Airway Endoscopy

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15.1 Introduction

Endoscopic management is often required for thoracic surgery for diagnostic and therapeutic purposes. Rigid or flexible endoscopes are selected depending on the age of the child and the particular disease being treated. Flexible endoscopes are indicated for dynamic evaluation of the airways, one-lung ventilation, and for obtaining microbiological samples. Rigid endoscopes are used for diagnostic and surgical procedures.

Laryngoscopy and airway management stimulate the sympathetic reflex. This can result in tachycardia, arrhythmias, systemic and intracranial hypertension, and catecholamine release. General and topical anesthesia protect the child from these responses [1–3].

15.2 Informed Consent

If endoscopic management is planned, the benefits and risks of the procedure must be explained to the parents and, if possible, to the child. Written informed consent must be obtained from the former.

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15.3 Equipment

Each team member must be skilled in the management of all endoscopic instruments and devices. Endoscopic instruments and devices must be available and assembled in a cart (Fig. 15.1). Back-up equipment must be readily available. Imaging documentation (photographs and videos) is important in all cases to ensure reviewing of the case, for comparisons, and for teaching purposes [4, 5].

15.4 Procedural Steps

Before starting the endoscopic procedure, the patient's medical history and imaging (chest radiography, ultrasound, CT, MRI) must be known. Each procedure should be scheduled and the entire Endoscopy Team should be informed.

Monitoring: Guidelines on patient safety recommend standard monitoring:

- electrocardiography (ECG);
- saturated oxygen ($SatO_2$);
- end-tidal carbon dioxide ($ETCO_2$);
- temperature;
- non-invasive blood pressure (NIBP);
- end-tidal levels of anesthetic halogenates;
- airway pressure.

During anaesthesia, it must be clear to all present that a rigid endoscope allows ventila-

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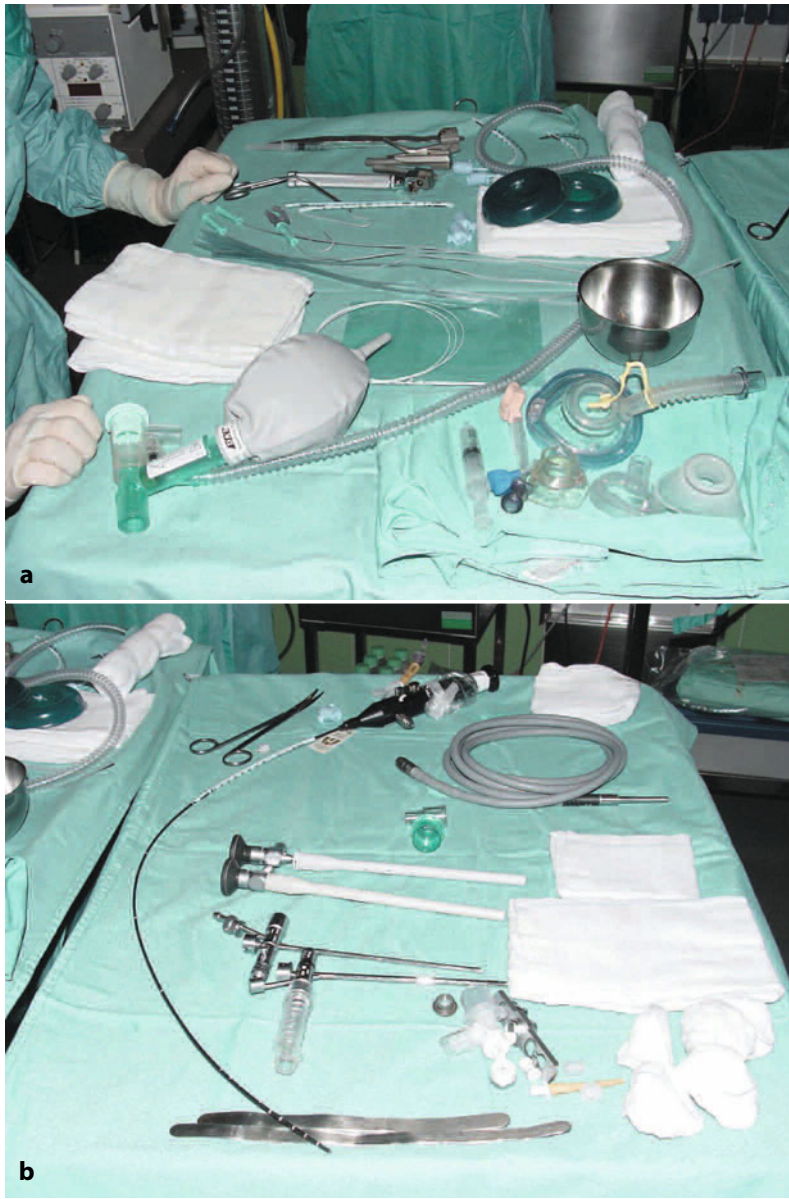

Fig. 15.1 Endoscopic instruments

tion and oxygenation, whereas a flexible endoscope determines airway obstruction [6].

Pre-oxygenation using a face mask: Inhalation of 100% oxygen for 5 minutes ensures denitrogenation before prolonged apnea is induced. Spontaneous ventilation is essential.

