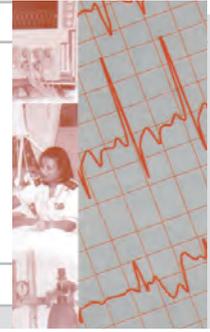


Post-extubation stridor in children

A case report and review of the literature



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We describe a case of post-extubation stridor in a 3-year-old child who had suffered multiple trauma. Post-extubation stridor is a not uncommon sequel of intubation in children. We review the literature on this complication and give recommendations on its prevention, prediction and management. Unplanned extubations, high 'cuff' pressures and movement of the tube in the trachea are the important risk factors. Although the 'cuff-leak test' has been proposed to predict post-extubation stridor, this test is unreliable in the younger child. Management has been by racemic adrenaline and steroids, but evidence to support this practice is lacking.

Failed extubation is an undesired event in children who have required ventilation, as it is associated with a higher complication rate (difficult re-intubation, increased length of stay in the intensive care unit (ICU) and higher mortality). Kurachek *et al.*,¹ in a multicentre study including 2 794 children, reported a failed extubation rate of 6.2%. The reasons for failed extubation included pulmonary dysfunction, respiratory muscle weakness, haemodynamic instability and neurological impairment. In 37% of cases in this study upper airway obstruction as a result of damage to the mucosa of the larynx and trachea was responsible for the need for re-intubation.

Case report

A 3-year-old boy was referred to the Trauma Unit at Inkosi Albert Luthuli Central Hospital, Durban, after being hit by a car as a pedestrian. After clinical and computed tomographic evaluation the following injuries were noted: base of skull fracture and small intraventricular bleed with a Glasgow Coma Scale of 9/15, bilateral lung contusions, and an intertrochanteric fracture of the right femur (Injury Severity Score 29).

Although the child initially managed well on a 40% oxygen mask, he deteriorated in the course of the night and required intubation (size of tube unknown). The child was sedated with midazolam and ventilated using synchronised intermittent mandatory ventilation with pressure control. On day 5 the child extubated himself, and required re-intubation using a size 4 uncuffed tube. By day 8 he had recovered sufficiently to warrant

extubation. He developed post-extubation stridor and tachypnoea requiring re-intubation. Of note was that a size 3.5 tube needed to be used because of 'airway oedema'. Copious secretions from the endotracheal tube were also noted. The patient was started on 4-hourly adrenaline nebulisations.

On day 14 another attempt at extubation was undertaken. However, again the child needed to be re-intubated because of signs of respiratory distress (chest recessions, tachycardia and laboured breathing). He was re-intubated using a size 4 uncuffed tube. A further attempted extubation on day 16 also failed, and on day 18 he was taken to theatre by the otorhinolaryngologist for an examination of the upper airway. There was extensive granulation tissue in the area of the vocal cords and marked mucosal inflammation in the trachea. The granulations were trimmed and the patient re-intubated nasally with a size 4 tube. Adrenaline nebulisations and dexamethasone were administered postoperatively. A trial of extubation 5 days later again failed, and a tracheostomy tube was inserted. Two weeks later the granulations and subglottic oedema had resolved and the patient was successfully decannulated.

