



PAEDIATRIC FLEXIBLE BRONCHOSCOPY*

A POSITION PAPER OF THE THORACIC SOCIETY OF AUSTRALIA AND NEW ZEALAND

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- This paper addresses to performance of bronchoscopy in children. A separate publication has been prepared for the performance of bronchoscopy in adults. This position paper has a currency of five years from the date of publication unless otherwise published in the Journal.

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Short title: Flexible bronchoscopy



Overview

Since the early 1980s the flexible bronchoscope has become widely used in paediatric respiratory medicine as a result of the availability of high quality optics in appropriately sized flexible instruments. The development of bronchoscopy in children has come about largely through the efforts of paediatric respiratory physicians originally trained in rigid bronchoscopy who have gained flexible bronchoscopy experience with adult thoracic physician colleagues. Over the past decade, however, increasing numbers of paediatric respiratory physicians have been trained solely with flexible instruments ^(1,2).

The use of the flexible bronchoscope has progressively increased to cover the visual diagnosis of the upper and lower airways lesions as well as interventional, therapeutic and supportive work such as bronchoalveolar lavage (BAL) for cytological, virological, bacteriological and immunological data; bronchoscopic intubation for anaesthetists; catheterisation of fistulae; intra-operative assistance for cardiac and airway surgery; removal of distal foreign bodies not reached by rigid instruments, and limited selective segmental or lobar bronchographic procedures. This increased range of indications has reflected clinical and research needs together with greater skill development within a paediatric based experience. The paediatric airway has many differences in anatomy and pathology and therefore skills and diagnostic awareness has to be very different to that of adults ⁽²⁾.

Equipment: General

An array of different brands and sizes of instruments ranging from 1.8mm to 4.9mm is now available for use in the paediatric setting. All



bronchoscopes have camera technology providing high quality monitor enhanced viewing while performing the procedures. Biopsy forceps and cytology brushes are available for most bronchoscopes larger than 3.5mm or can be adapted from urological ureteric instruments. Bronchoscopes with a diameter of 3.5mm or greater have a combined suction and biopsy port. Placement of a biopsy forceps through this port results in reduced suction capacity and tip control during a biopsy procedure.

Equipment: Bronchoscope Selection

- **Bronchoscope 3.5 - 3.6mm diameter**
Bronchoscopes of 3.5 or 3.6 mm diameter can be used for neonates, children and adults. . The suction ports are adequate for most BAL and suctioning procedures. However clearance and/or withdrawal of the bronchoscope will often be necessary when secretions are tenacious or copious. Biopsy is limited to very small and superficial mucosal or prominent tissues through these bronchoscopes. This bronchoscope has a very limited role in foreign body removal except in highly skilled hands. Generally removal of the entire bronchoscope with the foreign body attached to the suction port or biopsy forceps at the suction port is necessary.
- **Bronchoscope 4.7mm diameter**
Bronchoscopes of this size can be used in children over 6 years of age and have the advantage of enhanced view, suctioning and biopsy capacity. Airway compromise (obstructive effects) always needs to be considered in children when using adult sized bronchoscopes.



- Bronchoscope 1.8 - 2.4mm diameter

The use of these bronchoscopes is limited because of their relative fragility and lack of suction ports. They are however useful in Intensive Care Units (ICU) and Neonatal ICU areas to check for endotracheal tube patency and position and in the diagnosis of lower airway lesions without the need for removal of the endotracheal tube, general anaesthesia or enhanced sedation. Adequate airway suctioning must be carried out before and/or during the procedure to enhance the accuracy of visual assessment. These bronchoscopes can also be useful in assessing children with nasal space and laryngeal/vocal cord pathology without recourse to more than nasal space local topical anaesthesia.

Methodology

In Australia both general and local anaesthetic techniques are available to experienced practitioners but currently gaseous general anaesthetic techniques are used in all centres (personal communication). This technique has evolved because of a general preference to have an experienced anaesthetist present to assist in airway management particularly when difficult airway lesions are present. Anaesthetists are also concerned about the use of “conscious sedation” in children. Australia differs in this regard to many centres in the USA where cost factors and limited access to operating theatres have contributed to a preference for sedation and local anaesthesia⁽³⁾.

