Pediatric Difficult Airway Management

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Paediatric difficult airway management: what every anaesthetist should know!

The pediatric difficult airway is associated with a high risk for complications during airway management.
The pediatric difficult airway is associated with a high risk for complications

- A multicenter study of 1018 children with difficult airways in 13 pediatric centers
- more than 2 direct laryngoscopy attempts is associated with
  - high failure rates
  - increased incidence of severe complications.

- Cardiac arrest was most common severe complication (2%).
- Hypoxemia (SpO2<85%) was the most common complication.

N. Jagannathan, British Journal of Anaesthesia 117 (S1): i3–i5 (2016)
Definition and Incidence
Definition of Difficult Airway

the clinical situation in which a conventionally trained anesthesiologist experiences difficulty with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both.

ASA Practice Guidelines Management of the Difficult Airway 2013
Difficult Ventilation
- 484 children scheduled for elective surgery between 2007 and 2010
- the ages of 0-8 years
- unexpected difficult BMV was 6.6% (In adult 2.5%)
Predictors:
1. Younger age
2. ENT surgery
3. Neuromuscular blockade

Valois-Gomez, Peds Anesth 2013;23
Difficult Laryngoscopy
- From a 5-year time period (2005–2010)
- 11,219 general anesthesia procedures
- Neonate to adolescent
- Incidence DL was 1.35% (In adult 4.4%)

Predictors:
1. Age < 1 year
2. ASA III & IV
3. MP III & IV
4. Low BMI

Heinrich, Peds Anesth 2012;22
Differences between pediatric and adult airways
Anatomic differences between pediatric and adult airways

- Large occiput
- Narrow nares
- Large tongue
- Larynx more cephalad
- Narrow cricoid

Difficult ventilate and laryngoscopy
Diseases and Syndromes Associated with the Difficult Pediatric Airway
<table>
<thead>
<tr>
<th>Location</th>
<th>Conditions</th>
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</thead>
<tbody>
<tr>
<td>Nasopharynx</td>
<td>• Choanal atresia, stenosis, Cleft lip cleft palate</td>
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<tr>
<td></td>
<td>• Adenoidal hypertrophy</td>
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<tr>
<td>Tongue</td>
<td>• Hemangioma, Down syndrome</td>
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<td></td>
<td>• Beckwith-Wiedemann syndrome</td>
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<td>Mandible, maxilla</td>
<td>• Pierre Robin syndrome, Treacher Collins syndrome, Goldenhar syndrome, Apert syndrome</td>
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<td></td>
<td>• Neck burn with contracture,</td>
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<td></td>
<td>• Juvenile rheumatoid arthritis</td>
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<tr>
<td>Pharynx/larynx</td>
<td>• Laryngomalacia, Freeman-Sheldon syndrome</td>
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<tr>
<td></td>
<td>• Epiglottitis, peritonsillar abscess</td>
</tr>
<tr>
<td>Trachea</td>
<td>• Vascular ring, tracheal stenosis, tracheomalacia,</td>
</tr>
<tr>
<td></td>
<td>• Mediastinal tumors</td>
</tr>
</tbody>
</table>
Diseases and Syndromes Associated with the Difficult Pediatric Airway

- Congenital hydrocephalus
- Cleft lip cleft palate

Head & Nasopharynx
Diseases and Syndromes Associated with the Difficult Pediatric Airway

Tongue

Down syndrome

Hemangioma
Diseases and Syndromes Associated with the Difficult Pediatric Airway

- Pierre Robin syndrome
- Treacher Collins syndrome

Mandible & Maxilla
Diseases and Syndromes Associated with the Difficult Pediatric Airway

Mandible & Maxilla

Goldenhar syndrome

Apert syndrome
Diseases and Syndromes Associated with the Difficult Pediatric Airway

Mandible & Maxilla

Burn with contracture

Juvenile rheumatoid arthritis
Diseases and Syndromes Associated with the Difficult Pediatric Airway