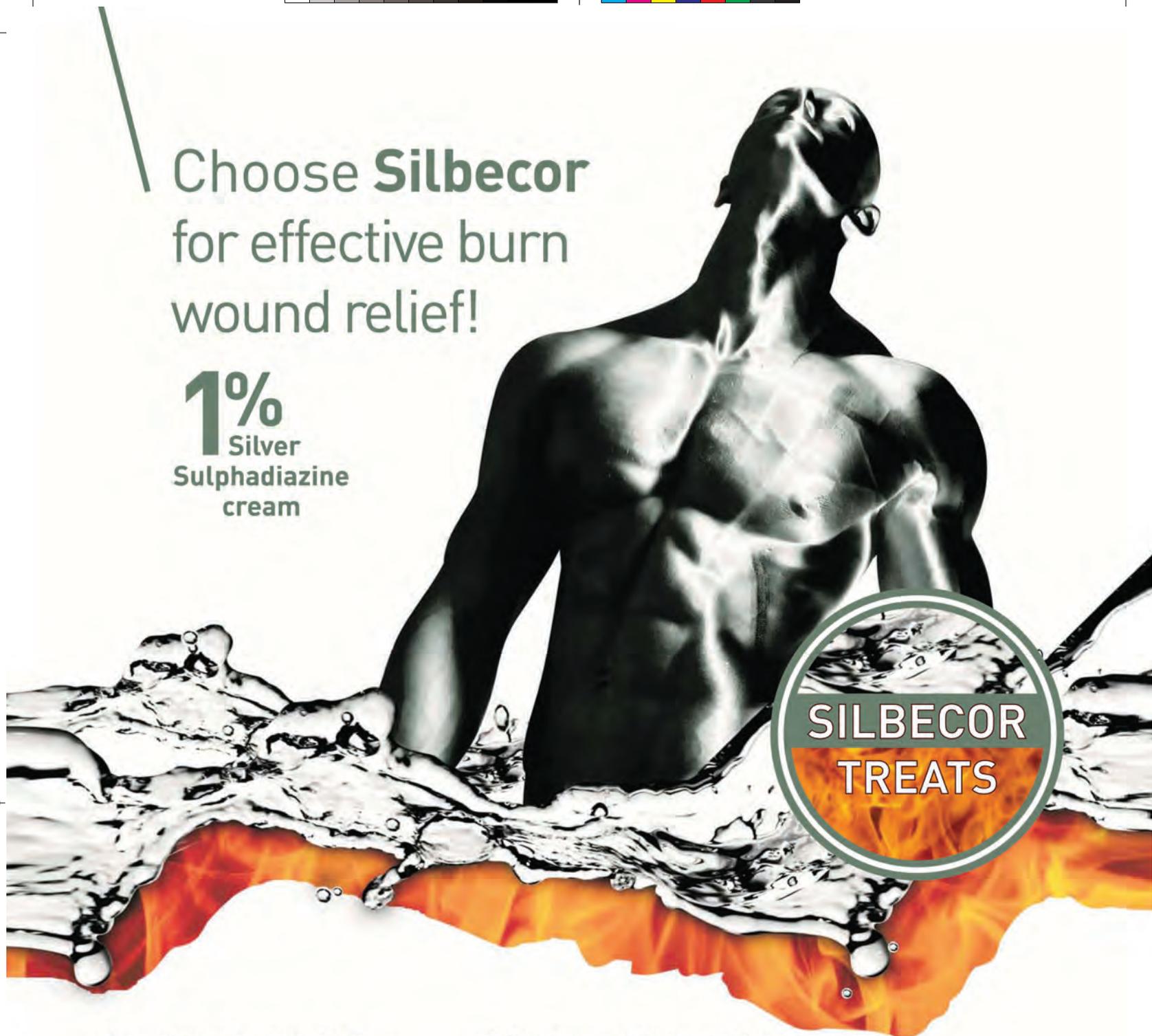
Discussion

Post-extubation stridor is a well-recognised complication of intubation lasting more than 24 hours, although it has been described after shorter periods. In fact, the first reports of 'post-extubation croup' (i.e. hoarseness, stridor and critical airway



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obstruction) were all in children who were extubated after anaesthesia requiring endotracheal intubation for surgical procedures.² Children are particularly at risk because of their narrower airway. Pathologically, post-extubation stridor is associated with nonspecific changes such as laryngeal oedema, formation of granulations and ulcerations. Although most cases resolve spontaneously with correct medical treatment, a minority develop more serious complications, including subglottic or tracheal stenosis, necrotising tracheobronchitis or tracheal perforation.

Incidence

In the earlier series of post-extubation stridor after anaesthesia, as reviewed by Koka *et al.*, the incidence was reported as 1.6 - 6%.² In Koka's own series the incidence was low in infants, reached a peak in the 1 - 4-year age group, and then decreased as children grew older.

Risk factors and prevention

The risk factors for development of post-extubation stridor are:

- **Patient-related factors.** Pre-existing tracheal irritation (gastro-oesophageal reflux, upper airway infection) or narrowing. Harel *et al.* found that neurological impairment was a better predictor of extubation failure in the paediatric ICU than upper airway lesions.³
- **Tube- and intubation-related factors.** Incorrect size, cuff pressure too high, traumatic intubation, repeated attempts at intubation.
- **Care-related factors.** Traumatic or multiple intubations, tube not fixed properly allowing excessive movement in the trachea, inadequate analgesia and sedation, patient who is trying to speak, too-aggressive tracheal aspiration and presence of a nasogastric tube.

