Using a nasopharyngeal airway during fiberoptic intubation in small children with a difficult airway

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Summary

Background: Induction of anesthesia and tracheal intubation in small children with a difficult airway is a challenging task. We report the experience with a procedure based on sevoflurane inhalation via a nasopharyngeal airway inserted early during induction before airway obstruction occurs. A pediatric fiberscope is used to perform a nasotracheal intubation via the opposite nostril.

Methods: All small children with suspected or known difficult airway needing tracheal intubation were scheduled for a fiberoptic intubation following the described protocol.

Results: In 3 years, we performed 27 successful fiberoptic guided tracheal intubations in 19 children, median age 8.2 months (1.0–39.1 months) and median weight 7.6 kg (3.0–15.0 kg). The optimal depth for placement of the nasopharyngeal airway was found to be 8.0 cm (7.0–8.5 cm) from the nostril in the first year of life and 8.5 cm (8.0–10 cm) in the second year. Oxygenation was sufficient during the entire procedure in all cases except one child who had short-lasting laryngeal spasm caused by instillation of lidocaine during light anesthesia. The duration of fiberoptic intubation was significantly shorter when performed by an experienced anesthesiologist (55 s vs. 120 s), but there was no significant correlation between the duration of fiberoscopy and oxygen saturation during fiberoscopy or endtidal CO2 after intubation.

Conclusion: The combination of nasopharyngeal airway and fiberoptic guided tracheal intubation seems to be a reliable and safe procedure for managing the difficult airway in small children.

Keywords: difficult airway; difficult intubation; fiberoptic intubation; nasopharyngeal airway; upper airway obstruction

Introduction

Induction of anesthesia and tracheal intubation in small children with a difficult airway is a challenging task for most anesthesiologists. Mask induction is usually preferred, but as soon as the child is asleep and the airway structures lose their tonus; partial or complete airway obstruction may occur. This obstruction may be severe and hard to overcome making it difficult or impossible to ensure ventilation and oxygenation of the child. Furthermore, direct laryngoscopy and conventional intubation
may prove to be impossible. As a consequence many studies and case reports have been published describing different ways of handling the situation.

The laryngeal mask airway (LMA) in combination with a fiberoptic bronchoscope seems to be the most popular method estimated by the number of publications (1–13). The LMA is often easy to insert, relieves obstruction and offers a possibility of ventilating the child. Furthermore the LMA may work as an excellent conduit for fiberoptic laryngoscopy and intubation. From the distal aperture of the LMA the glottis or part of the glottis is visible in 94% of cases in children with a normal airway (14). In children with difficult airways though, the number is somewhat lower (approximately 50%) (10).

The LMA is useful to maintain the airway, once the child is anesthetized. But unless the LMA is inserted in the conscious child, as in one case report (5), the risk of obstruction and severe desaturation during induction still may be a serious problem (10).

For several years fiberoptic guided tracheal intubation has become part of our routine, when intubating a small child with a suspected or known difficult airway. We have developed a protocol for handling these difficult airways. It is based on an inhalational induction and spontaneous ventilation with sevoflurane using a nasopharyngeal airway for anesthesia, oxygenation and monitoring of ventilation in one nostril, while the second nostril or the mouth is used for the fiberoptic intubation.

In this paper we describe our experience with this technique since March 2001 in small children with difficult airways.

**Methods**

*Protocol for the fiberoptic guided intubation*

In infants we usually prescribe an antisialagogue, atropine 40–50 µg·kg⁻¹, to be given 45 min before induction of anesthesia. We use rectal administration, as it is convenient and well accepted in small children in the Scandinavian countries.

Anesthesia is induced with sevoflurane in 100% oxygen. Our anesthesia machine is equipped with a circle circuit, and we use a high fresh gas flow to allow faster control of the endtidal concentration of sevoflurane. As soon as the child is asleep, and before any airway obstruction occurs, a Portex Blueline tracheal tube is introduced via the smallest nostril as a nasopharyngeal airway. The nasopharyngeal airway is 0.5–1.0 size smaller than the tracheal tube. If the chosen nasopharyngeal airway is too large, difficulty may arise during the insertion of the fiberscope or subsequently, the tracheal tube. The anesthesia circuit is attached to the nasopharyngeal airway, and induction is continued with spontaneous ventilation. If the child has a nasopharyngeal airway from the ward, this is used from the start of the induction. With the circuit attached to the nasopharyngeal airway it is possible to obtain tracing of the endtidal CO₂ and sevoflurane. It is important to close the mouth and the other nostril of the child in order to deliver sufficient anesthetic and oxygen, and to enable CO₂-reading on the monitor. The nasopharyngeal airway should not be secured to the nose, as it may be necessary to manipulate it by rotating or moving it up or down a few millimeters to obtain the best CO₂ tracing and the most optimal airway. Instead, an assistant should keep the nasopharyngeal airway in place and at the same time make a jaw thrust, close the mouth and the nostril, and hold the head of the child steady in the midline (Figure 1). A well-trained assistant is invaluable!

