Rigid Bronchoscopy

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Abstract
Paediatric bronchoscopy entails two endoscopic techniques: flexible and rigid bronchoscopy. Flexible bronchoscopy is mainly performed by pulmonologists, whereas rigid bronchoscopy is a more invasive procedure usually carried out by otorhinolaryngologists. Each method has advantages and drawbacks. The selection of flexible or rigid bronchoscopy depends on the indication, the clinical context and the expertise of each medical centre. Flexible bronchoscopy has an essential role in the diagnosis of airway disease. On the other hand, rigid bronchoscopy is more efficient in the intervention of airway lesions. Foreign-body removal is the most frequent indication for paediatric rigid bronchoscopy. Rigid tubes (laryngoscope and bronchoscope) are also used for the treatment of laryngeal and tracheal lesions thanks to the continuous evolution of various endoscopic techniques such as stenting, dilatation, debulking with laser or microdebrider, and intralesional injections. The rigid tube can secure the airway in case of obstruction, thus allowing for concomitant assisted ventilation. Rigid and flexible instruments complement each other in the evaluation of paediatric airways, and the close collaboration between otorhinolaryngologists and paediatric pulmonologists helps to ensure the selection of the most efficient and safe procedure.

The respiratory tract can be explored using two endoscopic methods: flexible (fig. 1) and rigid (fig. 2) laryngoscopy and bronchoscopy. This chapter discusses the methods of and the indications for rigid (tube) airway exploration in the paediatric population as well as the differences between flexible and rigid laryngotracheobronchoscopy.

Flexible bronchoscopy is carried out under light sedation or general anaesthesia usually by a pulmonologist whereas rigid bronchoscopy is invariably performed in the operating theatre under general anaesthesia, usually by an otorhinolaryngologist. Complications of either procedure are rare but paediatric rigid bronchoscopy in particular necessitates anaesthesia and careful monitoring, and good cooperation between the anaesthetist and otorhinolaryngologist. During rigid endoscopy, two surgical instruments are used for visualizing the respiratory tract: the rigid laryngoscope (assisted by rod lens telescope; fig. 3) and the rigid bronchoscope (also assisted by the rod lens telescope; fig. 4). The external diameter of the rigid bronchoscope is selected according to the weight of the child (table 1). There are several types of rigid telescopes, e.g. direct (0°) or angled vision (30° and 70°), and two main diameters, i.e. 2.7 and 4 mm. The main advantage of the rigid bronchoscope is that it secures the airway and allows for assisted ventilation during the procedure (fig. 4), whereas the rigid laryngoscope does not allow for simultaneous assisted ventilation.

Thanks to recent technological advancements, the therapeutic use of rigid endoscopy has expanded in the last 10 years. Current treatment of upper respiratory tract diseases by means of rigid bronchoscopy may render the performance of tracheostomy unnecessary, a procedure which is associated with high mortality (0.5–4%) and morbidity (44–70%) rates in neonates and children [1, 2].

Complete exploration of the airway with the rigid endoscope includes visualization of the larynx, the trachea and the proximal bronchi, i.e. the main and lobar bronchi, and the orifices of the segmental bronchi. The indications for laryngotracheoscopy will be detailed in the first part, and those of tracheobronchoscopy in the second part of this chapter.

Rigid Laryngoscopy

Flexible laryngoscopy is an excellent method for exploring lesions that cause stridor and respiratory distress in neonates and infants, with some notable exceptions such as laryngeal clefts and anomalies of the posterior aspect of the larynx (e.g. postcricoid haemangiomas) [3]. Yet, rigid laryngoscopy
is useful when flexible laryngoscopy is normal despite a high suspicion of disease, or when an endoscopic treatment is considered.

Rigid laryngotracheoscopy is performed under general anaesthesia with spontaneous respiration without endotracheal intubation [chapter 2, this vol., pp. 22–29]. Induction is made with gas, and local anaesthesia (lidocaine) is applied topically onto the larynx. Direct laryngoscopy is performed with rigid 0- and 30-degree telescopes. This method allows exploration of the supraglottis, the
Fig. 3. Laryngotraceoscopy with rigid endoscope assisted by rod lens telescope under general anaesthesia and spontaneous ventilation.

Fig. 4. Rigid bronchoscopy under general anaesthesia and assisted ventilation.

<table>
<thead>
<tr>
<th>Weight of patient</th>
<th>External diameter mm</th>
<th>Internal diameter mm</th>
<th>Size number (Storz)</th>
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glottis, the subglottis and the trachea, as well as the superior oesophagus. If necessary, endoscopic surgical treatment can be performed during rigid laryngotracheoscopy. The main paediatric laryngeal pathologies [chapter 11, this vol., pp. 120–129] are discussed below with an emphasis on the use of rigid laryngoscopy in their diagnosis and treatment.

**Laryngomalacia**
Laryngomalacia constitutes the major cause of congenital stridor, accounting for approximately 75% of all cases [4]. Laryngomalacia is usually diagnosed by flexible laryngoscopy. Rigid laryngoscopy is useful in the evaluation of laryngomalacia: firstly when an associated airway anomaly such as a laryngeal cleft is suspected, and secondly when laryngomalacia requires endoscopic surgical treatment.

In most cases, laryngomalacia resolves spontaneously by 2 years of age. Yet, in 11.6% of cases, surgery is still required when symptoms indicating severe disease such as chronic respiratory insufficiency, growth delay or apnoeic spells are present [5].

