Revista Mexicana de Anestesiología

CLINICAL CASE
Vol. 31. No. 3 July-September 2008
pp 201-205

Subglottic stenosis secondary to endotracheal intubation in pediatrics, and airway management. A two-case presentation

Carlos Castillo-Zamora, MD;* Luz Castillo-Peralta, MD**

* Head of the Department of Pediatric Anesthesiology, Hospital Infantil de Tlaxcala. Investigador en Ciencias Médicas.
** Medic Assigned to the Department of Pediatric Anesthesiology, Instituto Nacional de Pediatría. Médico adscrito del Departamento de Anestesiología Pediátrica, Hospital Infantil de Tlaxcala.

Reprints request:
Carlos Castillo Zamora.
Departamento de Anestesiología,
Hospital Infantil de Tlaxcala
Calle 20 de Noviembre San Matías, Tlaxcala.
Teléfono. 2464651700 Extensión 255.
E-mail: caszam2002@yahoo.com

Received for publication: 15-01-07
Accepted for publication: 14-09-07

SUMMARY

Introduction: The acquired subglottic stenosis secondary to prolonged endotracheal intubation affect airway in patients pediatric should obstruction and reduced airflow in upper airway, result: hypoxemia, hypercarbia, respiratory acidosis and difficulty respiratory. The management anesthetic in patients is able complicated treat of intubation because a reduced cavity and who in occasions not accountant with sounding endotracheal and/or laryngeal mask airway of number appropriate, are to have though use resources alternative. Report two cases of patients with subglottic stenosis between 70 and 80%. Submit anesthetics technical with management airway in base of use sounding endotracheal and laryngeal mask airway ProSeal. **Conclusions:** The management anesthetic in patients with subglottic stenosis is important maintenance airway; avoid obstruction, desaturation and laryngospasm. The laryngeal mask airway ProSeal is an alternative in subglottic stenosis.

Key words: Subglottic stenosis, airway obstruction, laryngeal mask airway, resources.

RESUMEN

Introducción: *La estenosis subglótica adquirida, secundaria a intubación endotraqueal prolongada, afecta la vía aérea en pacientes pediátricos, ocasionando obstrucción y reducción del flujo de aire en la vía aérea superior, resultando: hipoxemia, hipercarbia, acidosis respiratoria y dificultad respiratoria. El manejo de estos pacientes puede complicarse al tratar de intubarlos ya que presentan una reducida cavidad y que en ocasiones, al no contar con las sondas endotraqueales y/o mascarilla laríngea del número adecuado, se tiene que recurrir a utilizar recursos alternativos poco comunes. Reportamos 2 casos de pacientes con estenosis subglótica entre 70 y 80% sometidos a técnicas anestésicas con manejo de la vía aérea basada en utilización de sonda endotraqueal y mascarilla laríngea ProSeal.* ***Conclusiones:*** *En el manejo anestésico del paciente con estenosis subglótica es importante mantener permeable la vía aérea, evitando obstrucción, desaturación y laringoespasmo. La mascarilla laríngea ProSeal es una alternativa más en estenosis subglótica.*

Palabras clave: *Estenosis subglótica, obstrucción de vía aérea, mascarilla laríngea, recursos.*

INTRODUCTION

Subglottic stenosis is defined as the decrease in the laryngeal diameter circumscribed by the inferior vocal chords (vocal folds) and the inferior edge of the cricoid cartilage. This disease affects soft tissues and/or cartilaginous structures.

According to its etiology, subglottic stenosis can be classified as congenital or acquired; the latter form due to endotracheal intubation, external trauma, upper tracheotomy, or chemical or thermal burn. Acquired stenosis differs from congenital stenosis because the first one is produced by complications in more severe medical treatments and worse management problems.[1,2]

Since thirty-five years ago, acquired subglottic stenosis (ASS), secondary to prolonged tracheal intubation as a measurement for ventilation support, has prevailed in clinical practices being one of the problems that affects airways, specially in pediatric patients[1,3].

Endotracheal intubation may injure larynx and trachea very seriously, and subglottic stenosis is the most dangerous post-intubation consequence. This problem often happens due to prolonged tracheal intubation at pediatric age[4].

The age of ASS presentation is, firstly, at 3-5 years in children, followed by children being from 0 to 2 years old, and finally from 6 to 15 years old[1].