Sedation general anesthesia-local anesthesia: Sedation or general anesthesia (inhalatory anesthesia or total intravenous anesthesia, TIVA) combined with topical anesthesia is the best choice to maintain spontaneous ventilation. In our experience, topical anesthesia with lidocaine (3–5 mg/kg in progressive steps) affects the tongue, hypopharynx, epiglottis, larynx and trachea [7–9].

Patient positioning is dependent upon the choice of method. Flexible endoscopy can be undertaken with the head and neck in the neu-

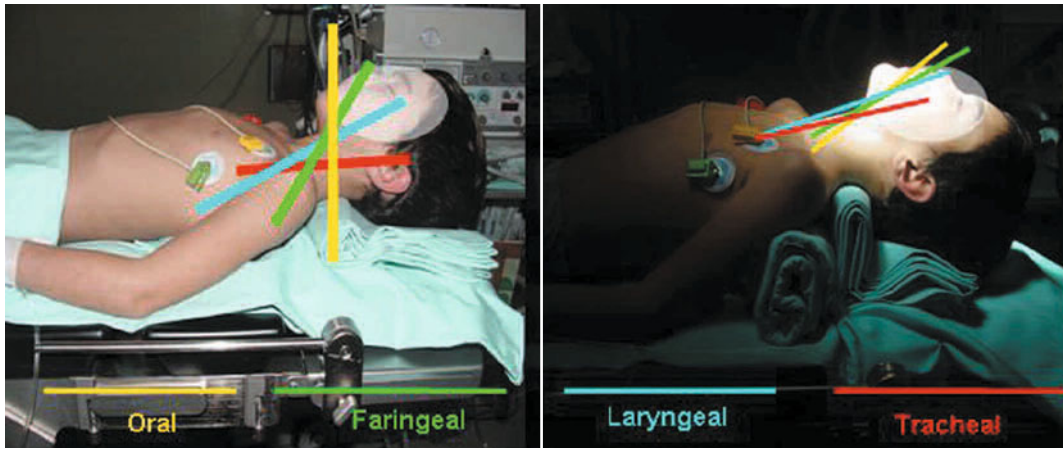

Fig. 15.2 Position of the head and neck for rigid endoscopy

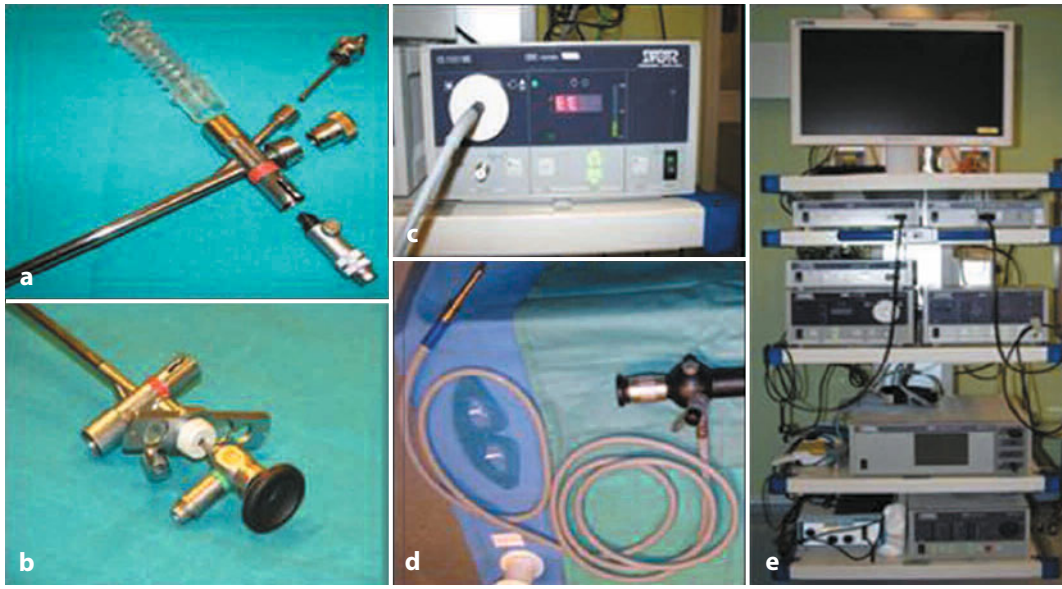

Fig. 15.3 Endoscopes and endoscopic system used for image acquisition. **a**,**b** Rigid endoscope. **c** Light source. **d** Flexible endoscope. **e** System for image acquisition

tral position. Rigid endoscopy requires correct alignment of the head and neck to introduce the instrument while avoiding airway trauma (Fig. 15.2). All instruments should be handled aseptically. Before starting, the endoscope, suction tube and the focus view must be checked. The possibility of image recording must also be considered (Fig. 15.3). Each member of the endoscopy team must occupy the planned position.

Flexible endoscopy: The flexible endoscope may be introduced *via* the nasal or oral routes through specific face masks that provide respiratory assistance, a laryngeal mask or an endotracheal tube (Fig. 15.4). The endoscopist should advance the instrument gently, atraumatically and slowly, recognizing the anatomical landmarks, avoiding trauma and, above all, bleeding. The endoscope is rotated and flexed to maintain the central field of vision [10].

