Laryngeal mask airway facilitated fibreoptic bronchoscopy in infants

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Purpose: To assess the efficacy of the laryngeal mask airway (LMA) for fibreoptic bronchoscopy (FOB) and bronchoalveolar lavage (BAL) in infants.

Methods: Observations were made in 19 consecutive infants undergoing FOB under general anaesthesia (GA) plus topical local anaesthesia. Anaesthesia was induced with N_2O, O_2, and halothane or sevoflurane except in two patients who received propofol and one who received thiopentone. Anaesthesia was maintained with oxygen and either sevoflurane, halothane, desflurane, or propofol infusion. No neuromuscular blockers were used. Size #1 or #2 LMAs were used through which a 3.5 mm fibreoptic bronchoscope was introduced. ECG, noninvasive blood pressure, pulse oximetry and, $P_{ET}CO_2$ were measured. Intra- and post-procedural complications were recorded.

Results: Mean age was 6 months; mean weight was 6.6 kg. Chronic wheezing was the indication for FOB in eight patients. Minor complications occurred in five patients: difficult LMA placement in one patient required changing size from #2 to #1; two patients had laryngospasm and bronchospasm that resolved with deepened anaesthesia and nebulised bronchodilator; one patient had transient arterial O_2 desaturation responding to increased FIO_2, and one patient required tracheal intubation because ventilation via LMA became inadequate.

Conclusion: The minor complications observed were similar to other series and did not result in morbidity or mortality. We feel that GA via LMA facilitates safe FOB in infants. It affords excellent airway management, a quiet patient, and passage of a larger fibreoptic bronchoscope for better imaging and suction channel required for BAL.

Objectif : Évaluer, en pédiatrie, l'efficacité du masque laryngé (ML) pour la bronchofibroscopie (BOF) et la lavage bronchoalvéolaire (LBA).

Méthodes : Les observations ont porté sur 19 BOF réalisées chez des enfants sous anesthésie générale (AG) complétée par une anesthésie topique. L'anesthésie générale était induite avec du N_2O, de l'O_2 et de l'halothane ou du sévoflurane à l'exception de deux patients qui ont reçu du propofol et un patient, du thiopental. L'anesthésie était maintenue avec de l'oxygène associé soit à du sévoflurane, de l'halothane, du desflurane, ou une perfusion de propofol. Aucun myorelaxant n'a été administré. On insérait un ML de taille 1 ou 2 par lequel un bronchofibroscope de 3,5 mm était introduit. L'ÉCG, l'oscillométrie automatisée, l'oxymétrie de pouls et la $P_{ET}CO_2$ étaient enregistrés. On notait les complications per- et postopératoires.

Résultats : Huit patients ont subi la BOF pour du wheezing. Des complications mineures sont survenues chez cinq patients : chez un patient, l'insertion laborieuse du ML a nécessité un changement de masque de taille 2 à taille 1 : deux patients ont présenté un laryngospasme et un bronchospasme maîtrisés par l'approfondissement de l'anesthésie et la nébulisation d'un bronchodilatateur ; un patient a présenté une désaturation artérielle transitoire résolue par l'augmentation de la FiO_2 et un patient a dû être intubé à cause de l'incapacité de ventiler sous ML.

Conclusion : Les complications mineures observées étaient les mêmes que celles notées dans d'autres études et n'ont provoqué ni morbidité ni mortalité. Nous croyons que l'AG par ML facilite la BOF chez les enfants. Cette méthode procure un excellent contrôle des voies aériennes, l'immobilité du patient et permet l'introduction d'un bronchofibroscope de plus grand calibre pour faciliter une meilleure visualisation et l'aspiration pendant le LBA.

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THE use of the laryngeal mask airway (LMA) for surgical anaesthesia and for management of the difficult airway, is well recognised.[1–3] Since the distal end of a properly placed LMA faces the laryngeal inlet, the LMA can be used as a guide to fibreoptic visualisation of the larynx and trachea. Several reports indicate the successful use of LMA for fibreoptic bronchoscopy (FOB) in adults and children.[4,5] The median age of the largest reported series on paediatric fibreoptic bronchoscopies via LMA from the Royal Liverpool Children's Hospital was six years.[6] The use of the LMA for surgical procedures in infants has previously been reported;[7] however, there are no published reports regarding the use of LMA for FOB exclusively in infants.

