PriMera Scientific Surgical
Research and Practice
Volume 7 Issue 2 February 2026
ISSN: 2836-0028

PriMera Scientific Publications

Novel Ways to Navigate the Pediatric Difficult Airway; Troubleshoot the Obstruction, Triangulate your Positioning, Truncate the Handling; the 3T Approach, A Case Series

Type: Case Series
Received: December 28, 2025
Published: January 29, 2026

Citation:
Farah Husain., et al. "Novel Ways to Navigate the Pediatric Difficult Airway; Troubleshoot the Obstruction, Triangulate your Positioning, Truncate the Handling; the 3T Approach, A Case Series". PriMera Scientific Surgical Research and Practice 7.2 (2026): 14-21.

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Abstract

Children admitted to a hospital are extremely anxious about procedures such as intravenous drug administration, cannulation, dressings, surgeries etc. Given the inability of a child to cooperate during procedures, the possibility of securing a difficult airway in an awake child is therefore limited. Moreover, airway related challenges may occur intraoperatively which require prompt tailoring of our anesthesia technique. Hence, a meticulous and multidisciplinary planning is required to manage the difficult airway in the perioperative period.

We report the successful management of 3 paediatric difficult airway cases under general anesthesia using a novel, tailored approach; troubleshoot the obstruction to reach the trachea, using a triangulated positioning for laryngoscopy and intubation in extra oral tumours and truncate the surgical and airway handling to ensure smooth extubation. We call this the 3T approach to managing paediatric difficult airways.

Keywords: difficult airway; paediatric; anxiety; general anaesthesia; laryngoscopy; troubleshoot

Introduction

Children who are admitted to a hospital are extremely anxious and may be uncooperative while undergoing invasive or surgical procedures such as intravenous drug administration, cannulation, dressings etc [1, 2]. This makes a child with an anticipated difficult airway even more challenging for the anaesthesiologist as they may not cooperate and allow for an awake fibreoptic intubation. Meticulous planning with an experienced approach is required in managing these patients as general anesthesia is usually required to secure the difficult airway in such a child. Despite optimal planning and preparation, unforeseen problems may arise during the conduct of general anaesthesia through which navigation becomes tricky, hence quick thinking, multidisciplinary collaboration and team work become the key to its management.

We present the successful airway management of three paediatric difficult airway cases under general anesthesia using novel approaches; troubleshooting an obstruction to reach the trachea, using a triangulated positioning for laryngoscopy by the anesthesiologists around the patient's head and truncating the surgical and airway handling to ensure a smooth extubation. We call this the 3T approach to managing paediatric difficult airways.

Case 1: Troubleshoot the laryngeal web to reach the trachea

History and clinical assessment: A 6 years old boy with history of corrosive acid ingestion one year ago, presented with increasing dysphagia to solids. There was no history of any breathing difficulty or voice change. His speech was normal but since the child did not allow a preoperative indirect laryngoscopy for assessment of the glottis in the outpatient department, a triple endoscopy (laryngoscopy, pharyngoscopy and esophagoscopy) evaluation to assess the cause of dysphagia was planned by the ENT surgical team under anesthesia. During the preanesthetic check-up, airway assessment showed a normal mouth opening, Mallampati grade 1, with a 5 cm thyromental distance and normal neck range of movements. All other routine investigations were normal.

Surgical Plan: Triple endoscopy evaluation and proceed under general anesthesia.

Airway related challenges

- No indirect laryngoscopy view of glottic chink available.
- Anticipated distorted airway anatomy post corrosive acid ingestion.

Securing the airway: In the operation theatre, after attaching all monitors, a 22-Gauge intravenous cannula was secured. The child was preoxygenated while premedication with injection midazolam 0.05mg/kg, injection dexamethasone 0.1mg/kg and injection fentanyl 2 mcg/kg were given intravenously. Injection propofol in sleep dose of 1mg/kg was given and once the child was sedated, bag and mask ventilation were gently attempted to confirm a visible chest rise. After confirmation of successful bag mask ventilation, propofol infusion was commenced with 50-75mcg/kg/min and general anesthesia with spontaneous ventilation was maintained. Thereafter, an experienced anaesthesiologist performed a gentle check video laryngoscopy (VL) to assess the glottic chink view before administering a muscle relaxant for intubation.

