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ORIGINAL ARTICLE

Gentle chest compression relieves extubation laryngospasm in children

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Abstract
Purpose Extubation laryngospasm is frequently encountered in children undergoing upper airway surgery. Different drugs and techniques have been used for its treatment. The objective of this study was to examine gentle chest compression as an alternative to standard practice for relief of laryngospasm.
Methods This study was conducted over 4 years on all children scheduled for elective tonsillectomy. During the first 2 years, extubation laryngospasm was managed with 100% O_2 with gentle positive pressure ventilation via a tight-fitting face mask (Standard-Practice Group), whereas in the following 2 years; laryngospasm was managed with 100% O_2 and concurrent gentle chest compression (Chest-Compression Group). In both groups, if the spasm was not relieved and oxygen saturation decreased to 85%, IV succinylcholine was administered with subsequent manual ventilation.
Results During the 4-year study period, 1226 children aged 3–12 years were studied. In the chest-compression group, 46/594 children (7.8%) developed laryngospasm compared with 52/632 children (8.2%) in the standard group ($P = 0.84$). Significantly more children who developed laryngospasm were successfully treated by chest compression 34/46 (73.9%) compared with those managed by the standard method 20/52 (38.4%); ($P < 0.001$). None of the children in the chest-compression group developed gastric distension compared with 45/52 (86.5%) in the standard group.
Conclusion Gentle chest compression with 100% oxygen is a simple and effective technique for immediate management of post extubation laryngeal spasm in children.

Keywords Chest compression · Extubation laryngospasm · Children

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Introduction

Extubation laryngospasm occurs more commonly in the pediatric population, with an incidence of 1.7% in the first 9 years of life [1]. There is a close association between laryngospasm and the type of surgery. Tonsillectomy and adenoidectomy have the highest incidence of extubation laryngospasm (21–26%) [2–4].

Because it is a life-threatening complication [1, 5], laryngospasm should be treated immediately. The standard management is maintaining a clear airway while using 100% oxygen with continuous positive airway pressure (CPAP) via a tight face mask [6, 7]. If this is ineffective, then succinylcholine is advised followed by subsequent manual ventilation with or without intubation [8, 9].

Chest compression for management of laryngospasm has been reported in the literature [5, 10], but no published trials have examined its effectiveness. It has some logical basis [11, 12] and was found to be effective in the management of anecdotal cases performed on a pilot basis in our institute. Additionally, chest compression was found effective in the management of severe asthma [13], and the proposed mechanism seems to be of value in cases of laryngeal spasm also. We hypothesized that gentle chest compression with 100% oxygen effectively relieves

extubation laryngospasm in children following adenoidectomy and/or tonsillectomy.

Methods

Following approval of the Research and Ethics Committee of the Anesthesia Department of King Fahd Hospital of the Dammam University, and informed parental consent, this prospective study was conducted over a period of 4 years (January 2004–2008) on all the children with ASA physical status I and II, who were scheduled for elective tonsillectomy with or without adenoidectomy under general anesthesia. Exclusion criteria included: history of asthma, upper respiratory tract infection in the previous 3 months, or exposure to smokers in the household. Because laryngospasm is an emergency that requires an immediate management, the policies and procedures (P&P) committee of the anesthesiology department in our institute required the technique to be fixed over a period of time and not changed from case to case. The cases were, thus, studied in a sequential manner with laryngospasms occurring in the first 2 years managed with the standard technique [6, 7] (Standard-Practice Group) and laryngospasms developing in the next 2 years managed with the chest compression technique (Chest-Compression Group). Both study groups were managed by the same researchers. The attending consultant anesthesiologists anesthetized the patients, one of the researchers managed laryngospasm according to the study protocol, and a third anesthesiologist who was naive to the objective of the study evaluated the efficacy of each technique. In both groups, anesthesia was induced with IV fentanyl 2 μg/kg and propofol 3 mg/kg. Endotracheal intubation was facilitated with rocuronium 0.6 mg/kg. Anesthesia was maintained with sevoflurane in a mixture of 70% nitrous oxide in oxygen. On finishing the operation, residual blood and secretions in the pharynx were carefully suctioned, and the patients were then turned to the lateral (recovery) position. Sevoflurane and nitrous oxide were then discontinued while positive pressure ventilation was continued using 100% oxygen until regular spontaneous ventilation returned following reversal of muscle relaxants. Absolutely no stimulation was allowed until the patients spontaneously woke up. Tracheal extubation was performed when the patients were able to open their eyes [3].

