next activation

Stop the Bleed, oxygenate, decompress, then ventilate to a PaCO2 of 35–45. If they crash remember DOPE.

NIV pathway

1 Is it indicated?

- Protected airway
- Mild–moderate WOB
- No: shock, GCS < 8, apnea, vomit, or face trauma

2 Interface

- Leak > 40%: full or
- total face mask
- Leak < 40%: nasal mask

3 Device

- Servo-U, NIV mode
- Under 5 kg: CPAP 5–8
- Others: PS, PEEP 5,
- PS 5–7 above PEEP

4 Initial targets

- SpO2 93–97%.
- Step PS by 2 cm H2O
- VT 6–10 mL/kg
- PEEP max 8

Then watch the ratios.

5 What qualifies as NIV-PARDS

- Full face mask and PEEP ≥ 5. P/F ≤ 300 or S/F ≤ 250
- SpO2 must be ≤ 97% to trust S/F
- Not PARDS if respiratory distress caused by bronchospasm
- HFNC is not this pathway

6 Oxygenation Severity Stratification

- Mild–moderate: P/F > 100 or S/F > 150
- Severe: P/F ≤ 100 or S/F ≤ 150
- Recheck on a steady SpO2, not a brief dip

Trial time: ED: 1-2 hours ICU: Max 6 hours.

Stay and adjust

Better rate, work of breathing, and S/F. Keep the trial. ED max time is 1–2 hours of no improvement.

Intubate

Severe ratio, apnea, shock, vomiting, or rising CO2 now. No improvement in 1–2 hours. Six hours is used for ICU, not ED.

Invasive pathway

1 Start

- Cuffed tube, ETCO2.
- VT 6–8 mL/kg IBW.
- PEEP 5. FiO2 100%. Wean SpO2 92-97%
- I:E 1:2 to 1:3
- RR: <4 kg: 24-40; 4-10 kg: 24-30;
- 10-40 kg: 15-25

2 Score at 4 hours

- OI = FiO2 × MAP × 100 / PaO2.
- OSI uses SpO2.
- SpO2 must be ≤ 97%.
- Do not using during desaturation.

3 Oxygenation

- Mild/moderate:
  - OI 4 to < 16,
  - OSI 5 to < 12.
- Severe:
  - OI ≥ 16
  - OSI ≥ 12.

4 Pressure Monitoring

- Pplat ≤ 28, or ≤ 32 if the chest wall is stiff.
- Driving pressure ≤ 15.
- VT down to 4–6 if needed.

If FiO2 will not wean, raise PEEP before more oxygen.

5

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

SpO2 goal

- 92–97% if mild or moderate. Avoid under 88 and over 97.
- Severe disease may accept under 92 only after PEEP is optimized.

Stay lung protective

- OI or OSI still mild/moderate and SpO2 is in range.
- Recheck the ratio after each PEEP change, and stable SpO2 & FIO2.

Severe — escalate, do not just turn FiO2

- PEEP at the table, VT 4–6, pH to 7.20 if no TBI. Prone & sedation.
- Hyperventilate only for herniation.

REGIONAL GENERAL HOSPITAL - DISCHARGE
Discharge Complete
EXIT
HFNC System
TAHOE FLORA
TAHOE FLORA
Discharge Certificate
DISCHARGE
SpO2 98
HR 110
GET WELL SOON