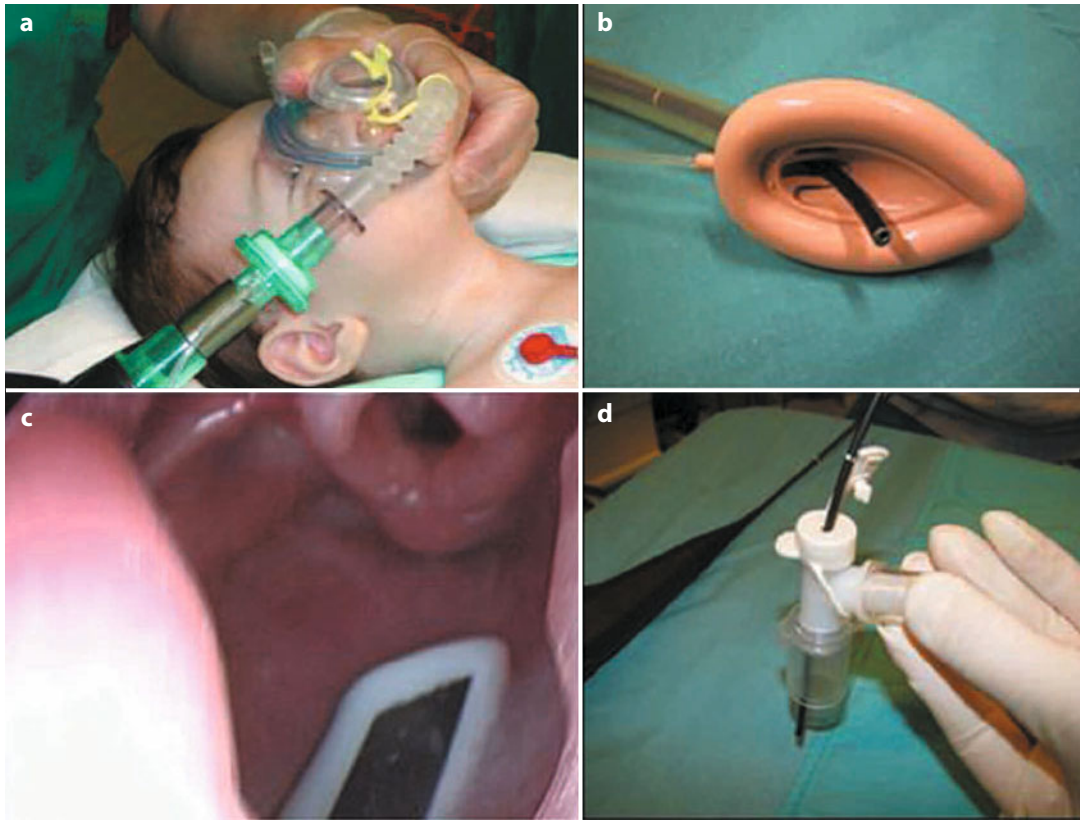

Fig. 15.4 Systems used for the introduction of flexible endoscopes. **a** Ventilation with specific mask. **b** Flexible endoscope through LM. **c** Position of pharyngeal tube. **d** Flexible endoscope through the connection for the endotracheal tube

Rigid endoscopy: Laryngoscopy using a 0° Hopkins Rod Laryngoscope should be done before introduction of a rigid instrument that has an optic rod inside. The choice of bronchoscope size is dependent upon several factors, but an indication can be given by the subglottic (cricoid) diameter, which is related to the age of the child (Table 15.1).

15.5 Complications

In experienced hands, complications are rare but nevertheless possible. Complications include: trauma to the nose, lips, tongue, vocal cords, teeth or tracheobronchial tree; bleeding; pneumothorax; and pneumomediastinum. Hy-

Table 15.1 Choosing the bronchoscope dimension according to the age of the child

Age	Cricoid diameter (mm)	Bronchoscope size	Internal diameter of bronchoscope (mm)	External diameter of bronchoscope (mm)
Newborn	4.0	2.5–3.0	3.2	4.0
Term newborn	4.5	3.0–3.5	4.2	5.0
6 months	5.0	3.5–4.0	4.2	5.0
1 year	5.5	4.0–4.5	4.9	5.7
2 years	6.0	4.5–5.0	4.9	5.7
3 years	6.5	4.5–5.0	5.9	6.7
5 years	7.0	5.0–5.5	7.0	7.8

