# Airway Assessment and Management in the Trauma Patient

Advanced Trauma Life Support (ATLS)

# Global Burden of Injuries and Violence

**4.4M**
Injury deaths per year (about 8% of all deaths)

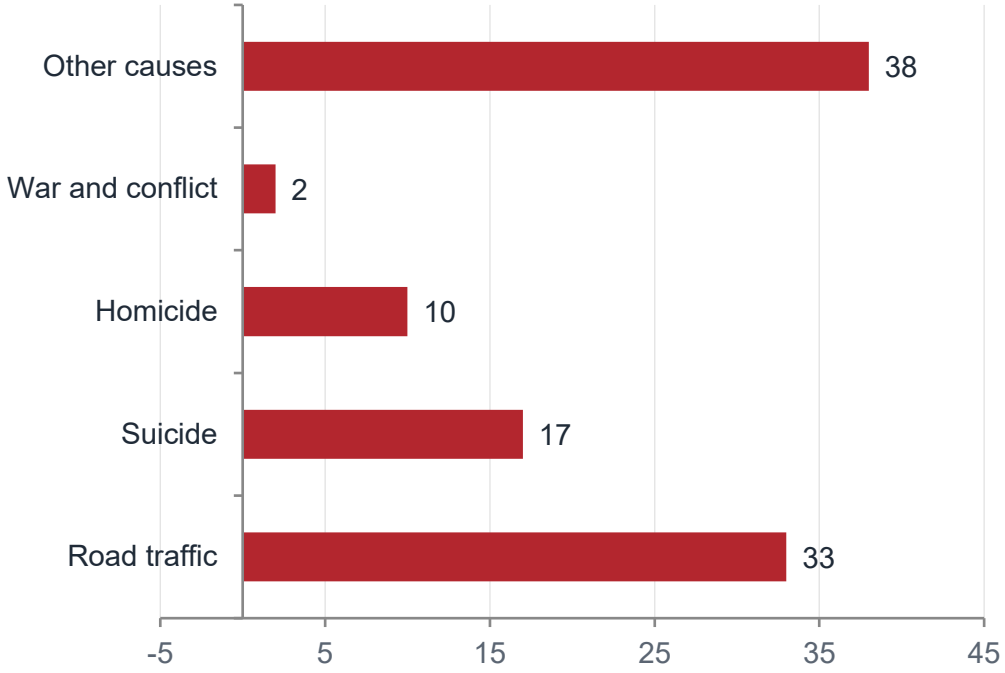
**3.16M**
Unintentional injury deaths per year

**1.25M**
Violence-related deaths per year

- About 90% of injury deaths occur in low- and middle-income countries
- Twice as many males as females die from injuries and violence
- For ages 5–29, 3 of the top 5 causes of death are injury-related: road traffic, homicide and suicide
- Falls cause over 684,000 deaths each year

Source: WHO, Injuries and violence fact sheet (2019 data; updated 2024)

# Share of Injury Deaths by Cause




- About 1 in 3 deaths: road traffic crashes
- 1 in 6: suicide
- 1 in 10: homicide
- 1 in 61: war and conflict
- Shares are approximate, derived from WHO fractions; "Other" includes falls, drowning, burns and poisoning

Source: WHO, Injuries and violence fact sheet

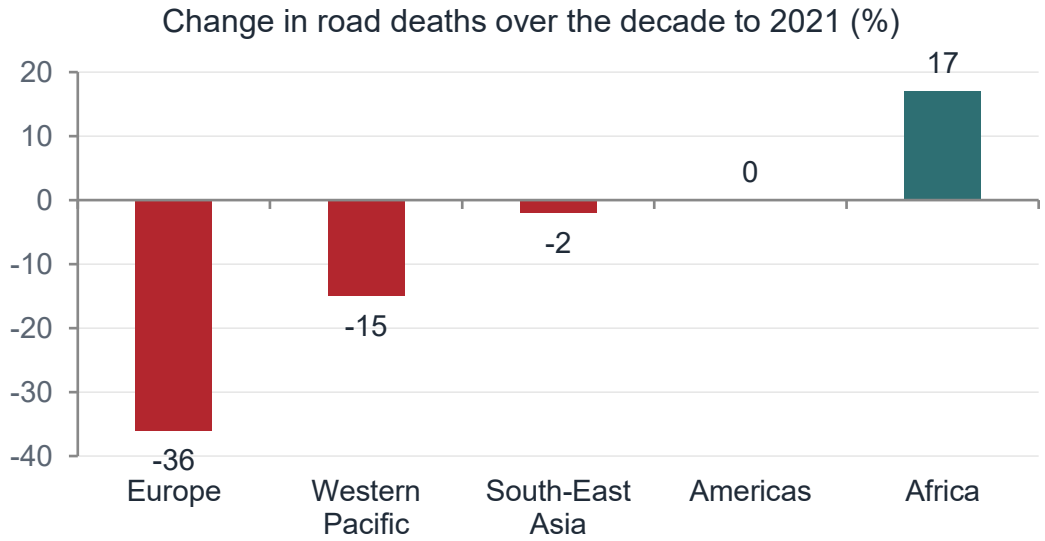
# Road Traffic Crashes: The Largest Single Cause

**1.16M**

Deaths per year (2025 data)

**20–50M**

Non-fatal injuries, many with disability




92% of deaths occur in low- and middle-income countries; over half of victims are pedestrians, cyclists or motorcyclists; road crashes are the leading cause of death at ages 5–29.