To our complete surprise, the VL view revealed a complete laryngeal web obliterating the glottic view with just a small 1 cm opening through which the child was breathing and phonating. It was not possible to pass a neonatal flexible fibrescope (OD -3.5 mm) through this small opening, thus we requested the surgeons to use their rigid Karl Storz 70^0, 3 mm scope to go beyond the opening in the web and see the glottic view. The endoscope revealed normal vocal cords and glottic inlet, there was no oedema of the arytenoids and glottic chink was adequate with bilateral normal cords movement. Hence, we decided to do an on-table tracheotomy to troubleshoot our way out of this web obstacle.

Once tracheotomy was performed, and airway was secured, muscle relaxant injection atracurium 0.5mg/kg was given and general anesthesia was maintained with 30:70::O2:N2O and 2% Isoflurane. The ENT team then performed a complete web resection till full glottis could be visualised and subsequently oesophageal dilation was performed. Haemostasis was achieved and once spontaneous

respiration resumed, anaesthetic agent was stopped and residual muscle relaxant was reversed. The trachea was subsequently decannulated on table. The child was comfortable, vitals were normal and he was shifted to the PACU. This collaborative approach to troubleshoot the airway difficulty with the team of surgeons, without losing the airway at any point in time, helped prevent a "cannot intubate cannot ventilate situation" (Figure 1).

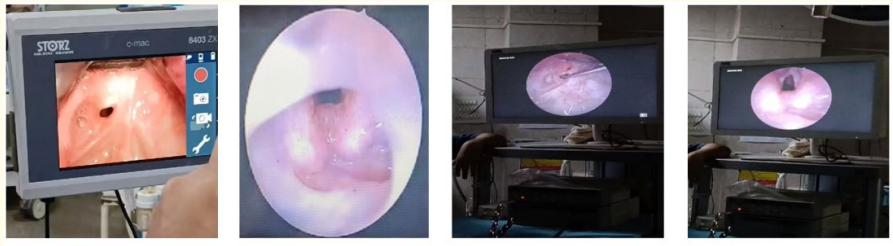

Figure 1: Case 1 Conduct Troubleshoot the laryngeal web to reach the trachea.

Case 2: Triangulated positioning for laryngoscopy

History and clinical assessment: An eight years old boy presented with a rapidly growing upper alveolus maxillary tumour covering the mouth opening since past 2 months. On airway assessment, there was a solid tumour mass with raw surface, measuring 10 cm by 5 cm that was completely obliterating the mouth opening in the frontal view with the head in neutral position. When we asked the child to open his mouth after a complete neck extension, we could see that a space could be created for laryngoscopy and endotracheal tube negotiation.

Surgical Plan - Excision of tumour and primary repair under general anesthesia

Airway related challenges

- Difficult mask ventilation with possibility of bleeding from the mass during mask placement and airway opening manoeuvre.
- With conventional direct laryngoscopy, laryngeal view may not visible due to overhanging mass.
- Introduction of laryngoscope blade and the endotracheal tube from head end would be technically difficult and may cause bleeding from the tumour mass.

Figure 2: Case 2 Midline maxillary osteosarcoma overhanging from the alveolar margin.

Securing the airway - In the operation theatre, after attaching all monitors, a 20-gauge intravenous cannula was secured. Premedication was given with injection midazolam 0.05mg/kg, injection dexamethasone 0.1mg/kg and injection fentanyl 2 mcg/kg.

Preinduction, the tumour mass was covered with a wet paraffin gauze to prevent bleeding during mask ventilation and intubation attempt. The child was preoxygenated using the closed circuit attached to an angle connector which was introduced through the right angle of the mouth since placing the mask on the face may have resulted in tumour bleed. Simultaneously, para-oxygenation was provided with nasal prongs at 4L/min. Injection propofol in sleep dose of 1.5 mg/kg was administered and spontaneous respiration was maintained.