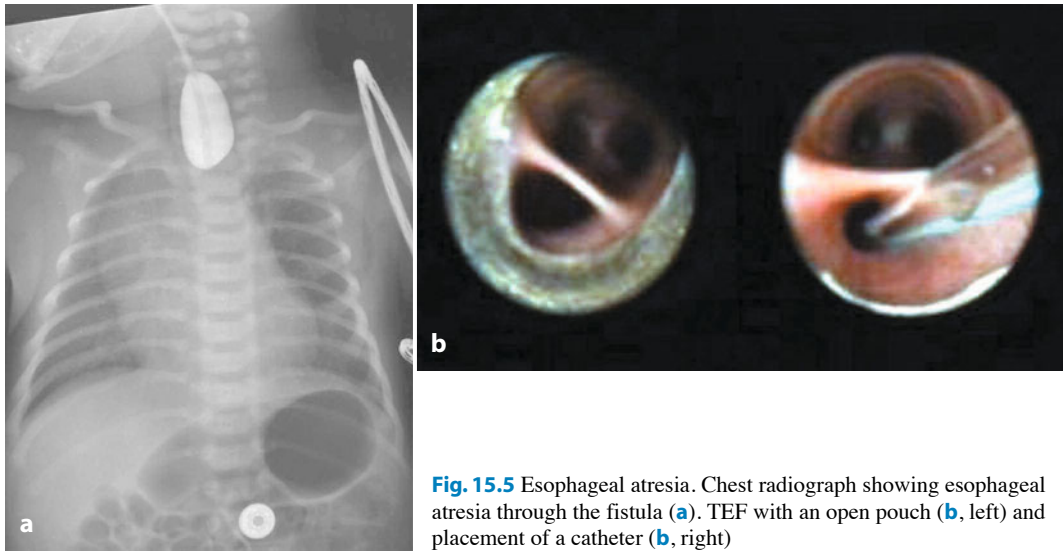

Fig. 15.5 Esophageal atresia. Chest radiograph showing esophageal atresia through the fistula (**a**). TEF with an open pouch (**b**, left) and placement of a catheter (**b**, right)

poxia may occur for reasons related to airway occlusion, excessive suctioning and atelectasis, laryngospasm/bronchospasm, or post-traumatic edema. Prolonged hypoxia can result in bradycardia and the need for prompt reoxygenation. A late complication, at the end of the procedure, is stridor related to post-traumatic subglottic edema. This complication can be treated successfully with nebulization using epinephrine (1:1,000 dilution in 0.25 mL/kg) plus dexamethasone (0.2–0.5 mg/kg, i.v.).

15.6 Principal Airway Anomalies and Thoracic Diseases

15.6.1 Tracheoesophageal Fistula (TEF) and Esophageal Atresia

Endoscopy of the airways enables determination of the: type of esophageal atresia (Fig. 15.5); presence, characteristics, and size of the fistula; anatomical relationship with the esophageal pouch. It also allows the fistula to be cannulated which, in the case of distal TEF, provides direct access to the stomach. With cannulation, the stomach can be drained, thereby reducing the risk of aspiration pneumonia and improving mechanical ventilation. Chest radiography will show the upper end of the esophagus. Examination using a rigid endoscope will show a pouch fistula and allows passage of a fine catheter to guide the surgeon to the correct site of repair [11, 12]. There is considerable variability in TEFs, but careful endoscopy can identify the position (Fig. 15.6). Tracheal bronchus (carinal trifurcation) is a differential diagnosis (Fig. 15.7).

15.6.2 Recurrent TEF

After surgical correction of esophageal atresia, cough, recurrent pulmonary infection and lobar atelectasis could appear, so a plan for diagnostic endoscopy may be necessary. For example, a 2-month-old child with symptoms suggestive of recurrent TEF underwent rigid endoscopy (Fig. 15.8). During the procedure, a recurrent TEF was diagnosed. As another example, a 2-month-old child with persistent cough during enteral feeding underwent rigid endoscopy that showed a second TEF in a distal fistula that had already been corrected. A catheter was placed in the upper fistula (Fig. 15.9).

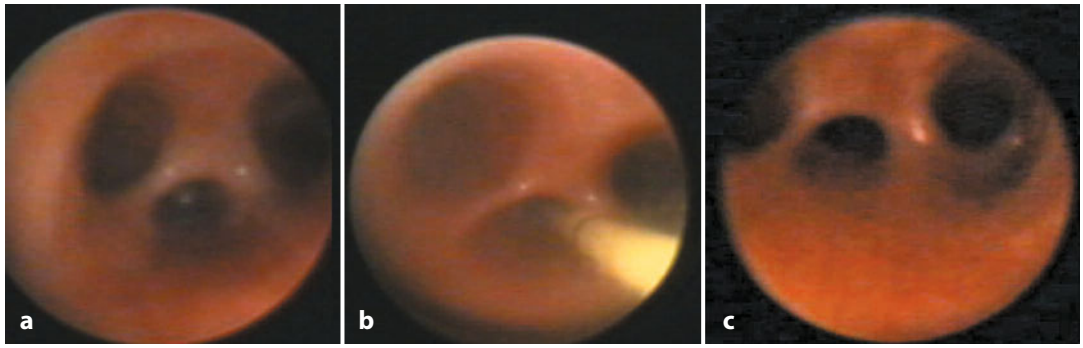

Fig. 15.6 Different types of TEF. TEF in carina: trifurcation (**a**). Trifurcation: catheter placed through the fistula (**b**). Trifurcation and tracheal bronchus (**c**)