Risk factors at endotracheal intubation, presenting a probable synergic effect for ASS, are: cricoid site as the injured place, since the upper airway is completely surrounded by its cartilage; early age; low weight; length of the endotracheal intubation; number of endotracheal intubations %every step of them increases mucosa harm risk; size of the endotracheal tube larger than the corresponding one; trauma at endotracheal intubation; absence of patient's sedation with endotracheal tube movement; improper fixing of endotracheal tube; movement causing traumatic ulceration after re-epithelization; failures at extubation; infections; hypotension; and hypoxia events[2,4].

Oral or naso-tracheal intubation does not appear to be a factor over ASS incidence. The designed endotracheal tube must be sterile and made of polyvinyl chloride or silastic (silicone plus plastic)[2].

Subglottic stenosis produces airflow obstruction and reduction in upper airway. This fact results in: hypoxemia (decrease in oxygen saturation), hypercarbia (increase in arterial carbon dioxide), respiratory acidosis and possibilities of respiratory difficulties[5].

ASS pathogenesis secondary to endotracheal intubation. The endotracheal tube produces ischemic necrosis through pressure over the cricoid membrane, what needs re-epithelization and cure. Data obtained from autopsy showed progressive ulceration and necrosis of the cricoid mucosa during the first hours and after some days of intubation, what establishes the destruction of the whole cricoid cartilage thickness[2].

The diagnostic is performed clinical record, and background of endotracheal intubation (injures to larynx). The signs and symptoms occur from one to 4 weeks after that, and they are related to airway, voice and feeding. Progressive respiratory difficulty is the first symptom of airway obstruction, with stridence, dyspnea, lack of air, and strong effort for breathing (with suprasternal, intercostal and diaphragmatic retraction), abnormal crying, aphonia, dysphagia, recurrent bronchoaspiration, and disability to extubation in intubated patients[2].

The endoscopic evaluation is performed by a flexible or rigid fiberscope, and larynx visualization is essential, with the subsequent surgery planning with regard to a specific lesion[1,2].

It is important that airway size be carefully measured through an endotracheal tube that fits the external dimensions and measuring peak pressure. If there is a lower than 10 cm of H_2O audible escape, the tube must be removed and replaced by a larger one. The escapeless peak pressure must be placed between 10 and 25 cm H_2O. The corresponding tube for the patient with subglottic stenosis should be compared to the ideal endotracheal tube for the patient's age, obtaining the obstruction percentage[2].

The grade of subglottic stenosis is determined by Cotton classification:

Grade 1: obstruction < 70%.

Grade 2: obstruction between 70 and 90%.

Grade 3: obstruction between 90 and 99%.

Grade 4: complete obstruction[1,4].

Treatment. In grade 1 subglottic stenosis, the following endoscopic methods are used: dilatations, laser beam, cryotherapy and steroid injection. These methods are useful when the lesions are present during the first weeks, but they are restricted by the emergence of dense collagen tissue. Tracheotomy and external reconstruction surgery, such as laryngotracheal reconstruction, is recommended in grade 2, 3 and 4 subglottic stenosis, respectively[1].

During the anesthetic management, it must be taken into account that patients are at risk of complications related to upper airway obstruction. Pre-operative sedation must be carefully administrated, and avoided in patients with severe subglottic stenosis. During induction, the patient is at risk of airway obstruction, desaturation, and laryngospasm. Respiratory depression may be caused by narcotics and/or benzodacepines[5].

The anesthetic handling of patients presenting ASS and subjected to diagnostic laryngoscopy through endoscope and/or tracheotomy, may present changes due to the absence of a safe and efficient airway.

We describe two cases of patients subjected to anesthetic techniques with airway management through endotracheal catheter and ProSeal Laryngeal Mask.

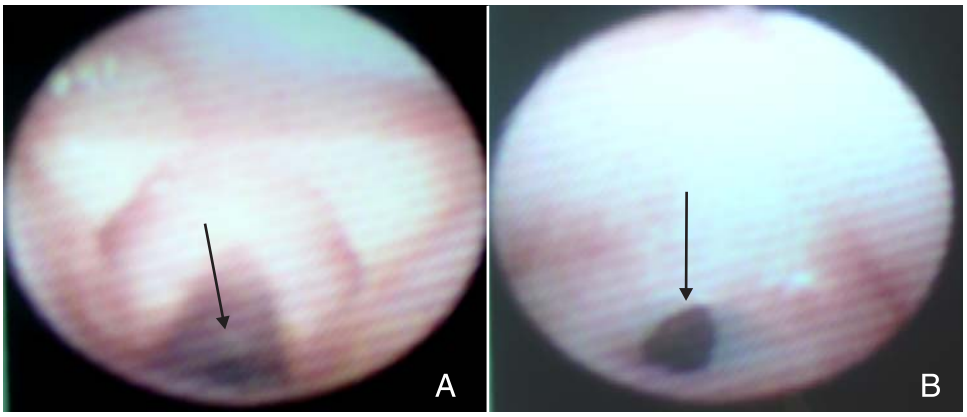

Figure 1. A and B. Laringoscopy with a flexible endoscope by 3.5 mm, subglotic stenosis is observed about 70%.