Infants constitute the majority of paediatric patients who undergo diagnostic FOB.[8] The incidence of pulmonary related morbidity and mortality of both congenital and acquired origin is higher in infants than in older children. Airway anatomy in infants differs from that in older children and adults. The infant epiglottis is narrow and angled away from the axis of the trachea, the glottis lies higher appearing to be more anterior, the vocal cords are attached higher posteriorly than anteriorly, and the narrowest portion of the airway is the non-expandable cricoid cartilage.[9] The LMAs size #1 (≤5 kg), size #1.5 (5–10 kg), and size #2 (10–20 kg) currently recommended for use in infants and small children are scaled down versions of the adult LMA. Their design may not take into account the differing anatomy of the upper airway of infants and young children.[10] Difficulties with insertion and positioning may be expected in infants. Even the size #1 LMA allows passage of a 3.5 mm flexible bronchoscope with a 1.2 mm suction channel facilitating bronchoalveolar lavage (BAL) in addition to diagnostic bronchoscopy. We undertook this study to ascertain the safety and efficacy of the use of the LMA in infants undergoing bronchoscopy and BAL under general anaesthesia.

Methods

Observations were made in 19 consecutive infants who underwent FOB via LMA. Routine informed consent had been obtained from the parents or legal guardians before each procedure. All infants were kept fasting for four hours prior to the procedure. All infants underwent bronchoscopy in the operating room under general anaesthesia with spontaneous ventilation with manual assistance as needed. Standard anaesthetic monitoring, including ECG, non-invasive blood pressure measurement, pulse oximetry and capnography was employed. Anaesthesia was induced by inhalation of nitrous oxide 50 to 70% in oxygen, and either halothane 1.3–1.5% or sevoflurane 1.8–5.0% in all except two patients who received 2.5–3 $mg \cdot kg^{-1}$ propofol *iv* and one who received 4 $mg \cdot kg^{-1}$ thiopentone *iv*. At an adequate depth of anaesthesia, when the jaw was relaxed, a #1 or #2 LMA was placed using the technique recommended by the manufacturer with the cuff fully deflated.[11] The #1.5 LMA was not available at the time the study was conducted. Anaesthesia was maintained with oxygen 100% and either sevoflurane 2.5–3.5%, halothane 1–1.5%, desflurane 4–6.5%, or 50–150 $\mu g \cdot kg^{-1} min^{-1}$ propofol infusion. No neuromuscular blockers were used.

General anaesthesia was supplemented by 0.25–0.5 ml aliquots of lidocaine 1% topically to the glottis and trachea via the bronchoscope suction channel, the total dose not exceeding 7 $mg \cdot kg^{-1}$. A standard 15 mm. Portex™ bronchoscopic adapter was attached to the LMA, and a 3.5 mm OD Olympus fibreoptic bronchoscope was used in all patients. It was the independent judgment of the anesthesiologists to remove the LMAs when the patients were fully awake because these infants had some element of airway or pulmonary compromise. Bronchoalveolar lavage was performed by wedging the bronchoscope in the appropriate segmental bronchus and instilling the non-bacteriostatic saline in multiple aliquots not exceeding 5–15% of the expected functional residual capacity (FRC) for that age.[12]

Results

The study group of 19 infants comprised 12 boys and seven girls. Mean age was six months (range 2–12 months) and the mean weight was 6.6 kg (range 3–11 kg). Patient demographic data, indication for the procedure, endoscopic diagnosis, and complications are recorded in the Table on page 1244.

Minor displacement of the epiglottis partially obscuring the view of the glottis occurred frequently. This did not preclude airway patency or cause ventilatory difficulty. Visualisation of the glottis was accomplished by manoeuvring the bronchoscope below the epiglottis. Neither observation of any patient with an epiglottis so displaced as to make visualisation of the glottis impossible, nor impingement of the epiglottis on the grill of the LMA was encountered. Size #1 LMAs were employed in 9 of the 19 (47%) infants in the study. No difficulties in insertion of LMAs with the exception of one patient (#10) were encountered. Deterioration of positioning over time did not occur in any patient in this study. Visually directed bronchial lavage was performed successfully in 14 of 15 (93%) infants, the youngest of whom was two months old.

Complications occurred in five of 19 infants. Difficulty in the introduction of #2 LMA occurred in patient #10, a two-month-old infant (6.5 kg) under-