Peritonsillar abscess

Acute epiglottitis
Diseases and Syndromes Associated with the Difficult Pediatric Airway

- Tracheal stenosis
- Tracheomalacia
Respiratory physiologic differences between children and adults

- High oxygen consumption: $7-9 \text{ mL O}_2/\text{kg/min} \text{ vs } 3 \text{ mL O}_2/\text{kg/min}$ in adult
- Reduced FRC
- Elevated closing volume

Rapid desaturation when apnea
Pediatric difficult airway management different from adult

• Awake approaches to intubation used in adult difficult airways are more problematic for pediatric patients
• For pediatric patients, anesthetized intubation remains most common
Complication
- 229 critical incidents were reported from 49,373 anesthetic procedures.
- between January 2008 and August 2013
- The most frequently reported incidents were associated with the respiratory system (55%)
- tracheal tube-related events accounting for 40.9% of respiratory incidents

Ji-Hyun Lee, Peds Anesth 2016
- 193 arrests (49%) were related to anesthesia.
- 27% of cardiac arrest due to respiratory causes → 8% due to difficult ventilation and intubation

Complication of difficult airway

Airway management complications in children with difficult tracheal intubation from the Pediatric Difficult Intubation (PeDI) registry: a prospective cohort analysis

John Edem Fiadjo, Akira Nishisaki, Narasimhan Jagann, Mohamed A Rehman, David M Polaner, Peter Szmuk, Vi

- Tracheal intubation failed in 19 (2%) of cases
- 30 (3%) of these were severe complication: cardiac arrest, death, aspiration, pneumothorax

Guideline for management of the unanticipated difficult airway in pediatric practice
Guideline for the management of the unanticipated difficult airway in pediatric practice

Original Article

Development of a guideline for the management of the unanticipated difficult airway in pediatric practice

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The Working Group established a panel of 27 consultant pediatric anesthetists, the ‘Delphi Group’. Delphi Group included anesthetists from 25 different hospitals in the UK and Ireland. Delphi Group reviewed research into airway management in children and graded papers for the level of evidence according to agreed criteria. A Delphi panel considered the steps of the acute airway management guidelines to reach consensus on the best interventions to use them.
3 Guidelines for pediatric airway management

- Difficult mask ventilation
- Unanticipated difficult tracheal intubation
- Cannot intubate and cannot ventilate (CICV)
Difficult mask ventilation (MV) – during routine induction of anaesthesia in a child aged 1 to 8 years

**Difficult MV** ➔ **Give 100% oxygen** ➔ **Call for help**

**Step A Optimise head position**
- **Consider:**
  - Adjusting chin lift/jaw thrust
  - Inserting shoulder roll if <2 years
  - Neutral head position if >2 years
  - Adjusting cricoid pressure if used
  - Ventilating using two person bag mask technique

  **Check equipment**
  - Consider changing:
    - Circuit
    - Mask
    - Connectors
    - If equipment failure is suspected, change to self-inflating bag and isolate from anaesthetic machine promptly

  **Depth of anaesthesia**
  - Consider deepening anaesthesia
  - Use CPAP

**Step B Insert oropharyngeal airway**
- **Assess for cause of difficult mask ventilation**
  - Light anaesthesia
  - Laryngospasm
  - Gastric distension – pass OG/NG tube

  **Call for help again if not arrived**
  - Maintain anaesthesia/CPAP
  - Deepen anaesthesia (Propofol first line)
    - If relaxant given – intubate
    - If intubation not successful, go to unanticipated difficult tracheal intubation algorithm

**Step C Second-line: Insert SAD (e.g. LMA™)**
- **Insert SAD (e.g. LMA™) – not > 3 attempts**
- **Consider nasopharyngeal airway**
- **Release cricoid pressure**
  - **Good airway**
    - **Yes**
    - SpO₂ > 80%
    - **Consider:**
      - SAD (e.g. LMA™) malposition/blockage
      - Equipment malfunction
      - Bronchosospasm
      - Pneumothorax
    - **Continue**
  - **No**
    - SpO₂ < 80%
    - **Attempt intubation**
      - **Succeed**
        - **Proceed**
      - **Fail**
        - Go to scenario cannot intubate cannot ventilate (CICV)
  - Continue

