Evaluation of routine tracheal extubation in children: inflating or suctioning technique?

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Summary
We studied prospectively the effects of the technique of tracheal extubation on arterial haemoglobin oxygen saturation ($S_{pO_2}$) in 120 ASA I–III children, mean age 5.3 (range 0.25–16.9) yr. At completion of surgery, tracheal extubation was performed when spontaneous ventilation had resumed, children were fully awake and $S_{pO_2}$ was 99–100%. Children were allocated randomly to receive a single lung inflation manoeuvre with 100% oxygen before tracheal extubation (group I; $n=59$) or to have the tracheal tube removed while applying suction through the tube (group S; $n=61$). $S_{pO_2}$ was monitored during the first 5 min after tracheal extubation in the operating room. Supplementary oxygen was given if $S_{pO_2}$ decreased to less than 92%. The time between tracheal extubation and decrease in $S_{pO_2}$ to 92% (T92) was recorded. Children in group S required oxygen administration more frequently after tracheal extubation than those in group I (65.6% vs 45.8%; $P=0.04$), and had a three-fold shortening of T92 (mean 25 (SD 19) s vs 85 (63) s; $P=0.0001$). These effects were more pronounced in children less than 4 yr of age compared with older children. We conclude that tracheal extubation greatly impaired oxygenation and therefore administration of oxygen was appropriate. This impairment was more marked when suction was used, and in young children. Lung inflation with 100% oxygen before removal of the tracheal tube is advised before routine tracheal extubation in children. (Br. J. Anaesth. 1998; 81: 692–695).

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Hypoxaemia is the most frequently encountered respiratory complication during emergence from anaesthesia in children. Approximately 40% of children less than 4 yr old experience arterial haemoglobin oxygen desaturation to less than 90% within the first 15 min after tracheal extubation, and approximately 30% on arrival in the post-anaesthesia care unit (PACU). Tracheal extubation techniques may influence the incidence of arterial haemoglobin oxygen desaturation during this period. Indeed, removal of the tracheal tube while children are still deeply anaesthetized reduces desaturation episodes compared with awake tracheal extubation. However, few studies have addressed the question of the influence of the tracheal tube removal technique itself.

Mehta reported that a technique combining pharyngeal suctioning followed by insertion of a suction catheter into the tracheal tube and removal of it while applying a negative pressure through the suction catheter eliminated pulmonary aspiration of a radiographic dye placed on the back of the tongue. However, this technique may reduce lung volumes and oxygen stores, favouring arterial haemoglobin oxygen desaturation. These effects may be more pronounced in young children because of their reduced functional residual capacity (FRC) and high oxygen consumption. As an alternative to a tracheal suctioning technique, a lung inflation manoeuvre with 100% oxygen before cuff deflation and removal of the tracheal tube has been advocated. This technique would theoretically maintain the patient with a clear airway (by expelling retained secretions by the positive pressure gradient created between the lungs and atmosphere) and the lungs would be filled with oxygen. This inflation manoeuvre is now recommended in some anaesthesia textbooks for routine tracheal extubation but it has never received clinical evaluation in daily anaesthesia practice. In particular, its effects on arterial haemoglobin oxygen saturation after removal of the tracheal tube are unknown.

Therefore, in this randomized, prospective, single-blind study, we assessed the effects of both extubation techniques (i.e. suctioning or inflating technique) on the frequency and onset of arterial haemoglobin oxygen desaturation after general anaesthesia in children, and the effects of age on the incidence of desaturation after tracheal extubation.

Patients and methods
After obtaining approval from our institute and informed consent from parents, we studied ASA I–III children undergoing elective surgery with general anaesthesia and orotracheal intubation. Patients with a full stomach, those undergoing thoracic surgical procedures, emergency surgery or ENT surgery, and those in whom intubation was rated difficult (defined as the need for more than two laryngoscopies) were excluded. No attempt was made to exclude children with upper respiratory tract infections if they were considered eligible for general anaesthesia by the attending anaesthetist.
All children received oral or intrarectal premedication with midazolam 0.3–0.5 mg kg\(^{-1}\). Administration of anaesthesia was left to the discretion of the attending anaesthetist. Anaesthesia was induced with propofol 3–5 mg kg\(^{-1}\) i.v. or inhaled sevoflurane according to the child’s age and preference. Tracheal intubation with a cuffed tube was performed with sevoflurane alone or after i.v. administration of atracurium 0.5 mg kg\(^{-1}\). Anaesthesia was maintained with desflurane or isoflurane and 60% nitrous oxide in oxygen, supplemented with i.v. bolus doses of alfentanil or sufentanil. Ventilation was controlled mechanically. After completion of the surgical procedure, the inhaled anaesthetics and nitrous oxide were discontinued and the lungs ventilated with 100% oxygen. Tracheal and pharyngeal suctioning were performed while the children were still in the surgical plane of anaesthesia. After re-establishing spontaneous ventilation, neuromuscular block was antagonized with neostigmine 40 μg kg\(^{-1}\) and atropin 20 μg kg\(^{-1}\) if less than four responses were observed on TOF stimulation of the adductor pollicis muscle. The trachea was extubated when the child was responding to verbal command or was opening his (her) eyes, provided that \(Sp_{O_2}\) was 99–100%.

The choice of extubation technique was randomized on a daily basis. On odd days, the lungs received a single lung inflation manoeuvre with 100% oxygen before cuff deflation and removal of the tracheal tube (group I). On even days, a suction catheter was introduced into the tracheal tube until a resistance was met, the cuff was then deflated and the catheter was removed, together with the tracheal tube, while applying a negative pressure of –150 cm H\(_2\)O (group S). The suction catheter was chosen so that its external diameter was half the internal diameter of the tracheal tube. After tracheal extubation, children were observed for 5 min in the operating room while breathing room air. Forward jaw displacement was allowed for alleviating airway obstruction if necessary, and pharyngeal suctioning was performed if retained secretions were suspected. Oxygen was given by face mask if arterial haemoglobin oxygen saturation decreased to less than 92%. After 5 min, children were transferred to the PACU, provided that \(Sp_{O_2}\) was > 97%.