- **General Anaesthetic Technique**

The general anaesthetic technique is usually a gaseous induction without premedication, after four to six hours of fasting. Halothane, sevoflurane and oxygen with intravenous atropine and local anaesthesia (lignocaine)



applied directly to the larynx and trachea via a Cass needle are the drugs commonly used for young children. However, there are different strengths of lignocaine solutions and sprays and delivery methods vary from the Cass needle approach to direct deposition through the bronchoscope or even nebulizer delivered drug. Care must be taken not to exceed the total topical dose of 3-4mg/kg for the former modes while doses up to 7-8mg/kg for the nebulizer route are reported to be safe. The potential risks of cardiac arrhythmias, cardiac arrest and seizures^{1,2,3} must be borne in mind. Where BAL procedures are to be carried out for bacteriology, lignocaine is usually not applied directly to the airway because of potential bacteriostatic effects, even though streptococcus pneumoniae appears to be the only organism affected⁽⁴⁾. Intravenous agent induction with agents such as propofol followed by gaseous anaesthetic maintenance can also be used in children. The usual method of airway maintenance is a shared airway procedure with the bronchoscope passed through a connector and facemask, laryngeal mask or endotracheal tube. . Recovery time is very short. Often less than 30 mins observation in a recovery ward is required. Most elective procedures are performed in a day surgery setting with one to two hours post-procedure observation of the patient before discharge. Post-procedure pain or discomfort rarely occurs. The intravenous line is usually removed before the patient is transferred to the recovery area. The advantage of this approach is the control of the airway, the ability to convert to rigid procedures should it be necessary to make detailed assessments of upper airway lesions, and to intervene if necessary with other procedures. These procedures should only be performed if supported by anaesthetists experienced and trained in paediatric anaesthesia. Thus formal operating theatre times are required.



- **Sedation / Local Anaesthesia**

The techniques of sedation and local anaesthesia usually involves a combination of premedication, opioids (fentanyl or pethidine) and sedative agents (e.g. midazolam), and supportive oxygen, with local anaesthesia applied to the nose, and then to the larynx and trachea via the bronchoscope^(1,2,3). Dosages are usually titrated to the patient's response. Reversal agents may be used in the post-procedure period but the apparent advantage of this approach is that patients are generally cooperative and anaesthetic staff and operating theatre space is not required. This method should not be used with a difficult patient or a patient with a potentially high-risk airway lesion⁽³⁾.

- **Other Local Anaesthesia Techniques**

Cricoid membrane puncture and injection of local anaesthetic into the airway with an expiratory manoeuvre followed by an inspiratory manoeuvre and subsequent application of local anaesthetic agents to the nose and oropharynx can be used in cooperative children/adolescents. Sedation may or may not be required for the procedure⁽³⁾.

Safety/Complications

Paediatric flexible bronchoscopy is generally regarded as a very safe procedure. It is not without risk and patient selection is therefore of paramount importance. There are rare case reports⁽⁵⁾ of deaths in extremely sick individuals in which the role of the bronchoscopy in directly causing death is at least debatable. In the past 10 years in Australia more than 3000 procedures have been performed using general anaesthetic techniques with only one fatality in a Class V classified patient (American Society of Anesthesiologists patient classification⁽³⁾, personal communication). The use of anaesthetic agents and technical



difficulties associated with a shared airway technique may cause transient hypoxaemia and hypercapnia. Other recognised complications are cardiac arrhythmia (bradycardia and tachycardia), laryngospasm during the application of local anaesthesia, minor airway trauma, bleeding, pneumothorax and sepsis. These are all uncommon or rare occurrences at a tertiary level of care, provided appropriate measures are taken prior to, and during the procedure to detect and correct potential problems. With experienced anaesthetic staff the risk of severe and uncontrolled cardio-respiratory compromise (during bronchoscopy) is low even in patients classified as Class IV or V⁽³⁾. Nevertheless these patients fall into a significantly high-risk group.

Febrile states may occur after a routine procedure. These are more frequent after a BAL procedure. The cause is often not determined and many resolve within four or five hours of the procedure. Atelectasis may also complicate BAL procedures; this too usually self resolves. Children with pre-existing immunological disorders and cardiac conditions may require antibiotic cover. However, no specific study has, as yet, addressed this issue^(1,2).

Staff Issues

If halothane anaesthetics are used for the procedure, staff are exposed, and scavenging traps or exhausts need to be used. Hospital infectious disease procedures for handling specimen that potentially contain specific infectious organisms (such as mycobacterium tuberculosis) need to be adhered to.