Since laryngoscopy was not possible from head end and laryngeal view using a conventional direct laryngoscopy would be obscured by the mass, it was decided to use the VL. Being a difficult mask ventilation and intubation, we decided to use a unique approach, with more hands for more help. Three anaesthesiologists', positioned themselves in the form of a triangle around the head of the patient. The first anaesthesiologist (no. 1 in the image) positioned at the head end, performed a head tilt and chin lift to extend the neck, and used the other hand to gently lift off the tumour creating more oral space for insertion of the VL blade. The second anaesthesiologist (no. 2 in the image) stood at the caudal side of the patient's head and performed the gentle check video laryngoscopy to visualise the glottis. The glottic view revealed a Cormack Lehane grade 1 and VL blade removed.

Subsequently neuromuscular blockade was achieved with injection succinylcholine 2mg/kg IV and paraoxygenation was maintained throughout to provide apnoeic oxygenation. The second anaesthesiologist reintroduced the VL blade and glottic view was obtained, after which the third anaesthesiologist (no. 3 in the image) standing on the right side of the head end, navigated the 6.0 mm cuffed orotracheal tube from the side under VL view. These three anaesthesiologists created a triangular positioning around the patient's head.

ETT was connected to the breathing circuit and appearance of ETCO2 graph was confirmed and final tube position confirmed by bilateral air entry on chest auscultation. The tube was secured to the right angle of the mouth and the patient was handed over to the surgeons. Using a tongue depressor, the surgeons put in an oropharyngeal pack. Anaesthesia was maintained as per institutional protocol. The tumour was removed uneventfully and the wound defect was repaired with primary closure with a minimal blood loss of 200 ml. The oral pack was removed under vision, anaesthetic agents were stopped and residual neuromuscular blockade was reversed. Once spontaneous ventilation returned, and child was conscious, trachea was extubated. Vitals were monitored, child was comfortable and shifted to the post operative ward.

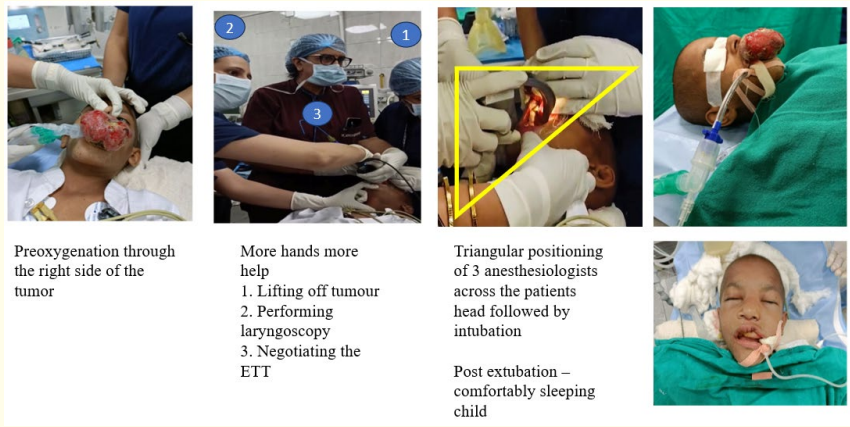

Figure 3: Case 2 conduct of airway management.

Case 3: Truncate the airway and surgical handling

History and clinical assessment: A 4 years old male child presented with a history of gradually increasing hoarseness of voice. An indirect laryngoscopy in the ENT OPD revealed papillomatous growths covering anterior one third of both the true vocal cords. The posterior two thirds of the glottic chink was clear (Figure 4). During the preanesthetic check-up, airway assessment showed a normal mouth opening, Mallampati grade 1, with a 6 cm thyromental distance and all routine investigations were normal.

Surgical Plan: Excision of papilloma and Injection Bevacizumab (humanized monoclonal antibody) into true vocal cords under general anesthesia.

Airway related challenges

- Possible loss of airway after induction with muscle relaxation due to loss of tone of the glottic structures and occlusion of glottic chink with the cord papilloma.
- Smaller space available for tube negotiation through the glottis and increasing number of intubation attempts may lead to cord oedema.
- Additionally prolonged and extensive surgical handling of the glottic area may worsen cord oedema.
- Prolonged vocal cord handling and intra-cord injection could lead to reduced glottic chink (cord oedema) making an on table extubation challenging.