Source: WHO Road traffic injuries fact sheet (20 July 2026); WHO news release, July 2026

# Head Trauma (Traumatic Brain Injury)

**69M**
New cases worldwide per year (estimate)

**939**
Cases per 100,000 people

**~89%**
Of cases in low- and middle-income countries

- Mild TBI: about 740 and severe TBI: about 73 cases per 100,000
- Largest burden in South-East Asia and Western Pacific; highest recorded incidence in North America and Europe (better data quality)
- Main causes: road crashes in young people, falls in older adults, violence and sports
- WHO EMRO's Regional Director cited the same 69 million figure at WHA79 in 2026

Sources: Dewan et al., J Neurosurg 2018; WHO-EMRO Regional Director remarks, WHA79, May 2026

# Head and Facial Trauma and Mortality

## Head and brain

- TBI is the leading cause of trauma death and disability under age 40
- A safe helmet cuts the risk of death more than 6-fold and brain injury by up to 74%

## Face and jaw

- Up to about 15% of trauma patients in emergency departments have facial injuries (2025 review)
- Road crashes are the top cause, followed by violence and falls

WHO has not published a separate global mortality figure for facial trauma or fractures; deaths in these injuries mostly relate to associated head injury, airway compromise and bleeding. Facial figures come from scientific reviews, not WHO.

Sources: WHO Road traffic injuries; Maniaci et al., Medicina 2025; Dewan et al. 2018

# Conclusions and Prevention

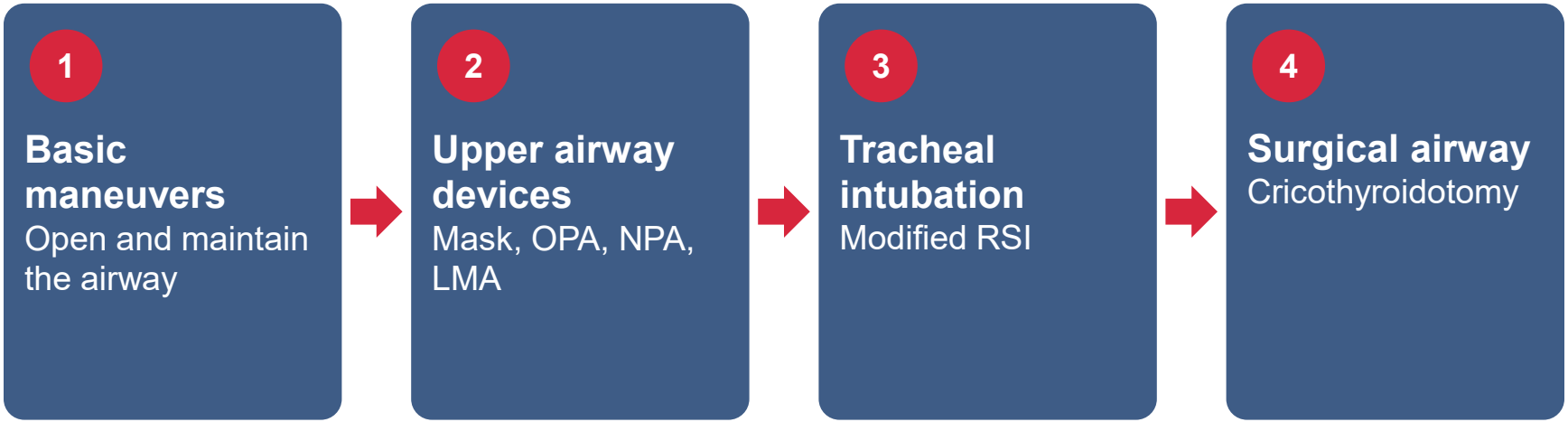
- Injuries cause 4.4 million deaths a year, with road crashes the largest share
- Head trauma is the most common and disabling injury: 69 million cases a year
- Helmets, seat belts, speed control and fast post-crash care are the most effective measures
- Data on facial trauma are weak and need standardized registration

Sources: WHO Injuries and violence (2024); WHO Road traffic injuries (2026); Dewan 2018; Maniaci 2025

# Learning Objectives

1. Describe the critical role of airway management and adequate oxygenation
2. Explain indications for techniques from basic maneuvers to advanced procedures
3. Apply an individualized, context-based approach (patient, team, environment)
4. Anticipate and manage complications, including failed intubation
5. Apply safe-airway principles: monitoring, planning, cognitive aids
6. Adapt techniques for pediatric, obstetric, and larger patients
7. Explain management of airway injuries and burns
8. Develop team-based approaches to airway management

# The Spectrum of Airway Interventions




Not every patient needs intubation; adequate oxygenation is the primary goal. Preoxygenation, apneic oxygenation, and confirmation of tube placement are critical components of RSI.