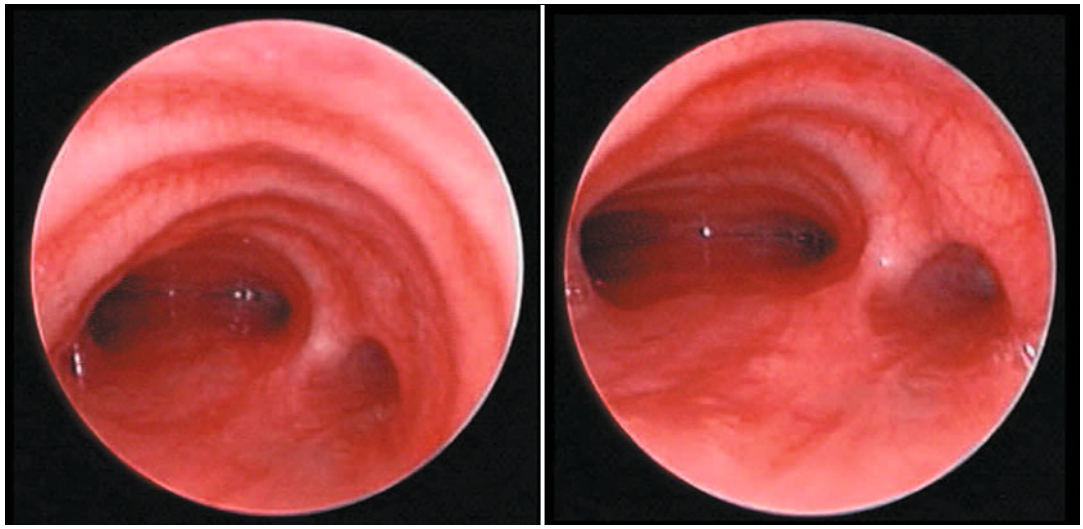

Fig. 15.7 Tracheal bronchus

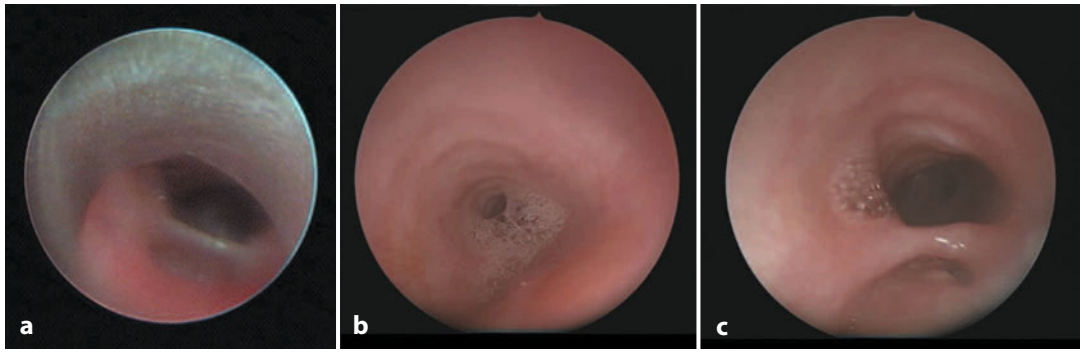

Fig. 15.8 Endoscopic images of a 2-month-old child with symptoms suggestive of recurrent TEF who underwent rigid endoscopy. An open pouch is shown in (**a**), gastric juice is shown bubbling up the fistula in (**b**) and the situation after aspiration is shown in (**c**)

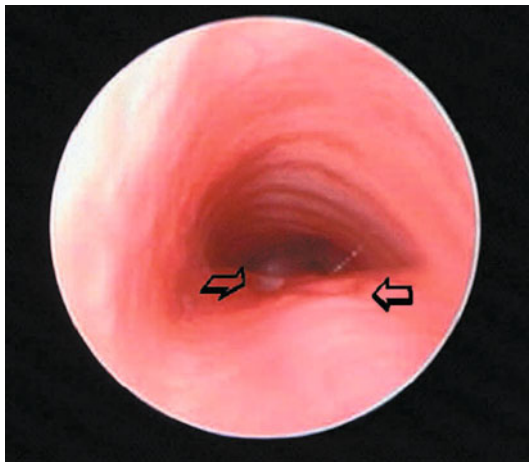

Fig. 15.9 Double TEF in esophageal atresia. A distal pouch fistula and upper fistula are shown (*arrows*)

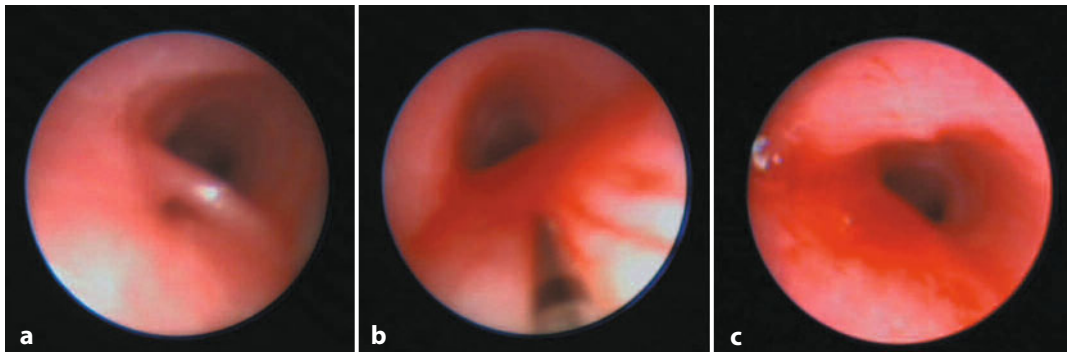

Fig. 15.10 Endoscopic sequence for obliteration of recurrent TEF in esophageal atresia. TEF (**a**). A needle is used to inject glue into the submucosal pouch (**b**). Obliteration of TEF (**c**)