Securing the Airway: In the operation theatre, after attaching all monitors, a 22 Gauge intravenous cannula was secured. The child was premedicated with injection midazolam 0.05mg/kg, injection dexamethasone 0.1mg/kg and injection fentanyl 2 mcg/kg and preoxygenation was started. The child became sedated without any signs of respiratory obstruction. Subsequently, a sleep dose with injection propofol 1mg/kg was administered while spontaneous ventilation was maintained; and adequacy of bag-mask ventilation was also confirmed.

An experienced anaesthesiologist performed a gentle check VL to visualise the glottic chink view before administering a muscle relaxant for intubation. The glottic view revealed an adequate chink between the vocal cords in the posterior two third area through which a smaller size tube could be negotiated. Hence, injection succinylcholine 2mg/kg IV was given to achieve neuromuscular blockade and to ensure optimal intubating conditions. A smaller size 4.0 mm microcuff ETT than the size appropriate for patient's age was negotiated through the glottis to avoid touching the papillomatous growths.

We requested the surgeon to use a truncated (shortened) approach during papilloma excision and vocal cord handling. Conventionally multiple attempts to excise the papilloma with attempst at achieving hemostasis is done by the surgeon. However, in this case the surgeon completed the excision in one go followed by pressure hemostasis (1:200000 epinephrine-soaked gauze) hence decreasing the duration and extent of surgical handling of the vocal cords in an attempt to reduce post procedure airway oedema. Once excision was complete, gentle suctioning was done just above the microcuff of the ETT distal to the vocal cords, to prevent any trickle below.

The vocal cords were then injected with injection Bevacizumab which led to cord swelling but lasted only for about 2-3 mins. Injection hydrocortisone 2mg/kg was administered intravenously and a gentle relook check laryngoscopy was done to ensure there was no cord oedema or any blood trickle post injection. After a thorough suctioning, we performed a cuff leak test to assess the airway's patency. Since a leak was detected by difference in the inspired and expired tidal volume, it re-emphasised that there was no cord oedema and an on table extubation could be attempted. Anaesthetic agent adminstration was stopped, residual neuromuscular blockade was reversed and 100% oxygen was administered. After the child regained consciousness and adequate spontaneous respiration, the trachea was extubated uneventfully. The child was nebulised in the post operative period with epinephrine saline and vitals were monitored.

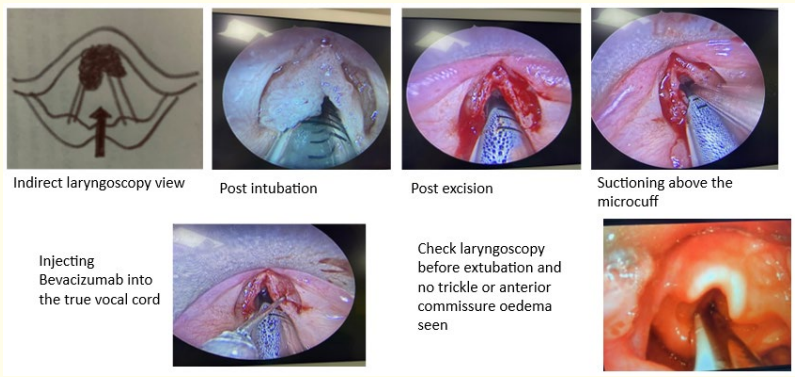

Figure 4: Case 3 Trucate surgical steps & shorten airway handling.

Discussion

The anticipated difficult airway can be classified into difficult mask ventilation, or difficult intubation, or both. Given the inability of children to cooperate during procedures, the possibility of using awake airway securing techniques in challenging airway cases is limited. While managing the paediatric difficult airway under general anesthesia, we may encounter further challenges such as the ones reported above requiring quick thinking and tailored multidisciplinary approach [3]. Troubleshooting these challenges involves a systematic approach that prioritizes patient safety and oxygenation.

While managing a difficult paediatric airway, our plan was guided by a series of questions like:

- If general anesthesia is attempted, can a patent airway with spontaneous ventilation and continuous oxygenation be maintained?
- Is bag and mask ventilation possible in my patient?
- Would it be possible to perform a check laryngoscopy for visualisation of the glottis?
- If yes, then which laryngoscope would be ideal - DL or VL?
- Should a surgical airway be electively performed or an emergent surgical airway be established if needed with the help of ENT surgical team in the OT?
- Can we successfully reverse anesthesia and extubate on table?