# Why Airway Management Matters

**8-15%**

of potentially preventable trauma deaths are due to airway management failure

**2011**

UK audit: catastrophic complications occur even among specialists

**2021**

INTUBE study: cardiovascular instability was common

An intervention can turn a partial obstruction into a complete one. Training and adherence to protocols prevent many of these complications.

# Individualized, Context-Based Approach

1

**Patient and injury**
Presenting injuries, airway anatomy, and physiology

2

**Team**
Expertise, experience, and training of the ATLS clinician and team

3

**Environment**
Equipment, human resources, and access to specialist help

For airway injuries or burns, early consultation with a specialist surgeon or critical care physician is important.

# Airway Anatomy and Physiology

1

**Oxygenation**
Top priority; permanent injury within minutes

2

**Ventilation**
CO2 removal; tolerance falls in TBI

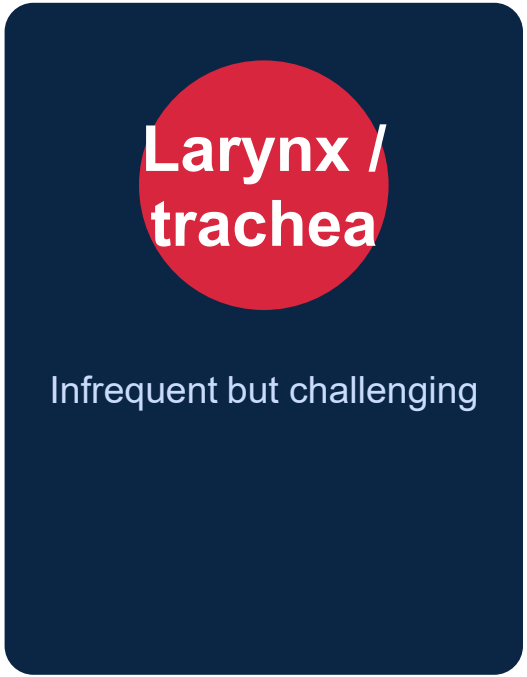
3

**Lung protection**
Prevent aspiration of gastric contents

Airway management focuses on patency down to the trachea; the main bronchi can also be injured.

# Direct Laryngotracheal Injury

- Signs: dysphagia, hoarseness, stridor
- Subcutaneous or mediastinal emphysema, crepitus
- Loss of laryngeal prominence, marked tenderness, expanding hematoma
- Allow the position of comfort (often upright); adjust the cervical collar to avoid obstruction
- If intubating, be gentle with surgical airway equipment ready
- The safest option may be an awake tracheostomy by a surgeon



# Maxillofacial and Mandibular Fractures

- Multiple fractures cause soft-tissue collapse and obstruction
- Obstruction is worse when the patient is supine
- Condylar fractures: trismus and very difficult oral access
- Airway bleeding: open the airway and control the bleeding
- Associated intracranial injury is often an indication for early airway management
- Progressive edema: reassess continuously



# Airway Burns

## Signs of imminent obstruction (urgent intubation)

- Decreased level of consciousness
- Dyspnea and decreased SpO2
- Stridor
- Suprasternal, substernal, or subcostal retraction
- Full-thickness facial burns
- Edema of oral structures or tongue

## Factors raising airway difficulty

- Confinement in a fire; smoke or hot gas inhalation
- Singed facial or nasal hair; carbon in the mouth
- Hoarseness, dysphagia, drooling
- Carbonaceous sputum, wheezing
- Large burns (edema during resuscitation)

These signs are neither sensitive nor specific; monitor and reassess frequently. CO and cyanide toxicity are common.

# Indications for Airway Management in the Primary Survey

| Domain | Indication |
|---|---|
| **Airway (A)** | Partial or complete obstruction, or impending obstruction (trauma, hemorrhage, burns) |
| **Breathing (B)** | Severe chest injury with respiratory failure; SpO2 < 90% despite high-flow oxygen; hypercapnia without a reversible cause |
| **Circulation (C)** | Altered mental status due to shock |
| **Disability (D)** | Severe TBI with GCS 8 or lower |
| **Exposure (E)** | High percentage body surface area burns |

# Airway Assessment in Trauma

1. **Anatomy**
   Individual variation

2. **Physiology**
   Derangements such as hypoxemia and hypotension

3. **Environment**
   Equipment, team dynamics, cognitive load, experience

4. **Injury**
   Direct airway trauma

A reassuring assessment does not exclude a difficult airway; airway management in trauma always has the potential to be difficult.