Arterial haemoglobin oxygen saturation (\(Sp_{O_2}\)) was monitored using an age-appropriate probe placed on the toe with a N-200 or N-250 Nelcor pulse oximeter adjusted to rapid update mode (mean integration time 2–3 s; accuracy ± 2% for 70–100%). \(Sp_{O_2}\) was recorded for 5 min in the operating room by an independent observer. This observer was not involved in the extubation procedure but was aware of the extubation technique used. The time between tracheal extubation and \(Sp_{O_2}\), to decrease to 92% (T92) was recorded, in addition to the occurrence of desaturation to less than 92%.

**STATISTICAL ANALYSIS**

Continuous data were compared using a two-sided \(t\) test and proportions with chi-square test. Kaplan–Meier analysis followed by the log-rank test was used to assess the effects of age on arterial haemoglobin oxygen desaturation after tracheal extubation. For this purpose, the population was divided into two groups: those more than 4 yr of age and those less than 4 yr. The end-point for Kaplan–Meier analysis was defined as the ability of a child to sustain an \(Sp_{O_2}\) equal to or greater than 92% (i.e. without supplementary oxygen administration) during the 5-min observation period in the operating room. \(P < 0.05\) was regarded as statistically significant. Data are expressed as mean (SD).

**Results**

We studied 120 children: 59 in the inflation group (I) and 61 in the suction group (S). Patient characteristics, anaesthetic technique and surgical procedures are presented in table 1.

The incidence of arterial haemoglobin oxygen desaturation requiring oxygen administration (i.e. less than 92%) in the operating room after tracheal extubation was significantly greater in group S compared with group I (table 2). Moreover, time to \(Sp_{O_2}\) to decrease to 92% after tracheal extubation was nearly three-fold shorter in group S compared with group I.

Kaplan–Meier survival curves are presented in figure 1. They demonstrate that, irrespective of the tracheal extubation technique used, the percentage of children with \(Sp_{O_2}\) ≥ 92% was greater in children aged more than 4 yr \((n = 60; 9.0\,(3.9)\,yr)\) than in those aged less than 4 yr \((n = 60; 1.6\,(1.0)\,yr)\) (fig. 1A). When the suctioning and inflating techniques are examined independently (fig. 1A, 1C), the percentage of children with \(Sp_{O_2}\) ≥ 92% was still greater in...
children aged more than 4 yr compared with those aged less than 4 yr, irrespective of the technique used for tracheal extubation.

Discussion

In this prospective, randomized study, we demonstrated that a single lung inflation manoeuvre with 100% oxygen before removal of the tracheal tube reduced the need for supplementary oxygen therapy during the first 5 min after tracheal extubation, and delayed the onset of desaturation compared with a suctioning procedure. These effects were more pronounced in children less than 4 yr of age compared with older children.

The reduced incidence of desaturation episodes observed with the inflation technique indicates that lung volumes and lung oxygen stores are critical determinants of early desaturation after tracheal extubation in children, in agreement with clinical studies in adult apnoeic patients. Indeed, there is an inverse relationship between both frequency and severity of desaturation after a 30-s voluntary apnoea in normal adult subjects, and pre-apnoea lung volume. Similarly, maintaining lung volumes and oxygen stores with intratracheal oxygen lessens the frequency and severity of desaturation during apnoea in patients undergoing mechanical ventilation. Conversely, tracheal suctioning reduces lung volumes, affecting shunt area appearance and hypoxaemia in critically ill patients undergoing mechanical ventilation. However, these effects on oxygenation could not be extended to anaesthetized patients. They were assessed after disconnection from the ventilator, either when they were sedated or paralysed without spontaneous ventilation. This differs markedly from the spontaneously breathing patient recovering from anaesthesia. In addition, a single lung inflation manoeuvre with 100% oxygen can suppress atelectasis and ventilation perfusion mismatches observed after experimental cardiopulmonary bypass, which are mainly responsible for postoperative hypoxaemia.

Time to onset of hypoxaemia during apnoea is dependent on the balance between oxygen supply (i.e. alveolar oxygen tension and lung volume) and extraction from the circulating blood (i.e. oxygen consumption). In our study, time to desaturation to 92% was three-fold shorter when tracheal suctioning was applied compared with the inflation technique. This suggests that lung volumes and oxygen stores modulate the onset of desaturation after tracheal extubation in the spontaneously breathing child in the same way as in apnoeic patients.

There is a strong relationship between weight and FRC, and between weight and oxygen consumption in children. This explains the positive relationship between age and onset of desaturation during apnoea: the younger the child, the more rapid the onset of desaturation. Moreover, the difference between FRC and closing volume increases linearly with age up to 20 yr, exposing younger children to a greater risk of postoperative hypoxaemia. On this basis, we hypothesized that younger children might be more prone to desaturation after tracheal extubation, and that desaturation might occur more rapidly. To test this assumption, we used Kaplan–Meier survival curves and we defined survival as the ability of a child to maintain $S_{O_2} \geq 92\%$ without oxygen administration during the 5-min observation period in the operating room.

In summary, tracheal extubation greatly impairs oxygenation, and systematic oxygen administration after tracheal tube removal is of clinical value. This impairment is more pronounced with a suctioning technique and in young children. A lung inflation manoeuvre with 100% oxygen before removal of the tracheal tube may be advised for routine extubation in children.

References