Instrument cleansing and storage

Strict guidelines to provide bactericidal, virucidal, fungicidal and



sporocidal sterilisation for protection from organisms such as TB /atypical TB and HIV and other viruses need to be followed. Peracetic acid is a low temperature, chemical cleansing/sterilising agent with non-toxic residuals and when used in equipment such as the STERIS System ⁽⁶⁾ meets Australian Standards (AS 4187) as a safe and effective system for bronchoscope sterilisation. However, it must be remembered that the sterilisation process takes a minimum of 40 minutes. A minimum of two bronchoscopes is therefore required for theatre lists to operate smoothly and quickly. In all bronchoscopic cleaning processes, toilet/flushing/brushing of the suction channel immediately post-bronchoscopy while secretions are still moist is very important in order to prevent potential obstruction of the bronchoscope by dried encrusted suctioned material.

Clinical issues

Indications for bronchoscopy

- ***Diagnostic***

The diagnosis of many of the conditions for which bronchoscopy is performed will be obvious to an experienced bronchoscopist before the procedure. It is therefore often confirmatory in function, adding the necessary degree of diagnostic precision for clinical decision making at a sub-specialty level.

Common indications for paediatric flexible bronchoscopy are stridor, voice disturbance, persistent moist cough, unusual cough, haemoptysis, persisting chest signs such as crackles in a localised area, radiographic infiltrates including persistent atelectasis, recurrent infiltrates, recurrent pneumonia or interstitial disorders¹.



Flexible bronchoscopy provides a dynamic, visual assessment of the airways. It can define abnormal anatomical features such as laryngomalacia, tracheomalacia, bronchomalacia, airway stenoses, bronchitis associated appearances and foreign bodies as well as vocal cord granulomata, laryngeal and tracheal cysts and endobronchial granulomata of non-infectious or infectious causes, including those associated with endotracheal or tracheostomy tubes ⁽²⁾. Following cessation of anaesthesia and lightening of the conscious state, the dynamics of the upper airway, particularly vocal cord movement and abnormal supraglottic indrawing as seen in laryngomalacia can be observed during spontaneous breathing. Assessment of the degree of pharyngeal collapse needs to be interpreted with care as the depth of anaesthesia and any positive pressure applied by the anaesthetist will influence the interpretation..

- ***Broncho-alveolar lavage (BAL)***

Broncho-alveolar lavage (BAL) procedures are now commonly performed for the diagnosis of opportunistic infections in the immuno-compromised child, although the correct timing of the procedure and the specificity of the results obtained are not clear. BAL may also be useful in the immuno-competent child in cases of endoscopically apparent bronchitis, interstitial lung disease, unusual infections and drug related diseases in the search for unexpected bacteriology, and to a lesser extent for cytological analysis ^(7,8,9).

The role of BAL in monitoring interstitial diseases via cytology and/or related cytokine assays and other biochemical parameters is not well developed. BAL derived bacteriological monitoring in chronic infective disorders such as tuberculosis (TB) and cystic fibrosis is controversial



and as yet not well defined for routine use^(6,7,10,11). In research however BAL is providing important insights into many paediatric respiratory conditions^(11,12,13,14,15,16,17,18,19).

- ***Biopsy***

Transbronchial lung biopsy and mucosal biopsy can be performed through paediatric flexible instruments (larger than 3.5mm) using the same techniques as for adults. Small tissue sample size, pneumothorax and bleeding remain significant barriers to routine use in young children^(2,20,21). The dominant role for transbronchial biopsy is currently in (older children) following lung transplant. Its use in immunocompromised children and interstitial lung diseases in childhood is very limited, the procedure of choice being thoracoscopic or open lung biopsy^(2,20,21).

- ***Therapeutic***

A useful therapeutic role for bronchoscopy is site-specific endobronchial toilet for airway obstructive lesions that cannot be cleared by more routine suctioning and lavage methods. Such situations may arise in ventilated patients with severe mucus plugging or mucus diaphragm type obstructions causing collapse or gas trapping. The usefulness of this procedure will depend very much on the size of the bronchoscope and hence the size of the suction channel available. Lung lavage for pulmonary alveolar proteinosis is not well described for the paediatric age group, although there are anecdotal reports of its use in the USA.^(1,2)

- ***Interventional***

Rigid “open tube” bronchoscopy is preferred for most, if not all areas of interventional bronchoscopy. The role of flexible bronchoscopy in removal of large foreign bodies is very limited. Flexible bronchoscopy



may have a role in demonstration and removal of distally located foreign bodies, which cannot be reached by rigid instruments. However great caution is required with its use in this situation as the size of the foreign body may be under estimated and objects may be substantially larger than expected ("tip of iceberg")^(2,20,21). When the clinical likelihood of a foreign body is low, the flexible approach is preferable, as the procedure is quicker and less traumatic. Bronchial dilatation procedures for strictures or stenoses can be performed through paediatric instruments using cardiac catheter balloons⁽²⁾. The same techniques can be used for severe local gas leak disorders using catheter balloon blockage of an airway as a temporary procedure⁽²⁾.