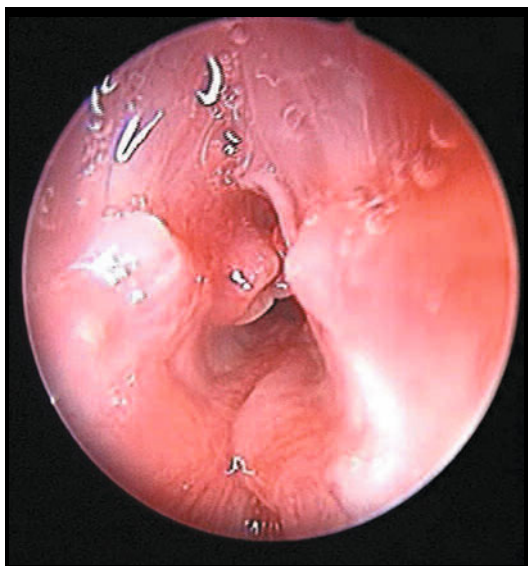

Fig. 15.11 Complication of prolonged tracheal intubation: laryngeal granulations

If a recurrent fistula is suspected, endoscopy must be carried out and, if confirmed, two strategies are available. Surgery is a possible treatment but endoscopic therapy can be applied [13]. For example, a 15-month-old child underwent injection of glue in the submucosal pouch of an open fistula (Fig. 15.10). Obliteration of the TEF was followed up 1-year later and a good outcome was documented.

15.6.3 Laryngotracheal Diseases

Granulations after prolonged intubation: The example of a 6-month-old child who was extubated under endoscopic control after prolonged intubation is shown in Figure 15.11.

Lymphangiomatosis: *Intra-utero* diagnosis of airway obstruction and planned *ex-utero* in-

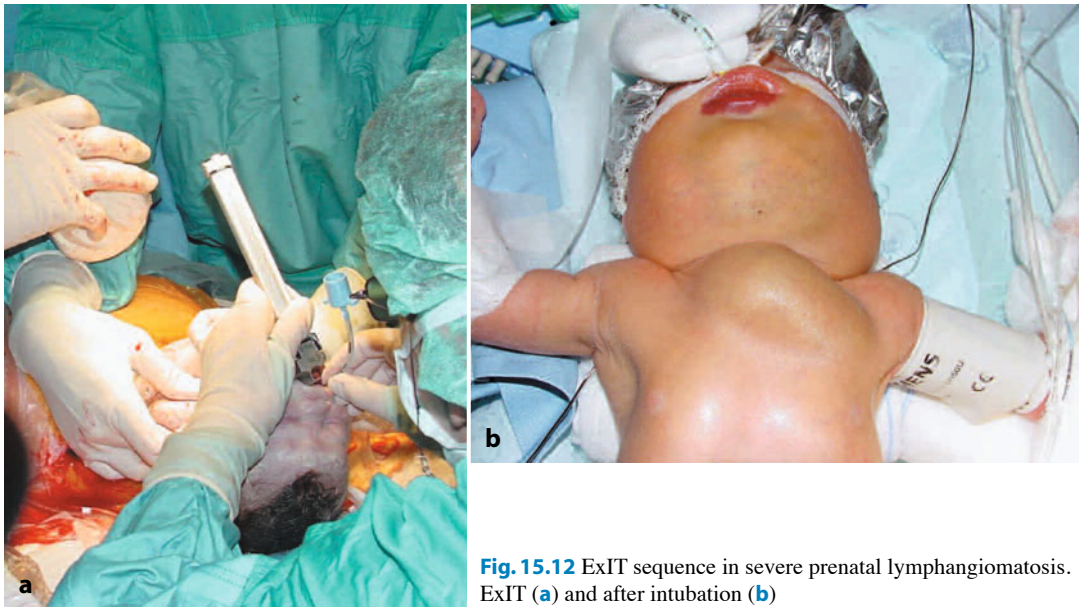

Fig. 15.12 ExIT sequence in severe prenatal lymphangiomatosis. ExIT (**a**) and after intubation (**b**)

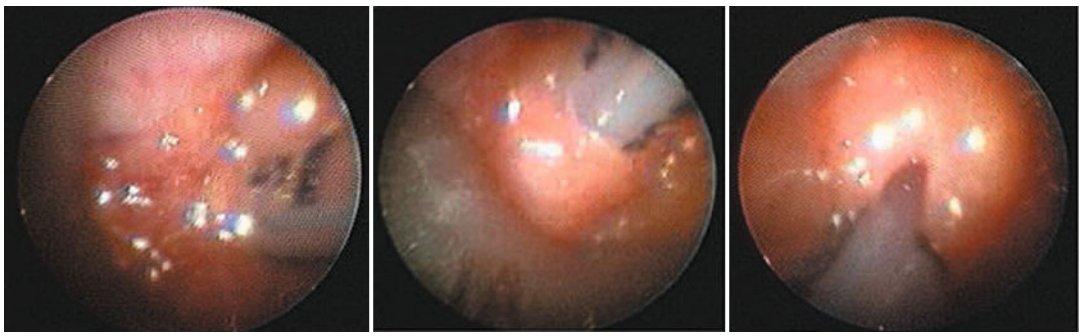

Fig.15.13 Rhinotracheal fiberoptic intubation at birth

trapartum treatment (ExIT) at birth are shown in Figure 15.12. The endoscopic view for intubation during ExIT is shown in Figure 15.13.