Laryngospasm was defined as a situation in which mask ventilation is difficult even with proper maneuvers, and the situation is frequently associated with varying degrees of airway obstruction with paradoxical chest movement, intercostal recession, and tracheal tug with or without characteristic noise after extubation. In the Standard-Practice Group, laryngospasm was treated with 100% O_2, CPAP, and gentle PPV via a tight-fitting face mask. In the Chest-Compression Group, the patients were managed with 100% O_2 via a tight-fitting face mask and immediate gentle chest compression, using the extended palm of the free hand placed on the middle of the chest, with the fingers directed caudally and performing a compression force half or less than half that used for cardiopulmonary resuscitation (CPR) at a rate of approximately 20–25 compressions per min. The force and rate of chest compressions were extrapolated from successfully managed pilot cases, and these guidelines were made available for all researchers. In both groups, if the spasm was not relieved and oxygen saturation decreased to 85%, succinylcholine (0.5 mg/kg IV) was administered with subsequent manual ventilation with or without intubation. The level of desaturation at which succinylcholine was administered was recommended by the P&P Committee. In both groups; the total number of children enrolled in the study, the number of children who developed laryngospasm, those who were successfully treated with either technique and those who required succinylcholine to relieve the spasm and the occurrence of any complications (gastric distension, aspiration, arrhythmias, negative pulmonary edema, and cardiac arrest) were recorded.

Statistical analysis

The period of recruiting cases for each study group was based on a study of the incidence of laryngeal spasm in our hospital data base, aiming at recruiting at least 37 cases in each study group. This number of cases was calculated with the objective of doubling the success rate of the initial management of laryngeal spasm from 35% [6] to 70% with type I error of 5% and type II error of 20%. The results of the study were examined routinely by the P&P committee to ensure the study technique was effective. Following verification of normal distribution using the Kolmogorov–Smirnov test, continuous data were analyzed using an independent samples t test. Chi-squared or Fisher's exact tests were used to compare the incidence of laryngospasm and the treatment success rate. Data were expressed as mean ± SD, ratio, or percentage. A P value <0.05 was considered significant. Analysis was performed using Statistica software version 7.0 for windows (Statsoft).

Results

During the study period, 1226 children aged 3–12 years were enrolled (632 children in the Standard-Practice Group and 594 children in the Chest-Compression Group). In the Chest-Compression Group, 46/594 children (7.8%) developed laryngospasm compared with 52/632 children (8.2%) in the Standard-Practice Group ($P = 0.84$) (Table 1). The

Table 1 Characteristics of children and treatment outcome

	Standard-Practice Group ($n = 632$)	Chest-Compression Group ($n = 594$)	P value
Age (years)	6.58 ± 2.49	6.4 ± 2.47	0.20
ASA grading			
I	440 (69.7%)	419 (70.6%)	0.77
II	192 (30.3%)	175 (29.4%)	
Gender			
Male	341 (54%)	309 (52%)	0.53
Female	291 (46%)	285 (48%)	
Type of surgery			
Tonsillectomy	492 (77.8%)	461 (73%)	0.97
Adenotonsillectomy	140 (22.2%)	133 (27%)	
Patients developing laryngospasm	52 (8.2%)	46 (7.8%)	0.83
Patients successfully treated	20 (38.4%)	34 (73.9%)	0.0005
Patients developing gastric distension	45 (86.5%)	None	<0.0001

Values are mean ± SD or number (percentage)

number of these patients who were successfully treated with chest compression 34/46 (73.9%) was significantly higher than those in the Standard-Practice Group 20/52 (38.4%), ($P < 0.001$). In the remaining children; 12/46 of the chest-compression group and 32/52 of the standard group, the spasm was treated with IV succinylcholine. None of the children in the Chest-Compression Group developed gastric distension compared with 45/52 (86.5%) children in the Standard-Practice Group. No other complications were recorded in both groups.