CASE 1

Male patient, being 1 year 3 months old, with ASS (Acquired Subglottic Stenosis) diagnostic, programmed for elective tracheotomy, and presenting the following important records:

- Hirschsprung disease at ten days of living, performing a colostomy under general anesthesia, with endotracheal intubation.
- A the age of 9 months, it was performed a colostomy closing, under general anesthesia, with endotracheal intubation.
- Four month later (13 months of age), it was performed an ileostomy through intestine perforation, under general anesthesia. This time, the patient was intubated for the third occasion and he coursed with septic shock; therefore, he had to stay intubated for the following ten days.
- The data about the endotracheal tube in the three previous intubations is unknown.
- Two months later, the patient was taken to a third-level hospital because he had presented respiratory laryngeal stridence, polypnea, respiratory frequency of 89-100x´, xiphoid retraction, intercostal pulling («pull-back») and cyanosis.

The patient was handled by inhaled general anesthesia: 2% halothane plus 3 Lx‘ oxygen. Once the peripheral vein was cannulated, the patient was given 100 μg IV atropine, which was maintained with ventilation automatism without endotracheal intubation, with 2-1% halothane. It was also performed a laryngoscopy by means of a flexible 3.5-mm laryngoscope, without achieving the passage through the subglottic lumen. Then the intervention was tried through a 2.0-mm-internal-diameter cannula, without achieving it.

Diagnostic: The patient presented Cotton II ASS, with an approximate obstruction of the 70% (Figure 1).

Conservative management treatment: The patient was treated by nebulized racemic epinephrine and dexamethasone, and he improved remarkably.

Figure 2. Endotracheal tube with an internal diameter of 1.8 mm designed with nelaton catheter (orogastric catheter) most of the endotracheal tube connector 2.0 mm, wich passed through the lumen of the subglottic stenosis.

- The following week (15 months old and 6.800 kilograms of weight), the patient was programmed for elective tracheotomy with Acquired Subglottic Stenosis diagnostic. He was subjected to balanced general anesthesia with the following initial vital signs: CF (cardiac frequency) 120x´, RF (respiratory frequency) 42x´, 95-60 mmHg AT (arterial tension), 98% SaO_2. After Intravenous induction with 100 mg of atropine, 30 mg of propofol 30 mg, with ventilation automatism, it was performed a direct laryngoscopy though Miller 1 sheet. It was tried to pass a 2.0-mm-internal-diameter catheter, without succeeding in this intervention. Endotracheal intubation was performed through a 1.8-mm-internal-diameter catheter, which was cut at about 15 cm-length and a connector of endotracheal 2 mm-tube was (Figure 2).

Table I. Comparison between endotracheal tube and orogastric catheter.

	Internal diameter mm	External diameter mm
Endotracheal tube 2.0	2.0	2.9
Orogastric catheter (nelaton) 8	1.8	2.6

Proper pulmonary ventilation was controlled, finding diminished bilateral thoracic expansion. The patient was maintained with 3Lx´ 100% O_2, 2-3% sevoflurane, 30 mg of propofol, 40 µg of fentanyl, with manual ventilation by Bain system with a respiratory frequency of 75-80 x´ by two pediatric anesthesiologists. The peak pressure was of 25-30 cm H_2O, $ETCO_2$ (End-Tidal Carbon Dioxide) 35-45 mmHg, SaO_2 (oxygen saturation) 97-99%.

The final vital signs were: CF, 104x´; AT, 100-60 mmHg; SaO2, 99%; RF, 28x´, with inherent ventilation automatism, normal gasometry, and two-hour anesthetic time.