Attention to the following details would therefore be successful in reducing the incidence of this complication:

Using the right tube

The optimal diameter of the tracheal tube used for children is determined by the opposing concerns of, on the one hand, an increasing airway resistance with increasingly smaller tubes, and ischaemic damage to the trachea with tubes of increasing diameter. Commonly used formulas for determining tube diameter are (age in years/4) + 4 for uncuffed tubes, and (age in years/4) + 3 for cuffed tubes. It should be appreciated that these formulas calculate the inner diameter of the tube, while it is the outer diameter that is important for the laryngeal and tracheal damage. There are

large differences in outer diameters between tubes of different manufacturers with the same internal diameter.⁴

Since the development of high-volume, low-pressure cuffs, cuffed endotracheal tubes are now considered safe for children under the age of 8 years, and are used increasingly.⁵ However, this makes it imperative that cuff pressures are rigorously monitored and kept at or below 20 cm H₂O. This implies that if the child is ventilated with inspiratory pressures above 20 cm above positive end-expiratory pressure (PEEP), leakage around the cuff should occur.⁴

Preventing friction of the tube in the trachea⁶

It is important to secure the tracheal tube properly. If strapping is used the tube should be fixed to the upper jaw rather than to the more mobile lower jaw. Nasotracheal intubation is associated with less friction than oropharyngeal intubation, but this benefit must be weighed against the disadvantages of the former, such as an increased risk of sinusitis. Kurachek *et al.*, however, did not find a difference in re-intubation rate between oral and nasal intubation.¹ Unnecessary movement of the child's head must be avoided, as this results in movement of the tube in the trachea.

Of equal importance is to prevent the child struggling while intubated. This almost always involves the use of sedation, for instance by a continuous midazolam infusion. It is particularly important to prevent the intubated child from coughing or straining.

Prevention of unplanned extubation

An unplanned extubation refers to the displacement or removal of an endotracheal tube either by the patient (self-extubation, treatment interference) or accidentally by medical personnel (e.g. while moving the patient). In a series of 96 unplanned extubations in adult trauma patients reported on by Christie *et al.*, re-intubation, usually within the hour, became necessary in 56% of patients, and 20% of these were difficult (i.e. requiring multiple or prolonged attempts or fiberoptic bronchoscopy).⁷ Risk factors for unplanned intubation in adults include agitation, confusion, lack of physical restraints, previous treatment interference and use of an oral as opposed to a nasotracheal tube.⁸ In a review of 55 unplanned intubations in 1 004 intubated patients in a paediatric ICU, Marcin *et al.* identified patient agitation and a patient-to-nurse ratio of 2:1 instead of 1:1 as the main risk factors.⁹ Chemical and physical restraints are often employed in order to prevent unplanned extubations, but the efficacy of these interventions remains controversial.¹⁰ Tung *et al.* reported that patients who self-extubated received benzodiazepines such as midazolam more often than intubated patients who did not suffer unplanned extubation, but it is unclear if this was merely an



indicator of a higher requirement for sedatives in a more agitated cohort, represented ineffectiveness of benzodiazepine sedation to prevent unplanned extubation, or was due to paradoxical agitation on benzodiazepine therapy.⁵ The same authors also reported that physical restraints were used more often in patients who self-extubated than in those who did not. International comparison suggests that countries with low patient-nurse ratios use less physical restraints. This confirms that the best way to prevent unplanned extubation is an experienced nurse who does not go out of sight of the patient. Daily interruption of sedation does not seem to increase the incidence of unplanned extubations.¹²

Steroids

A number of studies have addressed the use of prophylactic steroids given 6 - 12 hours before extubation. The Cochrane review of 2008¹³ reviewed 2 studies in neonates, 2 in children and 5 in adults. Although there was a trend towards fewer re-intubations in neonates and adults pretreated with steroids, which was more pronounced in patients at high risk, this never became statistically significant. The two studies in children provided contradictory results. The authors concluded that there is no evidence that prior treatment with steroids reduces re-intubation rates in children and neonates. Although total numbers are small the trend towards fewer intubations warrants further study. This is in contrast to the 2002 study by Markovitz and Randolph, who looked at the same studies but included a further study in neonates and concluded that steroids did significantly reduce the incidence of post-extubation stridor in children and neonates.¹⁴

The cuff-leak test

In 1987 Adderley and Mullins recommended the presence of 'leak' around the endotracheal tube as an indicator of successful extubation in children who had required intubation for viral croup.¹⁵ In their study they defined 'leak' as the presence of one of the following: vocalisation around the tube, an air leak heard with the child coughing, or an air leak demonstrated during positive-pressure ventilation with an inspiratory pressure of 40 cm H₂O. Sandhu *et al.*, in a study of adult patients that attempted to quantify the leak, used a leak of less than 10% of the tidal volume (V_T) before the cuff was deflated (V_T before inflation - V_T after deflation = >10% of V_T) to predict post-extubation stridor.¹⁶ In their series of 97 patients, 6 out of the 13 patients who developed post-extubation stridor required re-intubation. Chung *et al.*, using a tidal volume of 10 ml/kg, found that a leak of 140 ml was indicative of the presence of severe laryngeal oedema as noted on bronchoscopy during percutaneous tracheostomies for patients on long-term mechanical ventilation.⁶ The authors noted bronchoscopic findings of tracheal

granulation tissue or ulcerations in 32 and severe laryngeal oedema in 35 of their 95 patients. However, it is uncertain how many of their patients would have developed post-extubation stridor or would have required re-intubation for upper airway obstruction had they been extubated.