Laryngotracheal agenesis: A newborn who could not undergo tracheal intubation for laryngeal agenesia (Fig. 15.14) was oxygenated using a face mask [14]. A tracheoesophageal fistula was cannulated, thereby permitting ventilation (Fig. 15.15).

Tracheomalacia: A 5-month-old child with severe respiratory insufficiency is shown in Fig. 15.16. After endoscopy, aortopexy was carried out and the critical clinical condition resolved.

Tracheal stenosis is a possible consequence of prolonged tracheal intubation. However, it may also be associated with a vascular ring (Fig. 15.17) and a complete tracheal ring.

Tracheal stenosis and pulmonary artery sling: A 6-year-old child with recurrent episodes of asthma and pulmonary infection underwent endoscopy after CT (Fig. 15.18). Severe tracheal stenosis was documented and a vascular pulse was present at the principal carina caused by a pulmonary artery sling.

Mediastinal mass: A 16-month-old child with recurrent airway infections, wheezing

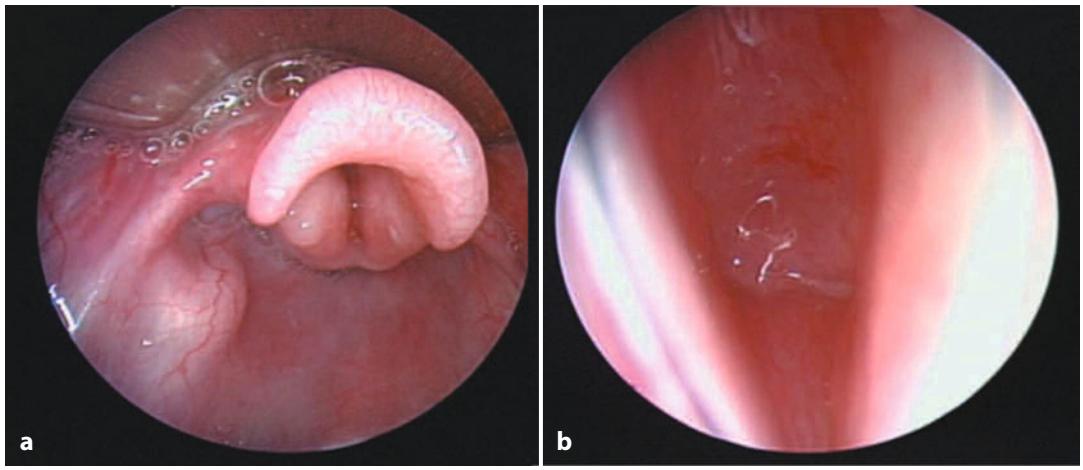

Fig. 15.14 Tracheal agenesis. View of the larynx (**a**). Subcordal stop (**b**)

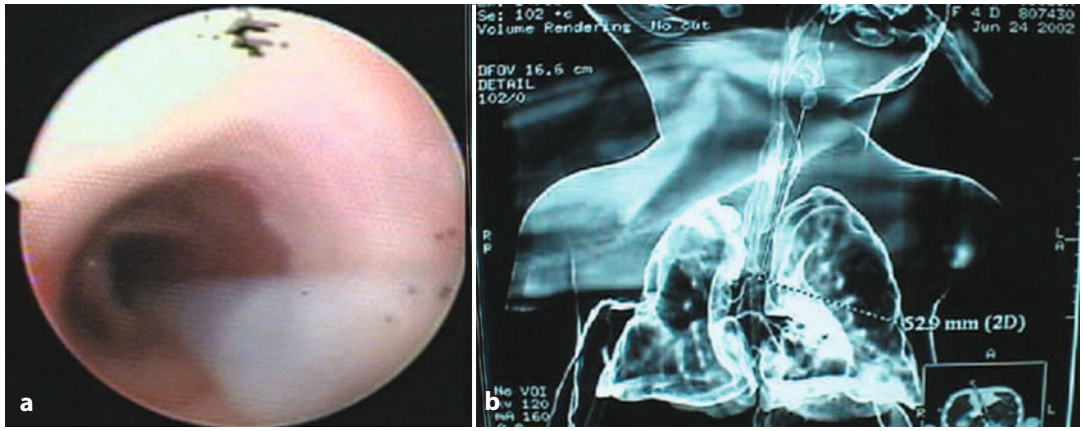

Fig. 15.15 Tracheal agenesis. A catheter inserted in the TEF in the distal tract of the trachea (**a**). CT (gap from upper stop and the TEF) (**b**)