CASE 2

Female patient being three years old, with probable ASS diagnostic, programmed for laryngoscopy by means of flexible fiberscope and according to findings at handling with the following important records:

- At the age of 2 years and 8 months, the patient coursed with pneumonia and endotracheal intubation assisted by mechanic ventilation for three days, with a 6-day hospital stay. The patient was discharged with dysphonia, stridence and difficult breathing; therefore, it was re-admitted and stayed intubated for 5 days, with a 24-day total hospital stay.
- The data about the endotracheal tube size at previous intubations is unknown.
- Three months after the aforementioned events, the patient was taken to a third-level hospital because she presented breathing difficulty, nasal flaring, thoraco-abdominal dissociation, xiphoid retraction, sibilant sound, stridence audible at distance, and intercostal pulling. The following parameters were recorded: Ph 7.36 gasometry; PO_2, 41; PCO_2, 46; HCO_3, 25, 76% SaO_2. The patient was treated with bronchodilatators and nebulizers. She improved considerably.
- Four days later, (when the patient was 3 years and weighed 27 lb (pounds) [12 kilograms], she was performed a laryngoscopy and tracheotomy. She entered the operating room in conscious condition and restless, on her own ventilation automatism, well-ventilated pulmonary areas, restless, on her own ventilation automatism, well ventilated pulmonary fields. She was pre-medicated with 1.5 mg of midazolam though peripheral venous route. The vital signs were stable: CF, 99X´; AT, 110-68 mmHg; SaO_2, 99%; RF, 26x´, It was practiced intravenous induction with 150 µg of atropine, 40 mg of propofol, 25 µg of fentanyl, maintenance with 3Lx´ of O_2, 3% sevoflurane through facial mask and ventilation automatism. It was practiced a laryngoscopy with a flexible 3.5-mm fiberscope, without succeeding in passing the subglottic lumen. It was required positive pressure due to the thoracic distension, observing abdominal distension too. The patient was diagnosed ASS with an obstruction of between 70% and 80%, Cotton grade II. During the elective tracheotomy, 40 mg of propofol, 50 µg of fentanyl, and after that, 3% sevoflurane were added, performing gastric draining with a nelaton #10 catheter, direct laryngoscopy with Miller sheet 2. After that, there was an attempt for passing an orotracheal catheter of 2.0-mm internal diameter, without succeeding in it. Then, a laryngeal ProSeal mask was applied, checking its proper positioning through the auscultation of the ventilated pulmonary fields with thoracic expansion. Then, it was applied a nelaton #10 catheter through the laryngeal mask, obtaining gastric juice (Figure 3).

Figure 3. ProSeal laryngeal mask # 2, by wich the catheter passes nelaton 10, to empty the stomach contents, ventilate power and positive pressure to the patient without abdominal distension.

The maintenance was carried out with 3Lx´ 100% O_2, 2-3% sevoflurane, and manual ventilation with pediatric circular circuit. Peak pressure of 20-25 cm of H_2O, RF of 40-45 x´, $ETCO_2$ of 38-44 mmHg, -99% SaO_2, CF of 100-88 x´, AT of 99-39 mmHg, and 99%.SaO_2.

It was decided to continue with the mechanic ventilation, controlled for pressure using PSVPro inside ventilator (Datex Ohmeda S/5 Aespire) with the same parameters as manual ventilation, observing an increase in $ETCO_2$ up to the 77%, despite the increased peak pressure up to 30 cm of H_2O, and FR to 45 x´. The peak pressure recorded by the monitor was of 18 and the respiratory frequency of 18x´. Due to those events, manual ventilation was kept all during the procedure. The final vital signs were: CF, 84x´; AT, 115-62 mmHg; RF, 20 x´; $ETCO_2$ 42 mm of Hg; and 99% SaO_2. It was given 150 mg of metamizol (dypirone) and normal gasometry practiced. The anesthetic time was of 2.5 hours.

DISCUSSION

Stenosis airway classification has been a problem during a long time. Endotracheal tubes are manufactured with a high quality and precision standard, and they may be used for the determination of airway obstruction size, inserting the endotracheal tube through the lumen, with a tolerance for normal peak pressure of 10 to 25 cm H_2O, compared to the proper age and the corresponding endotracheal tube size, according to the following formula: Internal diameter of endotracheal tube = (age in years/4) + 4. Through the use of the internal diameter of the endotracheal tube, the maximum percentage of obstruction can be determined[6,7].

Myer *et al*[6] established the percentage of obstruction with relation to the endotracheal tube size.

In the patient from case 1: the corresponding endotracheal tube would be 4.3 with regard to his age: one year and three months, however, in our patient, it was placed a nelaton catheter with an internal diameter of 1.8 mm corresponding to a 77.5% of subglottic obstruction, and presenting Cotton grade 2 classification with an obstruction of between 70% and 90%.

Endotracheal tubes, as any other tubes, offer resistance to airflow. The combination of cannula and connector may produce higher resistance than the one produced by the very same cannula. Cannula resistance can be reduced though increases of its diameter, as well as diminishing its length. Endotracheal tube affects breathing, decreasing the effective diameter of airways; therefore, it increases resistance to breathing[8].