- ***Supportive***

Other areas where the bronchoscopist can cooperate usefully with other specialties (such as ENT and surgery) are:

- Defining the position and canulation of fistulae in conditions such as H-shaped tracheo-oesophageal fistula;
- Defining the effect of surgical manipulations intra-operatively for aortopexy/tracheopexy procedures;
- Performing elective or emergency bronchoscopic intubations for patients with "difficult airways";
- Use in selective bronchograms in case of localised bronchiectasis.

These are uncommonly encountered situations for a bronchoscopist and require very high levels of training, skill and experience.

- ***Contraindications***

There are no absolute contraindications to flexible bronchoscopy. However, the presence of critical or progressive airway narrowing, or



suspected endobronchial foreign body, are strong indications for the use of rigid bronchoscopy. Premature age and extreme small size (e.g. < 800gms) are no longer specific contraindications, with the more recent development of very small calibre instruments.

Relative contraindications include hypoxia or hypercapnia which would be amplified by general anaesthesia, and bleeding diathesis. Thrombocytopenia and or coagulation disorders are risk factors particularly for BAL. These should be corrected pre- or peri-operatively, where possible however this may not guarantee haemostasis².

Acute intercurrent illness always needs to be considered carefully when elective procedures are being performed and the procedure should be postponed in such situations.

Data management

It is recommended that all procedures should be accurately recorded so that information can be retained for reference, teaching, quality assurance purposes and potentially for medico-legal issues. Various recording methods are available including videotape, computer disk and still photography for even the smallest bronchoscopes. Data editing and the need for organised storage systems are recommended² but they present significant logistic problems and no uniformly accepted system is available.

Training

There is no clearly defined training procedure in Australia and New Zealand. Minimal supervised experience of bronchoscopy in animals does not provide adequate training for the performance of



bronchoscopies in humans. Trainees must maintain diaries and log books of all procedures performed or observed. This is a current training requirement of the Royal Australasian College of Physicians for adult bronchoscopists. Supervisors must be confident that the trainee has achieved the necessary skills to practice in a solo fashion by the time training is completed.

There is no clear evidence from the literature to indicate how many procedures are necessary to acquire or maintain the skills to perform flexible bronchoscopy independently in children. The time to acquire these skills will vary from person to person and clearly the greater the number performed under supervision the higher the skill level that will be achieved. Thus, maximising the number of procedures performed during training is to be encouraged and training should be carried out under the direct supervision of an experienced bronchoscopist. The use of lung models and video libraries is of value in this regard. Training should also provide the necessary opportunity to learn the skills to negotiate the nasal and oral spaces in children and not merely place a bronchoscope through an endotracheal tube or laryngeal mask. Trainee paediatric bronchoscopists should learn and experience bronchoalveolar lavage and biopsy techniques. Training in rigid bronchoscopy is encouraged. Training should be offered to paediatric respiratory physicians rather than general paediatricians in a facility where adequate numbers of bronchoscopies are performed

In order for trained bronchoscopists to maintain competency it is important they continue to be actively involved in performing flexible bronchoscopy and bronchoalveolar lavage. In addition it is strongly recommended that a photographic or video record of all procedures is



maintained where possible, and a regular audit of outcome is undertaken.

Quality assurance

There is no current paediatric accreditation process for bronchoscopy. Whilst defined guidelines of high standard need to be developed for training accreditation and ongoing practice in this field, it is strongly recommended that log books containing relevant information be kept for auditing purposes. Where group practice is carried out internal auditing and reviews of log book data and video materials are also strongly recommended. Adult respiratory physicians should not perform procedures on children without appropriate training in paediatric bronchoscopy.

Regular checks of equipment safety from the point of view of infectious diseases and electrical safety of equipment in accordance with hospital accreditation guidelines and Universal Precautions are recommended. Departments and individuals carrying out these procedures must ensure that parental consent is obtained before procedures and develop materials suitable to parents and children so that they can be appropriately informed of the procedures.

Conclusion

Flexible bronchoscopy has now evolved into a useful and important tool for the diagnosis, management and research of paediatric respiratory diseases. The training guidelines and quality control issues outlined here provide a basis for trainers to ensure competency and safe practice in this area.



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