# Predicting a Difficult Airway

## History

- Previous difficult airway (strongly predictive)
- Pregnancy
- Obstructive sleep apnea
- Prior radiotherapy or surgery to the airway or neck

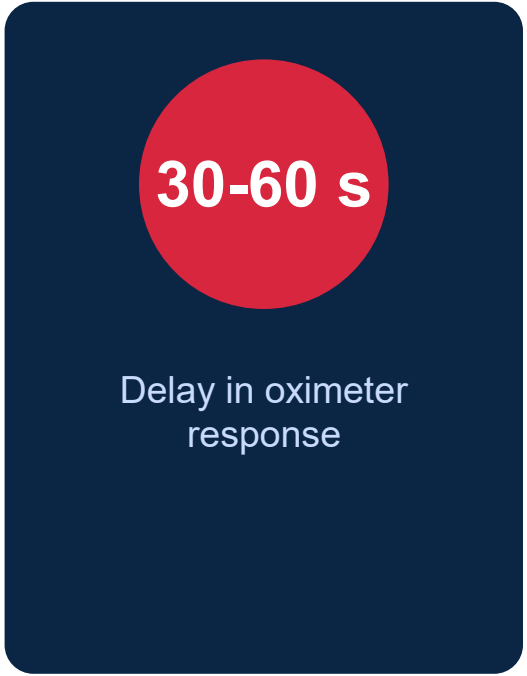
## Examination

- Obesity, large or abnormal neck
- Short thyromental distance, retrognathia
- Limited neck mobility (including spinal motion restriction)
- Beard (for mask ventilation)
- Limited mouth opening or mouth space

Mallampati needs a cooperative sitting patient and is of limited use in trauma; MACOCHA is not validated in trauma.

# Pulse Oximetry

- A fall in SpO2 is a late sign of obstruction, especially with supplemental oxygen
- The delay may be longer in shock
- No reading: investigate severe hypoxia and hypoperfusion (shock, hypothermia)
- Reads falsely high in carbon monoxide poisoning



# Capnography

- Absent exhaled $CO_2$ means obstruction until proven otherwise (even in cardiac arrest)
- Best practical indicator of successful intubation
- Waveform capnography also helps with mask, LMA, and spontaneous ventilation
- $ETCO_2$ values are accurate only in a sealed airway
- Low $ETCO_2$ may indicate low cardiac output



# Capnography Waveforms

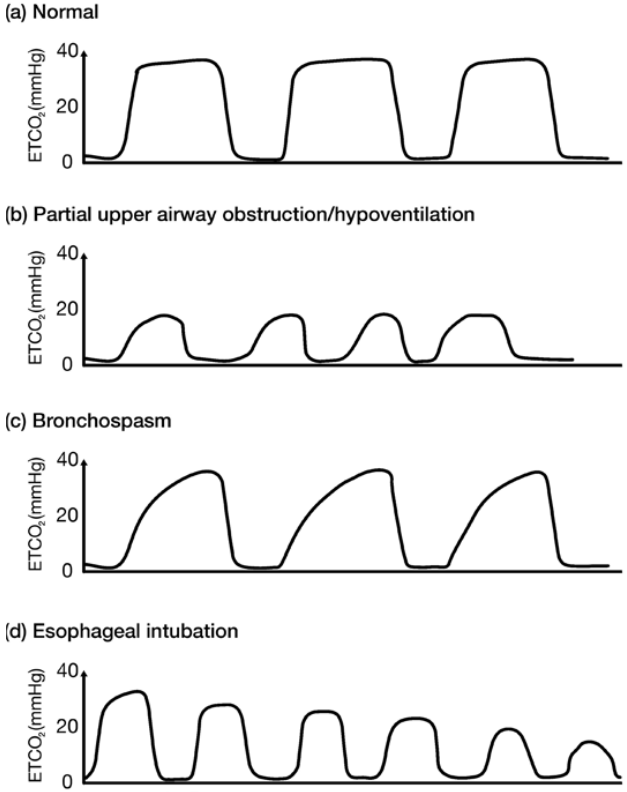
1. **A - Normal**
   ETCO2 accurately estimates PaCO2

2. **B - Partial obstruction / hypoventilation**
   Small rounded waves; ETCO2 underestimates PaCO2

3. **C - Bronchospasm**
   "Shark-fin" waveform

4. **D - Esophageal intubation**
   Initial CO2 from the stomach fades over time

Imaging has limited use: CT takes time and loses access to the airway. ETO2 above 85% suggests adequate preoxygenation.




■ **Figure 4-3: Common Capnography Waveforms.**
**A.** Normal capnograph where $ETCO_2$ can accurately estimate $PaCO_2$. **B.** Partial upper airway obstruction or hypoventilation. Smaller, rounded waves are seen if tidal volume is low. Measured $ETCO_2$ will underestimate $PaCO_2$. **C.** Bronchospasm. 'Shark-fin' waves are seen in bronchospasm and some other situations. The measured $ETCO_2$ will underestimate the $PaCO_2$. **D.** Esophageal intubation. $CO_2$ may be returned from the stomach initially but will diminish over time. In successful endotracheal intubation, exhaled $CO_2$ is sustained. This is defined as $CO_2$ being adequately detected on a minimum of seven breaths. This example shows a higher level of $CO_2$ than is often seen in esophageal intubation

# Oxygen Delivery

**94-98%**

Target SpO2

**15 L/min**

Start with a reservoir (non-rebreather) mask

**60 L/min**

HFNO flow; up to 100% O2

Give oxygen for SpO2 below 94%, obstruction, or when it cannot be measured. HFNO is contraindicated in severe facial trauma or basal skull fracture. Noninvasive ventilation raises aspiration risk.