A successful outcome in all our patients was possible with the execution of a step wise plan and procedural preparation with availability of a paediatric difficult airway cart [4]. The use of a VL in all our cases was guided by the fact that it uses the principles of indirect laryngoscopy and does not require the alignment of oral, pharyngeal, and laryngeal axes for the successful visualization of the glottis. Additionally, the visualisation of the glottic chink on the monitor makes team effort possible for troubleshooting. It is now an important equipment which is being regularly used in the management of paediatric difficult airways and hence we decided to use it for laryngoscopy in all the three cases [5].

Multiple strategies have been used to create a more humane, but safe environment to secure the difficult airway in children. This includes the use of a sedation or general anesthesia technique for fibreoptic intubation or gentle check laryngoscopy followed by intubation if glottis is visualised. In all our three cases, we maintained spontaneous ventilation with unobstructed airway under general anesthesia while performing a gentle check VL to assess glottic view before deciding the next step [6].

We decided that the most experienced anaesthesiologist would perform the laryngoscopy to avoid multiple attempts at airway handling as literature suggests that the incidence of laryngeal oedema and laryngospasm becomes higher with increased number of

attempts in younger children [7]. Fiadjoe JE et al conducted a large multicentric study with the difficult paediatric airway, and found that more than two direct laryngoscopy attempts in a difficult intubation were associated with a high rate of failure and complications even among paediatric anesthesiologists [8]. Jagannathan N et al recommend that the number of direct laryngoscopy attempts should be minimized, and when direct laryngoscopy fails, an indirect technique such as video laryngoscopy or fibreoptic bronchoscopy should be attempted [9]. If initial attempts at laryngoscopy fail, focus should be on maintaining oxygenation with bag-mask ventilation, while considering alternative intubation techniques or devices.

In the first case, following the difficult airway algorithm, soon after the check video laryngoscopy revealed a complete laryngeal web through which securing the airway was impossible, we decided to secure a surgical airway in order to proceed with the surgery, and this prevented a cannot intubate and cannot ventilate situation.

An article by K Robbinson et al [10] helped us to plan the airway management of our second case. In their article, they talk about training flight nurses and respiratory therapists who performed intubation from the foot end of a patient which is known as "inverse intubation", in patients with limited access at the head end in air ambulances. We thought this approach could be successfully employed in our patient where the maxillary alveolar tumour growth was obstructing the oral cavity. This technique is a more advanced approach, requiring specific expertise and training. The use of a modification of the inverse intubation technique with triangulated positioning of three anesthesiologists around the patient's head end, was our innovation for successfully securing the airway. A backup rescue plan was kept ready with a surgical team standby for an emergency tracheostomy if intubation failed.

In the third case, factors such as repeated surgical handling of glottis, trickling of secretions, or blood, airway instrumentation could increase the risk of laryngeal oedema and laryngospasm both during intubation and extubation [7]. In order to minimize the risk of airway oedema during surgery on the vocal cords, we focussed on minimizing tissue trauma by truncating (shortening) both the airway and surgical handling of the cords and the peri-glottic structures. The most experienced anaesthesiologist managed the airway and the surgeon was requested to minimise the time of surgical excision and vocal cord handling. Additionally, we used dexamethasone 0.1mg/kg IV and adrenaline saline nebulisation for minimising airway oedema [11-13]. It was crucial to assess the patency of the airway with a cuff leak test before extubation, in order to identify the laryngeal oedema and post extubation stridor. This multidisciplinary and methodical approach helped us in successfully extubating our patient on table and prevented the need for post operative elective ventilation.

We were able to successfully secure the airway in the first attempt in all three cases through this 3T (Troubleshoot, Triangulate and Truncate) approach. Simulation training to acquire skills such as indirect video laryngoscopy and managing difficult airway case scenarios should be conducted to enable emerging anesthesiologists to navigate, innovate and troubleshoot their way through the paediatric difficult airway.

Conclusion

Meticulous planning, teamwork and innovations are the key to successful management of the paediatric difficult airway. Current difficult airway practice guidelines and recommendations should be reviewed and practiced routinely, so that we can be ready to act quickly when problematic airway scenarios arise and tailor our approach for successful management.

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