Recently, however, the cuff-leak test has been reported to be unreliable in the younger child. Mhanna *et al.* in a study in children intubated in a paediatric ICU defined a positive leak test as the presence of an audible air leak at an inspiratory pressure of 20 mmHg.¹⁷ They found the cuff-leak test to be unreliable in children under the age of 7, while in older children a negative leak test was predictive of a higher risk of extubation stridor. Although only a third of their patients under the age of 7 had a cuffed tube, for this subgroup the predictive value of the air leak test was not different. Souminen *et al.* recently studied a group of children aged 0 - 10 years (median age 0.9 years) who had undergone cardiac surgery and were intubated with uncuffed tubes for a mean of 38 hours.¹⁸ A positive leak test was defined as an audible leak at an inspiratory pressure of 25 cm H₂O or more. Again they did not find the air-leak test reliable in predicting post-extubation stridor and the need for re-intubation in this age group.

It should be appreciated that there is a reciprocal relation between the air leak test as defined in the preceding two studies and laryngeal damage. If there is no air leak at an inspiratory pressure of 20 cm H₂O this implies that the pressure of the endotracheal tube on the mucosa is >20 cm H₂O. Cuff pressures above 30 cm H₂O in adults, and possibly lower in children, cause mucosal ischaemia. It should be appreciated that similar damage can be caused by uncuffed tubes that are too large for the child's age, or in the presence of laryngeal oedema. The cuff-leak test has therefore also been recommended as an adjunct to selecting the correct sizes of endotracheal tube in children. In this case the test is performed immediately after intubation of either a cuffed or an uncuffed tube.¹⁵

Management

As the title of the article by Koka *et al.*² indicates, from an early stage post-extubation stridor was understood as similar to viral croup, and treatment along similar lines recommended. Mild cases can be managed by reassuring the child and giving supplemental oxygen. If the child is crying the flow through the narrowed trachea changes from a laminar to a turbulent pattern, which is associated with a tenfold decrease in flow rate. The child should be sat up in Fowler's position or even be allowed to sit on the caregiver's lap. Although 'steaming' (running taps) has not proven to be of benefit in viral croup,¹⁹ supplemental oxygen should be humidified.

The use of aerosolised racemic adrenaline in the management of post-extubation failure was advised

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because of its effect in viral croup. The adrenaline was administered either via a facemask when the child was extubated, or through the endotracheal tube when re-intubation had been performed.² There are, however, no studies of its efficacy in post-extubation failure. Adrenaline will only be effective in laryngeal oedema but not for the management of the child with granulations or ulcerations of the laryngo-tracheal mucosa. The recommended dose is 0.5 ml of a 2.25% solution of racemic adrenaline in 3 ml of normal saline. Nebulisations can be repeated up to 3 times.²⁰

Steroids have been successfully used for the treatment of viral croup and are therefore often prescribed for extubation stridor. The only study addressing the use of dexamethasone for children in extubation stridor is that by Harel *et al.*³ This is a small randomised controlled trial including 32 children who failed extubation and required re-intubation. Dexamethasone or placebo was administered from 6 hours before to 12 hours after the planned second extubation. Three out of 12 patients receiving dexamethasone and 5 of 11 receiving placebo failed their second extubation. This difference did not reach statistical significance. However, the authors found that the reason for extubation failure in their patient group was more often neurological impairment than laryngeal oedema or subglottic stenosis, and it is therefore uncertain whether their findings can be taken as representative of all patients suffering from post-extubation stridor.

If re-intubation is required, use of a smaller uncuffed tube is recommended to avoid additional trauma to the airway. Some authors advise nasotracheal intubation to optimise securement and tube stabilisation.²¹

Conclusions

Post-extubation stridor is a not uncommon complication of both short- and long-term intubation in children. This complication may be prevented by paying attention to the details of paediatric intubation (correct tube, correct fixation), by repeated measurements of cuff pressure when a cuffed tube

is used, and by adequate sedation of the agitated patient. Steroids have not shown to be significantly effective in preventing post-intubation upper airway obstruction. Management is by providing a reassuring environment, oxygenation and re-intubation with a smaller-size tube where necessary. Although racemic adrenaline and steroids have traditionally been used in the management of this complication, their efficacy has not been proven in clinical trials.

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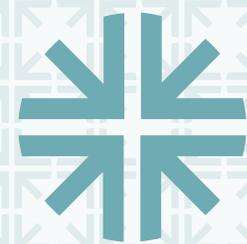


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