![Figure 1](image-url)

Management of difficult airway in an infant. A trained assistant holds the nasopharyngeal airway, makes a jaw thrust, closes the mouth and keeps the head of the child steady in the midline, ready for fiberoptic tracheal intubation via the right nostril.
The optimal position of the nasopharyngeal airway is found by listening to the breath sounds. When anesthesia is deep, lidocaine 4 mg·kg\(^{-1}\) is flushed into the nasopharyngeal airway. To ensure spread of the local anesthetic the larynx is manipulated by external massage to the neck.

Before introducing the fiberscope the pharynx is thoroughly suctioned to remove secretions.

A nasotracheal intubation is preferred if possible. The fiberscope is introduced into the nostril not occupied by the nasopharyngeal airway. In very retrognathic children the tongue, palate and the back of the pharyngeal wall quite often lie against each other, and it is not possible to get a clear view with the fiberscope until the root of the tongue is passed. In that case the fiberscope is advanced slowly without force, while slightly moving the tip until a view is obtained, often close to epiglottis. Secretions on the fiberscope may make the view cloudy, but moving the tip may relieve it. Otherwise the fiberscope is removed, cleaned and reintroduced after suctioning.

When the fiberscope is in the trachea the tube is railroaded into the trachea. When passing the larynx, the tracheal tube is rotated 90° anti-clockwise to avoid impingement of the tip of the tube at the arytenoids (15). The fiberscope and the tube should be generously lubricated, avoiding lubricants containing local anesthetics in order not to reach toxic levels.

The fiberscope we use is a Pentax Fl-7BS 2.4 mm, which fits tube size down to 3.0 mm. The fiberscope is equipped with a video camera, which makes it possible to supervise the fiberscope-operator when required.

During the procedure the following were registered for the study:
- Optimal depth of the nasopharyngeal airway.
- Lowest saturation during different stages of the airway management.
- Endtidal CO\(_2\) and endtidal sevoflurane when intubation was completed.
- Time from introducing the fiberscope until intubation was completed.
- Occurrence of adverse events.

After tracheal intubation the larynx was inspected via the fiberscope for signs of trauma.

**Patients**

All small children with suspected or known difficult airway needing tracheal intubation were scheduled for a fiberoptic intubation following the described protocol. However, immediately prior to introducing the fiberscope, a MacIntosh laryngoscope was used to classify the view of the glottic exposure according to Cormack–Lehane. If the score was grade 3 or 4, no attempt to intubate with the MacIntosh laryngoscope was done, and the child was included in this quality assurance study, and a fiberoptic-guided intubation was performed.

**Statistics**

Continuous data are reported with median and range. We compared the registered values between experienced and inexperienced anesthesiologists using Mann–Whitney’s test. The correlation between the duration of the procedure and the endtidal CO\(_2\) and oxygen saturation was assessed using Spearman’ rank sum correlation test. We considered \(P < 0.05\) as statistically significant. Data from different occasions in the same patients were considered as independent observations because they were managed at least 3 months apart and by a different anesthesiologist.

**Results**

Nineteen children were tracheally intubated on 27 occasions during a 3-year period. At the time of intubation the age was 8.2 months (1.0–39.1 months) and the weight 7.6 kg (3.0–15.0 kg). Twenty-four were nasotracheal and three were orotracheal intubations. Fifteen of the intubations were performed in children with a Cormack–Lehane grade 4, 11 were classified as grade 3 and one child had a severe temperomandibular ankylosis.

Six specialists in anesthesiology performed the tracheal intubations. One was highly experienced in fiberoptic intubation in children, and five were anesthesiologists with considerable skill in using the fiberscope in adults. The five were supervised by the experienced pediatric anesthesiologist. In all cases the intubation was completed successfully, and there were no need for the supervisor to take over in any case.
The optimal depth for placement of the nasopharyngeal airway was determined by listening to the breath sounds and found to be 8.0 cm (7.0–8.5 cm) from the nostril in the first year of life and 8.5 cm (8.0–10 cm) in the second year. During fiberoscopy the tip of the NPA in all children was seen to lie in close relation to the epiglottis. In one child it was necessary to retract the NPA 0.5 cm in order to get access to the trachea with the fiberscope.