Trachea airflow is turbulent. This way, tracheal resistance and pressure gradient required for maintaining flow cross, since the trachea is inversely related to the radius. The decrease of the diameter rate after intubation is calculated as: radius of the endotracheal tube divided by the radius of the trachea radius, in which pressure gradient may be increased[9]. In our patient, because of presenting ASS, the radius of the endotracheal tube, as well as the radius of the trachea, were reduced; therefore, there was an increase in resistance and the tracheal pressure resistance, requiring an increase in the peak pressure of 25 to 30 cm of H_2O, with an elevation of the CF of 75-80 x´, in order to keep proper oxemias and CO_2.

Regarding our patient from case 2, with ASS, the corresponding endotracheal tube would be 4.75 with relation to her age (3 years under normal conditions). There was an attempt to pass a 2.0-mm tube, without succeeding in it.. In case of achieving the passage of the tube through the stenosis, the percentage of obstruction would be of an 85%, with Cotton grade 2 classification and obstruction ranging from 70% to 90%.[6]

In a different way from classic laryngeal masks, ProSeal laryngeal mask presents a second lateral tube with an end in its extreme, which separates the gastric tract from the respiratory tract, allowing the access for fluid aspiration from the stomach, and reducing the risk of gastric insufflation and pulmonary aspiration[10,11].

We were able to control airway using ProSeal laryngeal mask with the use of manual ventilation and a peak pressure of 20-25 cm of H_2O.

CONCLUSIONS

At anesthetic management in patients suffering from ASS (acquired subglottic stenosis) secondary to prolonged intubation, the most important fact is to maintain a permeable route, avoiding obstruction, oxygen desaturation, $ETCO_2$, and laryngospasm.

The performed surgical procedures are: tracheal dilatations, elective or possibly urgent tracheotomy. If the nearest grade to stenosis is well known, the endotracheal tube that will pass through the stenosis lumen might be foreseen, and morbidity will be surely diminished. In patients with Cotton type 2 subglottic stenosis, ProSeal laryngeal mask may be an option for a safe management of airway through manual ventilation and with increased peak pressure.

REFERENCES

1. Cotton RT. Pediatric laringotracheal stenosis. J Pediatr Surg 1984;19:699-704.
2. Cotton RT. Management and prevention of subglottic stenosis in infants and children. In: Bluestone CD, Stool SE, Kenna MA, eds. Pediatric Otolaryngology, USA, WB Saunders Company. 1996:1373-1389.
3. Álvarez-Neri H, Penchyna-Grub J, Porras-Hernández JD. Primary cricotracheal resection with thyrotracheal anastomosis for the treatment of severe subglottic stenosis in children and adolescents. Ann Otol Rhinol Laryngol. 2005;114: 2-6.
4. Menighini L, Zadra N, Metrangolo S. Post-intubation subglottic stenosis in children. Risk-factors and prevention in pediatric intensive care. Minerva Anesthesiol 2000;66:467-472.
5. Blum HR, Mcgowan XF. Chronic upper airway obstruction and cardiac dysfunction: anatomy, pathophysiology and anesthetic implications. Paediatric Anaesthesia 2004;14:75-83.
6. Myer III CM, O'Connor DM, Cotton RT. Proposed grading system for subglottic stenosis based on endotracheal tube side. Ann Otol Rhinol Laryngol 1994;103:319-324.
7. Kettrick RG, Ludwing S. Resuscitation: pediatric basic and advanced life support. In: Fleisher GR, Ludwing S, eds. Textbook of pediatric emergency medicine. Baltimore, MD: Williams & Wilkins, 1983;pp1-30.
8. Doyle DJ. O´Grady FK. Physics and airways. In: Benumof JL American Anesthesiology Clinics (*Clínicas de Anestesiología de Norteamérica*). Airway problems: Part 1. 1995;13(2):251-277.
9. Bock KR, Silver P, Rom M. Reduction in tracheal lumen due to endotracheal intubation and its calculated clinical significance. Chest 2000;118:468-472.
10. Brain AIJ, Verghese C, Strube PJ. The LMA ProSeal -a laringeal mask with an oesophageal vent. Br J Anaesth 2000;84:650-654.
11. Wheeler M. ProSeal™ laryngeal mask airway in 120 pediatric surgical patients: a prospective evaluation of characteristics and performance. Paediatric Anaesthesia 2006;16:297-301.