TABLE Demographic and medical data

Pt #	*Sex*	*Age (mo)*	*Wt (kg)*	*LMA size*	*Indication for FOB*	*Bronchoscopic Dx*	*Complications*
1	M	6	9	2	Chronic wheezing	Tracheomalacia, left mainstem bronchomalacia	laryngospasm, bronchospasm
2	M	12	11	2	Chronic wheezing	Laryngomalacia	laryngospasm, bronchospasm
3	M	4	6	1	Chronic wheezing	Tracheo-broncho-malacia	several brief episodes of desaturation
4	F	7	6.8	2	Endobronchial tuberculosis	Compressing lesion, right mainstem & middle lobe bronchus (90%)	none
5	M	2	4.3	1	Noisy breathing, possible aspiration	Narrowing of left mainstem bronchus	none
6	M	9	8	2	Chronic wheezing	Mild tracheobronchial edema	none
7	M	9	9	2	Stridor, chronic wheezing	Mild to moderate tracheomalacia, left mainstem bronchomalacia	none
8	F	11	10	2	Chronic wheezing	Tracheomalacia, right mainstem bronchomalacia	none
9	M	6	5	2	Stridor, chronic wheezing	Normal airway	none
10	F	2	6.5	2 changed to 1	Stridor	Mild to moderate laryngomalacia	placement difficulty
11	F	7	4.8	1 failed -ETT 4.0	RUL atelectasis (severe)	Mild laryngeal narrowing, severe RUL collapse	laryngo-spasm, unable to ventilate per LMA
12	F	8	7.8	2	Chronic wheezing	Tracheomalacia, left mainstem bronchomalacia	none
13	F	2	4	1	Stridor	Laryngotracheo-malacia	none
14	M	8	8	2	Chronic wheezing	Normal anatomy	none
15	M	5	6.9	1	Recurrent pneumonia	Normal airway	none
16	F	2	3	1	Upper airway obstruction	Mild to moderate tracheomalacia, bilateral severe bronchomalacia	none
17	M	7	8	1	Chronic wheezing	Normal airway	none
18	M	4	2.1	1	Extubation failures	Mild right mainstem bronchomalacia	none
19	M	3	5.5	1	Stridor	Inflammed supraglottic area	none

going FOB for evaluation of stridor. A #1 LMA was subsequently placed successfully. Patients #1 and #2 developed transient laryngospasm and bronchospasm, resolving with deepening of anaesthesia. Transient arterial oxygen desaturation occurred in patient #3. Complications in these four patients were resolved intraoperatively and the procedures including BAL were completed successfully. Difficulty in ventilating via the LMA occurred in patient #11, when bronchoscopic stimulation of the airway under an inadequate depth of anaesthesia resulted in laryngospasm and airway obstruction, requiring tracheal intubation.

Bronchoscopy via the endotracheal tube using a 2.2 mm bronchoscope was accomplished. We did not observe any post-anaesthetic airway complications in any of these patients.

Discussion

The results of this series of infants suggest that general anaesthesia via the LMA can be an effective technique for FOB and BAL. Bronchoscopy was done successfully via LMA in all but one patient who required intubation. Visually directed BAL was facilitated by the use of the LMA. No serious complications related to the LMA or the FOB occurred.

The problems observed in five (26%) of the 19 infants are similar to those of Mason and Bingham (24%) and McGinn, Haynes and Morton (26%).[1,13] Difficulties with LMA placement occurred in patient number 10 (6.5 kg), requiring changing from #2 to #1 LMA. The incidence of difficult placement of LMAs in children has been reported to be 12 to 14%.[1,13] Problems with LMA placement may become less common with the availability of intermediate sizes LMA #1.5 & #2.5 and changes in weight-size recommendations. Reported rates of difficult LMA placement in adults ranges from 18–24.4% and the rates of failed LMA placements ranges from 2–6%.[14–16]

Laryngospasm occurred in two patients during passage of the bronchoscope via the LMA. Laryngospasm frequently occurs during placement of an LMA during induction, often related to an inadequate depth of anaesthesia for that level of stimulation, and occurs more frequently in pediatric than adult patients. The difference may be explained by the increased laryngotracheal reflexes in children.[17] Dubreuil *et al.* observed laryngospasm and bronchospasm in 13 of 33 (30%) patients with the use of #1 LMAs.[18] Tunkel and Fischer reported laryngospasm with use of LMA for fibreoptic bronchoscopy in 2/17 (12%) patients.[5] Infants appear to be at higher risk for laryngospasm and/or bronchospasm. In additional, instrumentation of the larynx and trachea during bronchoscopy represents an added stimulus. Laryngospasm in these patients resolved with an increased depth of anaesthesia and administration of positive pressure ventilation, allowing completion of the bronchoscopy.[19]

Ventilation via the LMA during general anaesthesia with the bronchoscope in place became inadequate because of laryngospasm in patient #11 who had been recovering from varicella pneumonia. Increased airway resistance with the presence of the bronchoscope and poor lung compliance necessitated positive pressure ventilation with peak pressures greater than 20 cm H_2O, which is approximately the upper limit of positive pressure commonly able to be delivered by LMA, requiring tracheal intubation.