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SAD = supraglottic airway device
Difficult mask ventilation

Step A: Optimizing head position

- Adjusting chin lift with or without jaw thrust in all aged
- Lateral position can improve obstructive airway
- Inserting shoulder roll if < 2 years
- Neutral head position if > 2 years
- Using a 2 hands technique for ventilation
Insert shoulder roll and chin lift
Neutral head position
Adjusting jaw thrust and ventilating using two person bag mask technique
Difficult mask ventilation

**Step A**

- Optimize head position
- Check equipment
- Depth of anesthesia

**Check equipment**

Check: circuit → Mask → connector

If equipment failure is suspect, change to self inflating bag and isolate from anesthetic machine
Difficult mask ventilation

**Step A**

- Optimize head position
- Check equipment
- Depth of anesthesia

**Depth of anesthesia**

Propofol is a first-line drug for deepen anesthesia or increase volatile agent concentration if not has IV access.
Difficult mask ventilation

- Maintain anesthesia with 100% oxygen
- Apply CPAP
- Insert oropharyngeal airway
Difficult mask ventilation

• Assess for cause of difficult mask ventilation
  - Light of anesthesia
  - Laryngospasm
  - Gastric distension—Pass OG/NG
• If relaxant given – Intubation
• If intubation not successful – Go to Unanticipated difficult tracheal intubation
Difficult mask ventilation

**Step C**

Use of a supraglottic airway device

Consider:
- SAD malposition/blockage
- Equipment malfunction
- Bronchospasm
- Pneumothorax
Difficult mask ventilation

Step C

Use of a supraglottic airway device

Step C Second-line: Insert SAD (e.g. LMA™)

- Insert SAD (e.g. LMA™) – not > 3 attempts
- Consider nasopharyngeal airway
- Release cricoid pressure

Good airway

- SpO₂ >80%

No

- SpO₂ <80%

Consider:
- SAD (e.g. LMA™) malposition/blockage
- Equipment malfunction
- Bronchospasm
- Pneumothorax

Succeed

Proceed

Fail

Go to scenario cannot intubate cannot ventilate (CICV)

Continue

Wake up patient

Attempt intubation

SAD = supraglottic airway device
Unanticipated difficult tracheal intubation
Unanticipated difficult tracheal intubation – during routine induction of anaesthesia in a child aged 1 to 8 years

Difficult direct laryngoscopy → Give 100% oxygen and maintain anaesthesia → Call for help

**Step A** Initial tracheal intubation plan when mask ventilation is satisfactory

- Direct laryngoscopy – not > 4 attempts
  - Check:
    - Neck flexion and head extension
    - Laryngoscopy technique
    - External laryngeal manipulation – remove or adjust
    - Vocal cords open and immobile (adequate paralysis)
  - If poor view – consider bougie, straight blade laryngoscope* and/or smaller ETT

  **Failed intubation with good oxygenation**

  **Step B** Secondary tracheal intubation plan

- Insert SAD (e.g. LMA™) – not > 3 attempts
- Oxygenate and ventilate
- Consider increasing size of SAD (e.g. LMA™) once if ventilation inadequate

  **Failed oxygenation e.g. SpO₂ <90% with FIO₂ 1.0**

  - Convert to face mask
  - Optimise head position
  - Oxygenate and ventilate
  - Ventilate using two person bag mask technique, CPAP and oromaskaryngeal airway
  - Manage gastric distension with OG/NG tube
  - Reverse non-dopolarising relaxant

  **Failed ventilation and oxygenation**

- Consider 1 attempt at FOI via SAD (e.g. LMA™)