Oxygenation was sufficient during both the anesthesia induction and the fiberoptic intubation in most children (Table 1). Only one clinically significant desaturation to 69% occurred because of laryngeal spasm caused by instillation of lidocaine during light anesthesia. The spasm resolved after positive pressure ventilation via the nasopharyngeal airway, and the intubation and anesthesia was completed without further problems. The fiberoscopy and intubation was performed faster, if the anesthesiologist was experienced in pediatric fiberoptic intubation, but there was no significant correlation between neither the experience of the anesthetist (Table 1) nor the duration of fibroscopy and oxygen saturation during fibroscopy or endtidal CO2 after intubation (Figures 2 and 3).

Besides the one case of laryngeal spasm, no adverse events occurred. No trauma to the larynx or significant bleeding from the nose was seen.

### Discussion

Despite the fact that a nasopharyngeal airway is a very old device, the way we use it with pediatric fiberoptic intubation, having a nasopharyngeal airway ‘dedicated’ to oxygenation and anesthesia, while performing the fiberoptic intubation via the free nostril is only mentioned in one case history (16) and one letter to the editor (17). In another case a technique resembling ours was used. Oxygen was insufflated via one nostril, while fiberoptic intubation was performed via the other (18). The principle is described also in one small case study in adults (19), but no systematic investigations have been published, and the technique does not seem to have gained widespread use.

We found the nasopharyngeal airway to be a very useful tool during fiberoptic intubation in small children with a difficult airway as in Pierre Robin sequence, Treacher Collins and similar syndromes. The nasopharyngeal airway ensures a patent airway and sufficient oxygenation and anesthesia. Thus, it was possible to perform a fiberoptic intubation via the opposite nostril or the mouth in all cases. One of the strengths of the method is, that it is possible to insert the nasopharyngeal airway before, or at the very start of anesthesia, before obstruction occurs, so the airway is kept patent throughout the induction. The insertion did not cause laryngeal spasm in any case despite the light anaesthesia. Another

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**Table 1**

Characteristics and time used from start of fiberoscopy until tracheal intubation was completed in children with difficult airway

<table>
<thead>
<tr>
<th></th>
<th>Experienced (n = 12)</th>
<th>Inexperienced (n = 15)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (days)</td>
<td>159.5 (29–1173)</td>
<td>363 (32–801)</td>
<td>0.18</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>4.95 (3.7–15.0)</td>
<td>8.5 (3.0–12.0)</td>
<td>0.49</td>
</tr>
<tr>
<td>Time from start of fibroscopy to intubation (s)</td>
<td>54.5 (35–198)</td>
<td>120 (37–282)</td>
<td>0.004</td>
</tr>
<tr>
<td>Endtidal carbon dioxide concentration after intubation (%)</td>
<td>6.35 (5.3–10.0)</td>
<td>6.9 (5.4–10.4)</td>
<td>0.43</td>
</tr>
<tr>
<td>Endtidal sevoflurane concentration after intubation (%)</td>
<td>4.45 (3.3–7.1)</td>
<td>4.3 (2.7–7.5)</td>
<td>0.62</td>
</tr>
<tr>
<td>Lowest oxygen saturation (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From start of induction until insertion of nasopharyngeal airway</td>
<td>98.5 (96–100)</td>
<td>99 (93–100)</td>
<td>0.65</td>
</tr>
<tr>
<td>From insertion of nasopharyngeal airway to direct laryngoscopy</td>
<td>98 (95–100)</td>
<td>98 (69–100)</td>
<td>0.79</td>
</tr>
<tr>
<td>During direct laryngoscopy</td>
<td>97 (91–100)</td>
<td>98.5 (90–100)</td>
<td>0.32</td>
</tr>
<tr>
<td>During fiberoscopy</td>
<td>98 (95–100)</td>
<td>99 (90–100)</td>
<td>0.87</td>
</tr>
<tr>
<td>During railroading of tracheal tube</td>
<td>98.5 (93–100)</td>
<td>99 (89–100)</td>
<td>0.73</td>
</tr>
<tr>
<td>First minute after intubation</td>
<td>98 (97–100)</td>
<td>99 (87–100)</td>
<td>0.73</td>
</tr>
</tbody>
</table>

The endtidal sevoflurane and endtidal CO2 values are noted at the third expiration after intubation. The saturation is the lowest value observed during different stages of the procedure. The data are reported separately for the experienced pediatric anesthesiologist and the five supervised.

Median is reported with range.

P-value: Mann–Whitney’s test.