Oxygen desaturation (SpO_2 <95%) was observed in one infant with a history of bronchopulmonary dysplasia and previous right lower lobectomy. Hypoxaemia requiring supplemental oxygen occurs in infants and small children during any type of manipulation of the airway and it is rarely considered a complication. In a study of 36 children undergoing FOB via the transnasal route with sedation, Schnapf reported that 81% had a decrease in oxygen haemoglobin saturation of ≥5% during the procedure. Patients <12 months old had the greatest decrease (mean 10.5% from baseline value).[20] Karetsky *et al.* noted a consistent decline in the PaO_2 in all patients undergoing FOB, which normalised immediately after removal of the bronchoscope.[21] In summary, the complications observed in our series are comparable with those reported in the literature, and none of the complications resulted in post procedure morbidity.

Generally, the route of FOB and anaesthetic technique employed depends on the preference of the endoscopist, the underlying condition of the patient, and the ability to sedate the patient adequately. In many centres in the United Kingdom, general anaesthesia rather than sedation is used for all paediatric bronchoscopies.[6] In the United States, for reasons of cost and convenience, paediatric FOB is commonly done via the transnasal approach with topical anaesthesia and sedation. The smallest available fibreoptic bronchoscope with a clinically useful suction channel is 3.5 mm OD. In infants the 3.5 mm bronchoscope produces considerable airway obstruction. This leads to increased work of breathing and may result in transient hypoxaemia and hypercapnia, especially without ventilatory assistance. Although supplemental oxygen usually relieves the hypoxaemia, hypercapnia may persist, and airway compromise can result in a hurried procedure with a suboptimal examination of the airways. Occasionally, procedures are terminated prematurely because of these problems. Bronchoscopy can be performed using the 2.2 mm OD fibreoptic bronchoscope, reducing the airway obstruction caused by the larger bronchoscope; however it does not have a suction channel to clear secretions or obtain samples and has a lower optical resolution. The 3.5 mm bronchoscope with the suction channel is necessary to perform the BAL. Additionally BAL increases the procedure time which may worsen the hypoxemia and hypercapnia.

Without general anaesthesia, successful FOB, especially when done with BAL, depends on adequate sedation and topical anaesthesia that eliminates cough and gagging and minimises movement, while allowing the

infant to make the increased respiratory effort necessitated by the airway, caused by the bronchoscope. The traditional transnasal approach under topical anaesthesia and conscious sedation used for older children and adults may not always be appropriate for infants. Indeed, deep sedation, bordering on general anaesthesia, is more often needed for this age group.

Fibreoptic bronchoscopy can be done via an endotracheal tube under general anaesthesia. The endoscopist evaluates the nasopharynx, supraglottic airway, the vocal cords and subglottis by passing the bronchoscope transnasally after induction of mask anaesthesia. Upon completion of this portion of the study, the bronchoscope is removed and the trachea is intubated. The procedure is completed by passing the bronchoscope through the endotracheal tube to inspect the distal trachea and lower airway. There are several problems with this approach. First, there is the risk of airway trauma associated with tracheal intubation.[22,23] Second, the view of the trachea after intubation is limited to the area distal to the tip of the endotracheal tube. The subglottic airway examination is particularly important in infants and is difficult with this approach. Third, the size of the endotracheal tube limits the bronchoscope size. Using the 3.5 mm fibreoptic bronchoscope requires the placement of at least a 4.5 mm internal diameter endotracheal tube. This size endotracheal tube is too large for most infants under one year of age and usually is not appropriate until nearly two years of age. Even when this size endotracheal tube is used, ventilation is still hampered by the occlusion of a large portion of the cross sectional area of the airway by the bronchoscope.

Fibreoptic bronchoscopy via LMA during general anaesthesia is especially useful in infants because it allows better control of the airway. It allows for positive pressure ventilation without occupying part of the internal diameter of the larynx and trachea in contrast to the endotracheal tube. Thus airway resistance is lower improving the chance for effective spontaneous ventilation or decreasing the positive pressure required for assisted or controlled ventilation. In addition, excellent views of the glottis and trachea under dynamic conditions are easily obtained.

In conclusion, we describe the first report of a series of infants who underwent diagnostic bronchoscopy with bronchoalveolar lavage via LMA. We observed no serious morbidity or mortality associated with the use of the LMA for bronchoscopy. Bronchoscopy via LMA during general anaesthesia produced a comfortable, stable patient, permitting the use of a larger bronchoscope allowing BAL under direct vision. General anaesthesia via LMA did not result in adverse outcome related to aspiration in this series of patients. The minor complications observed are similar in nature and frequency to other studies of LMA use for surgery. In our experience in small infants and in infants with borderline cardiorespiratory status who need bronchoscopic airway examination and BAL, the LMA route appears to be efficacious. Safety cannot be ascertained due to insufficient numbers of patients in our series.

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