# Basic Airway Maneuvers

1

**Left lateral position**
Effective and noninvasive; useful in mass casualty; keep spine aligned

2

**Jaw thrust and vise grip**
Mandible displaced anteriorly; chin lift is less effective

3

**Suction**
Under direct vision; Magill or Boedeker forceps for solids

Positive pressure alone does not overcome obstruction; combine mask ventilation with jaw thrust and OPA/NPA. A two-handed mask hold is best.

# Upper Airway Devices

1

**OPA (oropharyngeal)**
Size: incisors to angle of jaw; remove if gagging

2

**NPA (nasopharyngeal)**
Size: nose to tragus; contraindicated in facial and basilar skull fractures

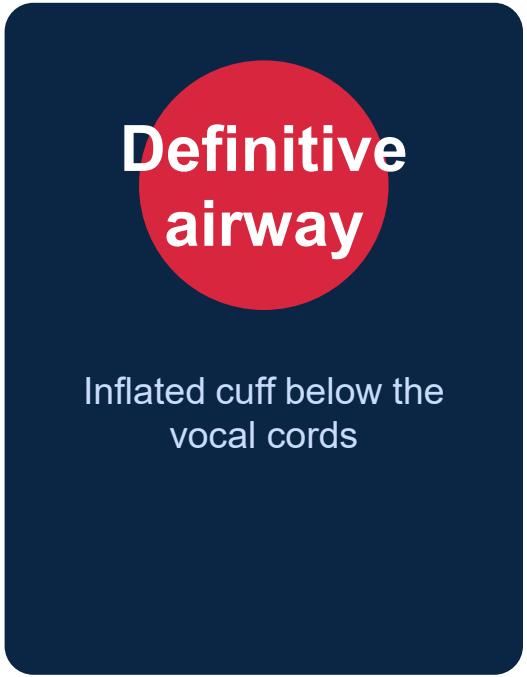
3

**Laryngeal mask (LMA)**
Inserted without laryngoscopy; obtunded patients only; abandon if gagging

An LMA offers better ventilation and some protection against regurgitation and aspiration than an OPA or NPA with a mask.

# Tracheal Intubation and RSI

- Usually an endotracheal tube or surgical airway; continuous reassessment is still required
- Absolute indication: life-threatening hypoxia from obstruction not relieved by basic maneuvers
- Serious complications are higher than with noninvasive maneuvers
- Except in cardiac arrest, drug-facilitated (RSI) intubation is used
- "Rapid" means a short drug-to-airway interval; preparation takes 5-10 minutes



# Risks of RSI

1. **Loss of the airway**
   After drugs are given, the clinician is committed to providing airway and ventilation

2. **Esophageal intubation**
   Catastrophic; recognized by lack of sustained CO2; remove the tube

3. **Airway injury**
   Increases with repeated attempts; limit the number of attempts

4. **Hemodynamic collapse**
   Reduce doses, resuscitate first with fluid or blood, give vasopressors

# Timing of RSI

## Factors toward immediate RSI

- Inability to oxygenate by mask or supraglottic airway (absolute)
- Appropriate resuscitation and adequate hemodynamics
- Cannot maintain patency (bleeding, regurgitation, emesis)
- Lack of or prolonged delay to an airway specialist
- Definitive airway needed for safe transfer

## Factors toward delaying RSI

- Well-functioning upper airway device or spontaneous airway
- Hypotension or hemodynamic abnormality
- Difficult airway with rapid expert arrival
- More urgent priorities
- Inadequate staff or experience
- Multi-casualty scenario

If a prehospital airway is working, replacement can be deferred until better personnel and equipment are available.

# RSI Equipment

1. **Endotracheal tubes**
   Roughly 7-9 mm ID for adults; cuffed tubes for all ages

2. **Laryngoscopes**
   At least two; video laryngoscope (VL) is optimal with a screen visible to the team

3. **Bougie and stylet**
   Bougie for difficult intubation; stylet holds the tube shape

4. **Ventilator and suction**
   Ventilator prevents hypo/hyperventilation and fatigue; wide-bore suction

# RSI Medications and Sample Doses

| Drug | Dose | Comment |
|---|---|---|
| **Ketamine** | 0.5-2 mg/kg | Reduce dose in shock |
| **Etomidate** | 0.2-0.3 mg/kg | Fewer hemodynamic effects |
| **Fentanyl** | 0.5-1 mcg/kg | Useful in isolated head injury; may cause hypotension |
| **Rocuronium** | 0.6-1.2 mg/kg | At least 1.2 mg/kg for comparable conditions |
| **Suxamethonium** | 1 mg/kg | Onset 45-60 seconds |
| **Phenylephrine / epinephrine** | 50 mcg / 10-50 mcg | Boluses to offset vasodilation |

Doses are examples; adjust to clinical judgment and hemodynamic status.