Aryepiglottoplasty is currently the standard procedure for severe laryngomalacia; it entails resection of aryepiglottic folds and the mucosa over the arytenoids and excision of accessory arytenoid cartilages or of the lateral border of the epiglottis (fig. 5). The extent of the procedure depends on the location of tissue prolapsing into the airway. Several methods have been described to perform aryepiglottoplasty: cold steel dissection, CO₂ laser, KTP (potassium-titanyl-phosphate) laser and microdebrider. Other surgical techniques used to treat laryngomalacia include laser epiglottopexy and epiglottic suturing [6, 7]. The aim of the latter methods is to reduce epiglottic obstruction. Thanks to the development of endoscopic surgical procedures, severe laryngomalacia rarely requires tracheostomy.

**Vocal Cord Paralysis**
This is the second most frequent cause of stridor in neonates after laryngomalacia [8]. Laryngeal paralysis can be unilateral or bilateral. Diagnosis can be made either by flexible or by rigid laryngoscopy under general anaesthesia with spontaneous breathing.

Bilateral abductor muscle paralysis results in adduction of both vocal cords and closure of the glottis with severe dyspnoea that requires urgent treatment. In half of the cases,
paediatric bilateral laryngeal paralysis resolves spontaneously but tracheostomy may still be required sometimes [8]. Several surgical treatments have been suggested to avoid tracheostomy: enlarged laryngoplasty, arytenoidopexy, arytenoidectomy and lateral posterior partial cordotomy. Rigid laryngoscopy is used to perform arytenoidectomy or cordotomy. This endoscopic technique uses CO₂ laser (online suppl. video 1) or KTP laser [9, 10]. Because of the relatively small size of the larynx in children, cordotomy usually suffices for airway enlargement. A second cordotomy, ipsilateral or bilateral, is indicated if one surgical session is not sufficient.

Endoscopic cordotomy is currently the procedure of choice for the treatment of bilateral abductor paralysis. This is a minimally invasive technique that provides no functional sequelae. It can be proposed even if the patient is expected to recover later [10]. Cordotomy is preferred to tracheostomy because of the deleterious effects of tracheostomy in the child such as tracheal stenosis and tracheomalacia.

Haemangioma

Usually symptoms of airway obstruction due to haemangiomas are not present at birth but arise in the first 3 months of life because of the haemangioma’s natural history (a phase of rapid growth between 3 and 12 months of age, then a gradual involution leading to complete resolution before the age of 7 years in 70% of cases) [11].

Laryngoscopy (rigid or flexible) establishes the diagnosis and assesses the size and the location of the haemangioma. In many cases, the lesion is located in the left posterolateral wall of the subglottis (fig. 6). Laryngoscopy should not be preceded by systemic corticosteroid administration because corticosteroids can lead to virtually complete transient regression of the haemangioma, thus making the diagnosis difficult.

Because of the natural evolution and benign character of the lesion, some cases do not require treatment. Tracheostomy was initially the treatment of choice in cases of severe airway obstruction. A variety of medical and surgical treatment options exist but no consensus has yet been established. Many patients undergo different types of treatments during the course of their disease. Currently, endoscopic treatment is the best surgical option for symptomatic non-circumferential haemangiomas. Open surgical excision or medical treatment (corticosteroids, interferon, vincristine and, recently, propranolol) are preferred in case of symptomatic bilateral or circumferential haemangiomas [12]. Rigid laryngoscopy is used to perform several types of endoscopic treatment: laser, microdebrider and intralesional injection. Commonly used methods include CO₂, YAG (yttrium-aluminium-garnet), KTP, thulium and diode (formed from a positive-negative junction and powered by injected electric current) laser [chapter 6, this vol., pp. 64–74]. The YAG laser and KTP laser are preferentially absorbed by haemoglobin. Therefore, they are preferred for the treatment of haemangiomas as they theoretically decrease the risk of stenosis [13]. Laser treatment requires several endoscopic sessions to obtain complete resection or to excise granulomas or adhesions. The use of the endoscopic microdebrider to excise haemangiomas appears to reduce the risk of subglottic stenosis [14]. Intralesional steroid injection through the rigid laryngoscope has also been reported to be successful but administration of systemic steroids and intubation for variable lengths of time may be required when using this treatment modality [15].

Papillomatosis

Recurrent respiratory papillomatosis is the most common benign tumour of the larynx among children, whereas haemangioma is the most common paediatric tumour when all other possible localizations (e.g. skin, oral mucosa) are considered [11]. Laryngeal papillomas are very challenging to manage because of their tendency to recur [16].

Following voice change, stridor is the second most common symptom. Other symptoms include cough, recurrent pneumonia, dyspnoea, acute respiratory distress, dysphagia and failure to thrive.

Rigid laryngoscopy allows biopsy and then removal of the lesion (fig. 7). Repeated endoscopic debulking is currently the treatment of choice. The goal is to maintain a safe airway with preservation of normal vocal cord anatomy and avoid complications such as stenosis or web formation. Several methods of debulking can be used that entail use of cold instruments, microdebrider, CO₂ laser, KTP laser, argon laser and thulium laser. However, no treatment is entirely effective in eradicating respiratory papillomatosis. Indeed, the latent virus remains in the tissue even when