  **Failed intubation via SAD (e.g. LMA™)**

- Consider modifying anaesthesia and surgery plan
- Assess safety of proceeding with surgery using a SAD (e.g. LMA™)

  **Unsafe**
  - Postpone surgery
  - Wake up patient

  **Safe**
  - Proceed with surgery

  **Succeed**
  - Postpone surgery
  - Wake up patient

  **Go to scenario cannot intubate cannot ventilate (CIVC)**

Following intubation attempts, consider:
- Trauma to the airway
- Extubation in a controlled setting

*Consider using indirect laryngoscope if experienced in their use

SAD = supraglottic airway device
Unanticipated difficult tracheal intubation

- **Step A**: Initial tracheal intubation plan when mask ventilation is satisfactory

![Diagram showing the steps of tracheal intubation](image-url)
Unanticipated difficult tracheal intubation

- **Step A**: Initial tracheal intubation plan when mask ventilation is satisfactory

  After failed intubation attempt
  - Adjustment head and neck extension
    - With or without pillow and shoulders rolls
  - External laryngeal manipulation: remove or adjust
  - Laryngoscope and adjuvants to intubation
    - Straight blade DL in 1-3 years, Glidescope, Airtraq
  - Consider smaller ETT size

  Succeed tracheal intubation
  - Capnography (Gold standard)
  - Auscultation
  - If ETT too small consider using throat pack

Failed intubation with good oxygenation go to **Step B**
Unanticipated difficult tracheal intubation

- **Step B**: Secondary tracheal intubation plan

- Failed intubation with good oxygenation
  - Insert SAD (e.g. LMA™) – not > 3 attempts
  - Oxygenate and ventilate
  - Consider increasing size of SAD (e.g. LMA™) once if ventilation inadequate

- Failed oxygenation e.g. $\text{SpO}_2 < 90\%$ with $\text{FiO}_2 1.0$
  - Convert to face mask
  - Optimise head position
  - Oxygenate and ventilate
  - Ventilate using two person bag mask technique, CPAP and oro/nasopharyngeal airway
  - Manage gastric distension with OG/NG tube
  - Reverse non-depolarising relaxant

- Call for help again if not arrived
  - Consider modifying anaesthesia and surgery plan
  - Assess safety of proceeding with surgery using a SAD (e.g. LMA™)

- Succeed
  - Safe
    - Verify intubation, leave SAD (e.g. LMA™) in place and proceed with surgery
    - Proceed with surgery

- Unsafe
  - Postpone surgery
    - Wake up patient

- Failed intubation via SAD (e.g. LMA™)
  - Succeed
    - Go to scenario cannot intubate cannot ventilate (CICV)

- Failed ventilation and oxygenation
  - Postpone surgery
    - Wake up patient
**Step B** : Secondary tracheal intubation plan

- **Insert SAD (eg. LMA) with good oxygenation**

- Assess safety of proceeding surgery with LMA

  - **Safe**
    - Proceed with surgery

  - **Unsafe**
    - Postpone surgery and wake up patient
Unanticipated difficult tracheal intubation

**Step B**: Secondary tracheal intubation plan

Placement of the SAD and inadequate oxygenation (SpO2<90, FiO2 1.0)

- Convert to face mask ventilation
- Ventilate using two person bag mask technique
- Manage gastric distension with OG/NG tube
- Reverse non-depolarizing relaxant

Succeed

Postpone surgery and wake up patient

Failed ventilation and oxygenation

Go to scenario CICV
Cannot intubate and cannot ventilate
Cannot intubate and cannot ventilate (CICV) in a paralysed anaesthetised child aged 1 to 8 years

Failed intubation
inadequate ventilation

Step A: Continue to attempt oxygenation and ventilation
- FiO₂ 1.0
- Optimise head position and chin lift/jaw thrust
- Insert oropharyngeal airway or SAD (e.g. LMA™)
- Ventilate using two person bag mask technique
- Manage gastric distension with an OG/NG tube