Discussion

The principal finding in this study is that chest compression with 100% O_2 via a tight-fitting face mask was effective in relieving extubation laryngospasm in most children (73.9%) after tonsillectomy or adenoidectomy surgery. Additionally, none of the patients managed by chest compression developed gastric distension compared to 86.5% of children in the Standard-Practice Group.

The mechanism of chest compression in the relief of laryngospasm is unknown. However, some mechanisms may be proposed. First, in laryngospasm, either the true vocal cords alone or the true and false vocal cords become opposed in the midline and close the glottis. When the true vocal cords are in opposition, they prevent the entrance of air, but not its exit, whereas apposition of false vocal cords was capable of preventing both entrance and exit of air [11]. Chest compression pushes air in the lung to act directly on the vocal cords to relieve the spasm. In cases of true vocal cord opposition; chest compression will force the air through a small lumen left open at the posterior commissure of the vocal cords. This will ensure ventilation and gas exchange between air trapped in the lung and oxygen in the pharynx, which will cause rapid relief of laryngeal spasm. In complete laryngeal spasm, in which both true and false vocal cords are opposed, our technique could help in converting complete to partial laryngeal spasm as air force from below could push the area just above the false cords away from each other, opening the entrance of the larynx. Second, chest compression stimulates fast, shallow breathing with or without increases in minute ventilation [12, 14–16]. This increased respiratory drive has been suggested as the mechanism of action [17]. Third, the Hering–Breuer deflation reflex, which is mediated via the vagus nerve, might be activated. It is initiated either by stimulation of stretch receptors or stimulation of proprioceptors activated by lung deflation. The impulses through the vagus nerve, would favor relaxation of the vocal cords [18].

In this study, the success rate of laryngospasm relief in the Standard-Practice Group was 38.4% which is similar to that in a previous study [6] in which the success rate was 35%. Several reasons can explain the low success rate and the high incidence of gastric distension (86.5%) with the standard management of laryngeal spasm. Attempts to provide positive-pressure ventilation with a face mask may distend the stomach, splinting the diaphragm, thus delaying hypoxia resolution [19, 20]. Additionally, in complete spasm, positive pressure ventilation may make the situation worse by forcing the area just above the false cords against each other closing the entrance to the larynx [21, 22]. Nonetheless, there is a lack of level I evidence-based consensus to support the standard technique as a definitive procedure for the management of laryngospasm [23].

In our study, we used 0.5 mg/kg succinylcholine to ensure its effectiveness and to avoid bradycardia of a larger

dose. Some authors have shown that succinylcholine 0.1 mg/kg was successful in treating the laryngospasm [8]. The point at which trials were terminated and succinylcholine was administered was decided by the P&P committee in view of patients' safety and the novelty of the technique.

This study has some limitations. First, the study was not randomized. However, laryngospasm is an emergency which requires a clear management procedure that should be fixed over a period of time to avoid confusion in a critical situation. Second, the study was lacking a control group because intervention occurred in both groups. However, in such cases, exposing the patients to intervention believed to be inferior to current treatment is often thought unethical. Because the results of our study were promising, further scientific validation in the form of a prospective randomized double-blind study is warranted to determine the true efficacy and safety of gentle chest compression in the treatment of postextubation laryngospasm. Third, we did not record the time course of laryngospasm with each treatment and further studies are required to outline this issue. Last, although the force and rate of chest compressions in this study were determined in a pilot study, the optimum rate and force should be examined in future studies.

In summary, gentle chest compression with 100% oxygen via a tight-fitting face mask is an effective method for immediate management of extubation laryngospasm.

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