# Sedatives and Neuromuscular Blockers

## Sedatives and anesthetics

- Ketamine and etomidate: fewer hemodynamic changes
- Propofol and thiopentone: significant hypotension; only if experienced and not hypovolemic
- Benzodiazepines and opioids: notable hypotension risk
- Maintenance sedation after intubation

## Neuromuscular blockers (NMBD)

- Suxamethonium: onset 45-60 s, metabolized in 3-5 min
- Risk: hyperkalemia (burns, prolonged immobilization, spinal injury)
- Rocuronium (at least 1.2 mg/kg): fewer side effects
- NMBDs give no sedation or analgesia

# Preparation: Checklists and Teamwork

1. **Checklists**
   Pre- and post-intubation; complete before giving RSI drugs

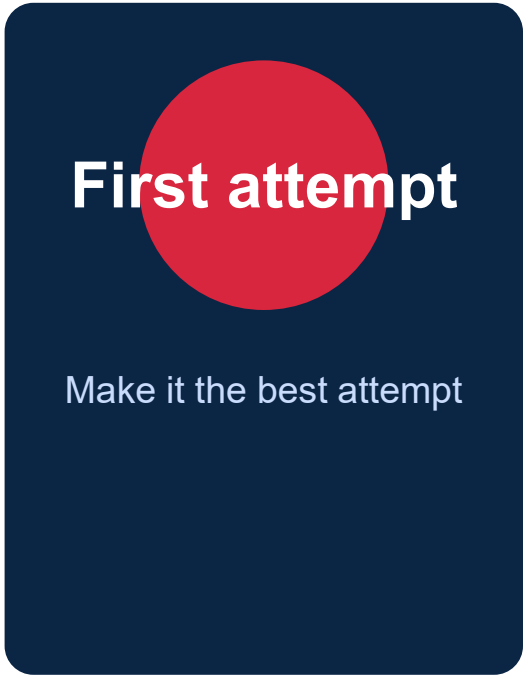
2. **Cognitive aids**
   Flow diagrams, task cards, and role stickers

3. **Equipment layout**
   Consistent, organized layout using a template

4. **Teamwork**
   Team leader is not the intubator; one person monitors vitals; brief the failure plan; shared VL screen

# Spine Protection and Optimizing Attempts

- Manual inline stabilization (MILS) as a single unit; no traction
- When life is threatened, oxygenation takes primacy over spine stabilization
- Routine cricoid pressure is not performed (effectiveness not shown)
- Success factors: experienced operator, VL, bougie or stylet, optimal positioning

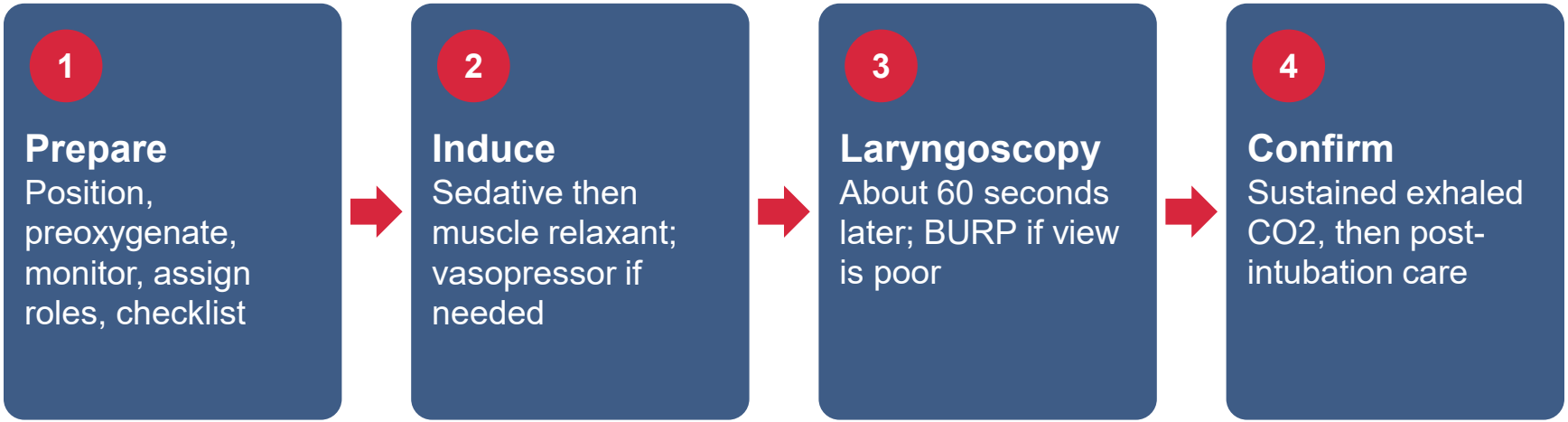


# Positioning and Preoxygenation

- Position: reverse Trendelenburg 20-30 degrees, patient at head of bed
- Preoxygenation = denitrogenation, creating an oxygen reservoir
- BVM with PEEP valve or HFNO; reservoir mask is less effective
- SpO2 is not an indicator of adequate preoxygenation
- Apneic oxygenation: nasal cannula up to 15 L/min plus gentle mask ventilation
- Agitated patient: delayed-sequence intubation with titrated ketamine