Step B: Attempt wake up if maintaining SpO₂ >80%
If vecuronium or vecuronium used, consider sugammadex (16mg/kg) for full reversal
Prepare for rescue techniques in case child deteriorates

Step C: Airway rescue techniques for CICV (SpO₂ <80% and falling) and/or heart rate decreasing

Call for help again if not arrived

Consider:
- Surgical tracheostomy
- Rigid bronchoscopy + ventilate / jet ventilation (pressure limited)

Continue jet ventilation set to lowest delivery pressure until wake up or definitive airway established
- Perform surgical cricothyroidotomy / transtracheal and insertion of ETT / tracheostomy tube*
- Consider passive O₂ insufflation while preparing

Cannula cricothyroidotomy
- Extend the neck (shoulder roll)
- Stabilise larynx with non-dominant hand
- Access the cricothyroidotomy membrane with a dedicated 14/16 gauge cannula
- Aim in a caudad direction
- Confirm position by air aspiration using a syringe with saline
- Connect to either:
  - Adjustable pressure limiting device, set to lowest delivery pressure
  - 4Bar O₂ source with a flowmeter (match flow l/min to child’s age) and Y connector
- Cautiously increase inflation pressure/flow rate to achieve adequate chest expansion
- Wait for full expiration before next inflation
- Maintain upper airway patency to aid expiration

SAD = supraglottic airway device

*Note: Cricothyroidotomy techniques can have serious complications and training is required – only use in life-threatening situations and convert to a definitive airway as soon as possible
Cannot intubate and cannot ventilate

• **Step A:** Continue to attempt oxygenation and ventilation

  - FiO₂ 1.0
  - Optimise head position and chin lift/jaw thrust
  - Insert oropharyngeal airway or SAD (e.g. LMA™)
  - Ventilate using two person bag mask technique
  - Manage gastric distension with an OG/NG tube
Cannot intubate and cannot ventilate

- **Step B:** Attempt wake up if SpO2 > 80%

  - Continue efforts to oxygenation and ventilation.
  - Prepare for rescue techniques in case child deteriorate. (Desaturation, hemodynamic unstable)
  - If rocuronium or vecuronium used consider sugammadex 16 mg/kg for full reversal
• **Step C**: Airway rescue techniques for CICV (SpO2 < 80% and falling) and/or heart rate decreasing

*Note: Cricothyroidotomy techniques can have serious complications and training is required — only use in life-threatening situations and convert to a definitive airway as soon as possible*
**Step C** : Airway rescue techniques for CICV (SpO2 < 80% and falling) and/or heart rate decreasing

- **Call for specialist ENT**
  - **ENT available**
    - Consider:
      - Surgical tracheostomy
      - Rigid bronchoscopy + ventilation/Jet ventilation
  - **ENT not available**
Cannot intubate and cannot ventilate

- **Step C**: Airway rescue techniques for CICV (SpO2 < 80% and falling) and/or heart rate decreasing

  - ENT not available
  - Percutaneous cannula cricothyroidotomy / Tracheal jet ventilation

  - **Succeed**
    - Continue jet ventilation (Lowest pressure until wake up or definite airway established)

  - **Fail**
    - Surgical cricothyroidotomy or transtracheal and insertion of ETT or tracheostomy tube
Practice Guidelines for Management of the Difficult Airway in pediatric and adult

- There are awake intubation guideline for adult but not have in pediatric practice.

ASA, 2013
Case scenario
Large mass in oral cavity

- 5 years old boy with big size (6×4 cm) sublingual dermoid cyst was pushing the anterior part of the tongue and displacing the tongue superiorly and posteriorly
- Patient has normal mouth opening, can protrude tongue.
- Plan excision of sublingual dermoid cyst.