The advantage is, that intubation is not performed through the device used to anesthetize the patient and keep the airway patent. The fiberscopy is easier to perform, when one is not troubled or limited by a hole in the facemask or whether the LMA is perfectly aligned to larynx, and there is no worry about difficulties in passing the tracheal tube through the facemask or the LMA, as this is not necessary. Because the nasopharyngeal airway ensures a patent airway while the child is breathing spontaneously, the situation is well controlled. Furthermore, as the airway-circuit system is nearly closed, pollution is minimal and it gives a good tracing on the capnograph. This allows monitoring of the endtidal values of sevoflurane and CO₂. If the ventilation becomes too shallow it is easy to assist or even control it via the nasopharyngeal airway. The mouth and the other nostril are kept closed (Figure 1). We did not find the time used for intubation related to the endtidal CO₂ or the lowest saturation, which makes the method useful, also for training in fiberoptic intubation. Finally, the method can be used even with a relatively small nasopharyngeal airway. In one neonate with Treacher Collins Syndrome we used a size 2, which worked perfectly well for the time needed for intubation.

A weakness of the method is that at least one patent nostril is required for an oral and both for nasal intubation. In children with choanal atresia or in some children with mucopolysaccharide disorders the nostrils are not an option. Instead, one of the other described techniques and modified devices may be chosen. A facemask has been modified with a membrane that allows for fiberscopy during mask ventilation (20,21), and the LMA has proven useful to facilitate oral fiberoptic intubation in difficult pediatric airways (1–13).

If the option of a nasal tracheal intubation is available, this route offers a more direct way to the larynx with a smaller risk of problems railroading the tube because of impingement on the arytenoids (22–24).

Thomas (17) used shortened uncuffed tubes as nasopharyngeal airways in order to avoid laryngeal spasm. We did not find this necessary. Insertion of the ‘long’ nasopharyngeal airway did not precipitate laryngeal spasm. In expected difficult airway cases we insert the nasopharyngeal airway as soon as the child ‘relaxes’, and before obstruction occurs. Otherwise, the child will begin to desaturate, before the obstruction is relieved. In our experience the distance from the nostrils should be approximately 8 cm in the first year of life.

The risk of desaturation during induction of children with difficult airways is well known (10). Walker published a series of 31 intubations where a LMA was used as a conduit during fiberoptic intubation. In five cases clinically significant desaturation occurred during induction and in two cases
during railroading of the tracheal tube. The treatment of the desaturation during induction was in some of the cases the use of a nasopharyngeal airway. If this had been used from the beginning, the desaturation may have been avoided. Only six of the intubations were performed in patients not having a form of mucopolysaccharidosis, which makes comparison difficult. However, in five of these six patients some kind of complication was seen. The type is not specified, except one case of desaturation during attempt of conventional intubation in a neonate with Pierre Robin sequence. In our series of younger children we only had one case of a significant desaturation in 27 intubations, and we did not have any technical complications. We used the setup with the nasopharyngeal airway in all suspected difficult airways, and we did not try conventional intubation if the direct laryngoscopy revealed a Cormack–Lehane grade 3 or 4.

Bleeding from the nose during insertion of the nasopharyngeal airway or the fiberscope would make intubation more difficult. This did not occur in any case. We did not routinely use nasal vasoconstrictors in children below the age of 2 years. The only precaution we took was to choose an appropriate small sized nasopharyngeal airway, which could be inserted without difficulty. Using a cut suction catheter as a guide was sometimes helpful.

There is no ideal, universally applicable method for management of all difficult airways in children. The use of a nasopharyngeal airway inserted during light anesthesia seems to be a very versatile tool if a patent nostril is available. Nasotracheal fiberoptic intubation is easy to perform using the setup described, but even if an orotracheal intubation is needed the technique can be used. If a laryngeal mask airway is preferred as a conduit for the fiberscope, a combination of the techniques may be worthwhile. A nasopharyngeal airway inserted early during the induction is useful until a level of anesthesia sufficient for insertion of a laryngeal mask airway is reached.

It is not surprising that fiberoptic intubation was more rapidly completed in experienced hands, but we were unable to show a significant relationship between duration of fiberoscopy and endtidal carbon dioxide or oxygen saturation. This confirms that ventilation and oxygenation are unimpaired and it also justifies that less experienced anesthesiologists are allowed to use this procedure under appropriate supervision. It should, however, also be taken into account that the total duration of the procedure will be underestimated when looking at Table 1 because we did not record the time used for preparation and sevoflurane inhalation until a level of anesthesia sufficient for fiberoscopy was reached.

We admit that this study does not document that success rate or safety is improved by using the described procedure but we believe that it is a method which can be successfully adopted by most anesthesiologists familiar with fiberoptic intubation. A definite scientific proof will require a randomized study including a large number of children with anticipated difficult airway. With the reported success using the described procedure, we would have great ethical difficulty in conducting such a comparison.

The combination of a nasopharyngeal airway and fiberoptic guided tracheal intubation seems to be a reliable and safe procedure for managing the difficult airway in small children.

References
11 Muraika L, Heyman JS, Shvchenko Y. Fiberoptic tracheal intubation through a laryngeal mask airway in a child with...


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