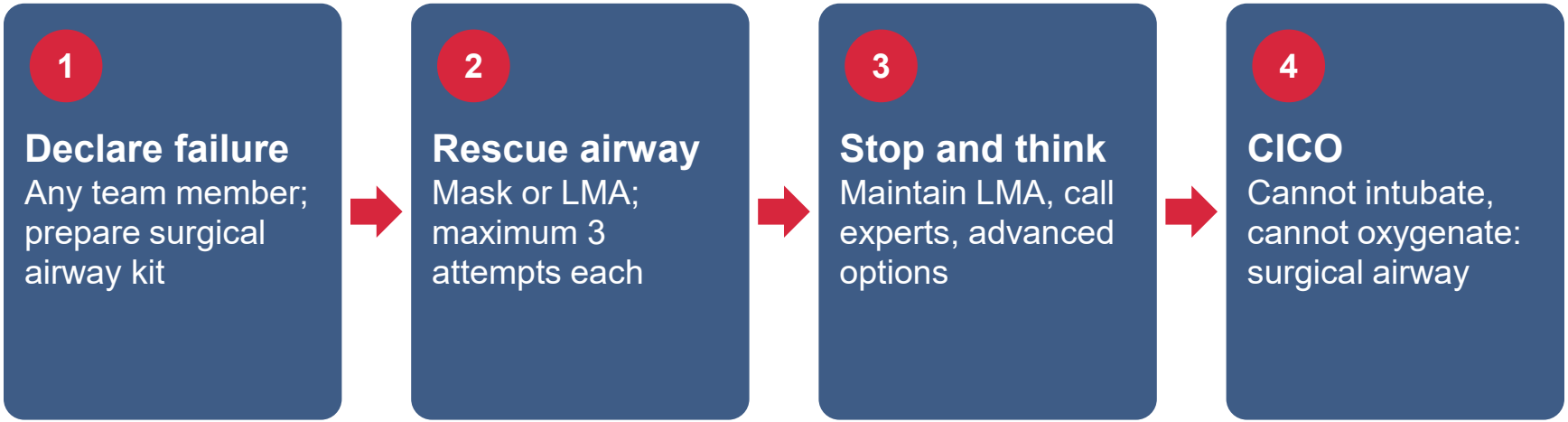


# RSI Procedure




Maximum of 3 laryngoscopy attempts; keep oxygenating with mask or LMA between attempts.

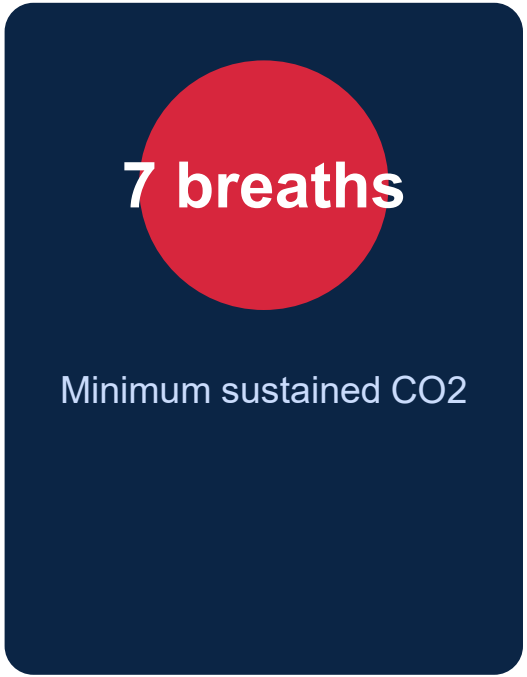
# Failed Intubation and Rescue




Identical repeat attempts rarely succeed; change something (position, equipment, operator). Up to 3 attempts per operator, plus one by a more experienced operator.

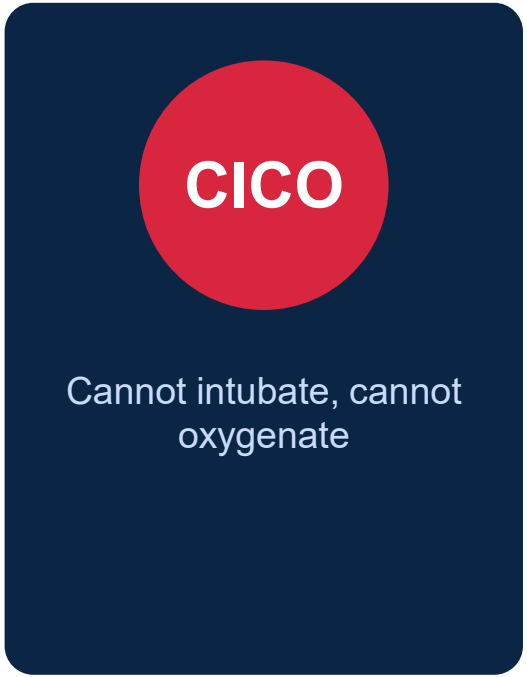
# Confirming Tube Placement

- Unrecognized esophageal intubation is catastrophic
- Confirm with sustained exhaled CO2 (even in cardiac arrest)
- Seeing the tube pass the cords and clinical signs are unreliable
- Secure the tube and record depth at the teeth
- Chest x-ray detects mainstem intubation and pneumothorax; it cannot exclude esophageal placement