What technique and equipment you consider using for intubation in this patient??
CASE REPORT – GlideScope A rescuer in difficult pediatric airway

• The pharynx was anaesthetized topically using 4% viscous lidocaine and 10% Lidocaine spray.
• The child was awakened and spontaneous breathing with 100% oxygen.
• Then direct laryngoscopy was attempted and could see only the posterior commissure. And could not intubated.
• Succeeded intubation with GlideScope® visualising and intubating the trachea with 5.5 mm uncuffed endotracheal...
Limitation

• Some mouth opening is required
• Learning curve
• Difficulty passing tube despite excellent view
### GlideScope cobalt sizes

<table>
<thead>
<tr>
<th>Size (GVL)</th>
<th>Age</th>
<th>Weight (kg)</th>
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<tbody>
<tr>
<td>0</td>
<td>Preterm</td>
<td>&lt;1.5</td>
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<tr>
<td>1</td>
<td>Full term</td>
<td>1.5-3.6</td>
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<tr>
<td>2</td>
<td>Toddler</td>
<td>1.8-11</td>
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<tr>
<td>2.5</td>
<td>Child</td>
<td>11-28</td>
</tr>
<tr>
<td>3</td>
<td>Adult</td>
<td>11-adult</td>
</tr>
</tbody>
</table>
Case report: Airway management in Pierre Robin Syndrome

- A 2 years old girl
- Plan for repair of cleft palate
- She was a known case of Pierre Robin Syndrome
  - had short receding jaw
  - mouth opening limited to 1.5 cm,
  - tongue was large and retracted posteriorly.
  - The breathing was noisy due to obstruction of the airways by large tongue and her resting SpO₂ was 90% on room air.

What technique and equipment you consider using for intubation in this patient??
Case report – Successful intubation with intubating LMA in Pierre Robin syndrome

1. Inhalation induction with spontaneous ventilation.
2. McIntosh blade No. 1 was inserted but failed.
3. An attempt with Miller blade also failed.
4. Then LMA No. 1.5 was inserted and easy ventilated.
5. After ventilation for five minutes, ETT No. 3.5 was inserted through the intubating LMA.
6. The intubating LMA was pulled out. Manual ventilation was resumed through the ETT.

Intubating LMA

• Several methods for placing the ETT through the LMA
  – Blind
  – Fiberoptic assisted
  – Stylet or bougie assisted

• Ventilation can be provided during intubation attempts
Intubating LMA

Limitation

• Smaller LMA may not allow passage of pilot balloon of cuffed tubes.
• LMA removal over the ETT may cause simultaneous withdrawal of the ETT.
Case report: Hunter syndrome with difficult airway

- A 5 years old boy
- Plan for dental examination under GA requiring nasal intubation
- He was a known case of Hunter syndrome
  - Coarse facial features, macrocephaly, macroglossia
  - Limited mouth opening
  - Limited range of motion of the neck
  - had a history of asthma, bicuspid aortic valve

What technique and equipment you consider using for intubation in this patient??
Case report – Successful intubation with fiberoptic in Hunter syndrome

- Inhalation induction with spontaneous ventilation.
- Easy mask ventilation was confirmed.
- Rocuronium was administered.
- Laryngoscopy with Glidescope blade size 3 and showed a very anterior larynx with enlarged epiglottis.
- At this point decision was made to proceed with nasal fiberoptic intubation.
- Flexible bronchoscope was passed and vocal cords were visualized, ETT Size 4.5 was passed over bronchoscope.

Palatnik md Y, pedsanesthesia; 2012
Fiberoptic Bronchoscope

- gold standard for the management of the difficult airway
- can use with variety of abnormal airway
- It is well tolerated by the awake, sedate and spontaneously breathing child
Fiberoptic Bronchoscope

Limitations:

• Optical problems with fogging, blood or secretions

• Requires extensive experience

• Fragile and Expensive
Pediatric airway equipment in Siriraj hospital
Glidescope
Pentax
Bonfils
LMA

1
1.5
2
2.5
3

< 5 kg
5-10 kg
10-20 kg
20-30 kg
30-50 kg
LMA i-gel
Fiberoptic Bronchoscope