# Surgical (Incisional) Airway

- Indicated when oxygenation fails by mask, LMA, or intubation
- Any team member may call it; delay can be catastrophic
- May be done first in severe facial or upper airway injury
- Equipment: scalpel (size 10 or 15), tube about 6.0, bougie
- Once started, complete it despite bleeding



# Cricothyroidotomy Technique

1. Stabilize the neck manually; remove the front of the collar
2. Palpate the thyroid cartilage and cricothyroid space (laryngeal handshake)
3. Vertical midline incision of 3-5 cm
4. Identify the cricothyroid membrane by dissection
5. Incise the membrane transversely
6. Rotate the scalpel handle to dilate the opening
7. Insert the tube (or over a bougie) until the cuff is in the trachea
8. Inflate the cuff, confirm CO2, and suture the tube

# Post-Intubation Management

## Initial ventilator settings

- Volume-control ventilation
- Tidal volume: max 6 mL/kg ideal body weight
- PEEP: 5 cm H2O
- FiO2: 100%, titrate to SpO2
- Rate 14/min; target PaCO2 35-45 mm Hg
- In TBI target PaCO2 closer to 35

## Other priorities

- Secure tube, continuous ETCO2, chest x-ray
- Maintenance sedation with analgesia
- Continue resuscitation; vasopressors if needed
- Limited neuro exam; pupils remain reliable
- Prevent hypothermia; insert gastric tube

# Reassessment:

1. **D - Displacement**
   Mainstem or dislodged tube

2. **O - Obstruction**
   Mucous plug or kinked tube

3. **P - Pneumothorax**
   Simple or tension, from positive pressure

4. **E - Equipment failure**
   Ventilator disconnect; ventilate manually

Recheck the airway after any patient movement (e.g., log roll). If dislodgement is suspected, remove and reinsert unless position is quickly confirmed.

# Special Populations

1. **Traumatic brain injury**
   Avoid hypotension, hypoxia, hypercapnia; intubation without sedation raises ICP

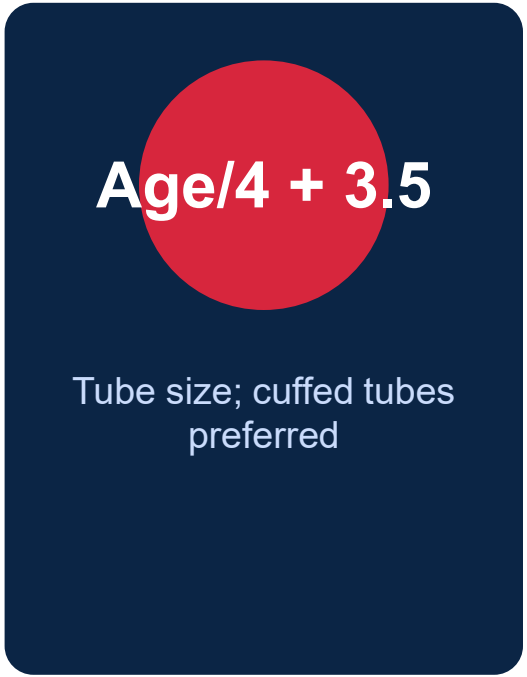
2. **Larger patients**
   Faster hypoxia; head-up position, early adjuncts, higher PEEP

3. **Obstetric patients**
   Reflux and regurgitation, reduced FRC; similar to larger patients

4. **Older patients**
   Collapsed cheeks impair mask seal; hypotension after RSI; reduce doses

# Pediatric Patients

- Smaller structures; larger head: pad under the torso
- Larger tongue and epiglottis; more anterior larynx
- Shorter trachea: risk of mainstem intubation
- Elliptical cricoid: resistance during tube passage
- Faster hypoxemia leading to bradycardia and arrest
- Weight-based doses; length-based tape and pediatric trolley



# Key Learning Points

1. Oxygenation is the most important priority
2. Every emergent airway is potentially difficult; always have a failure plan
3. Airways can be managed without intubation; intubation can be deferred
4. The first attempt is the optimal attempt; identical repeats rarely work
5. Confirm intubation with sustained exhaled CO2 (7 breaths)
6. Teamwork, checklists, and equipment selection improve safety

# Summary

Airway management ranges from basic maneuvers and upper airway devices to intubation and surgical airways, and not every patient needs intubation. Modified RSI is performed with simultaneous resuscitation, preoxygenation, and apneic oxygenation. Make the first attempt the best attempt, and always have a plan for airway failure.