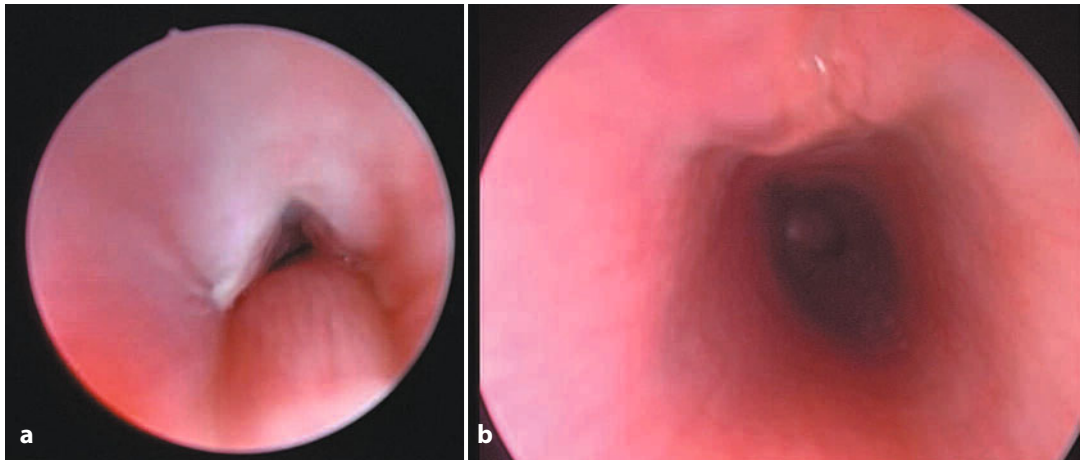

Fig. 15.16 Tracheomalacia. Severe tracheomalacia (**a**) and after aortopexy (**b**)

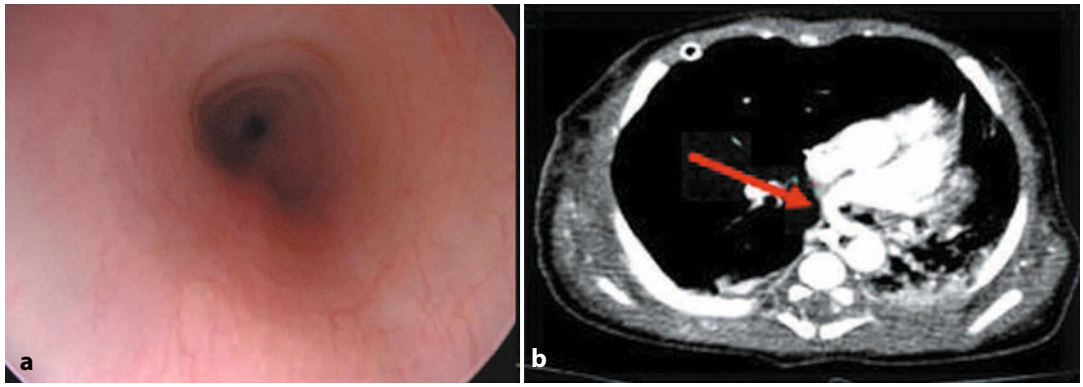

Fig. 15.17 Tracheal stenosis. Endoscopic view (**a**). CT showing pulmonary artery sling (**b**)

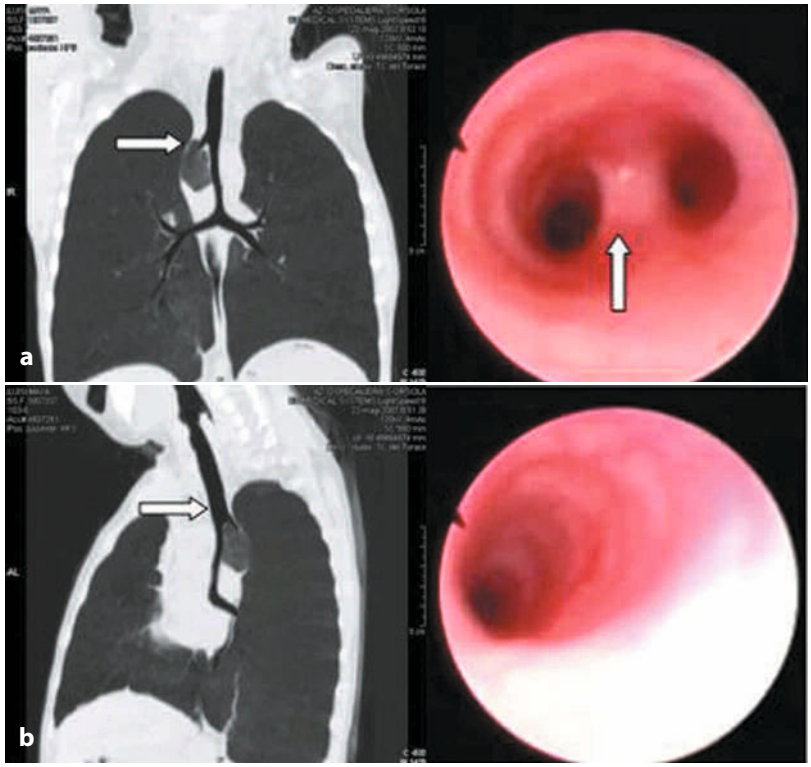

Fig. 15.18 Tracheal stenosis in accessory pulmonary lobe and pulmonary artery sling. Upper carina of the trachea (**a**). Tracheal stenosis (**b**)

and asthmatic status is shown in Figure 15.19. Endoscopy showed right bronchial closure. Radiological studies were needed to give a more precise definition of the pathology for the pediatric thoracic surgeons.

We have described only a few examples of laryngotracheal diseases to demonstrate that all endoscopic procedures (flexible and rigid) are useful in the evaluation of thoracic disease. Pediatric airway management is necessary in many situations with particular regard to subjects who may undergo surgery.

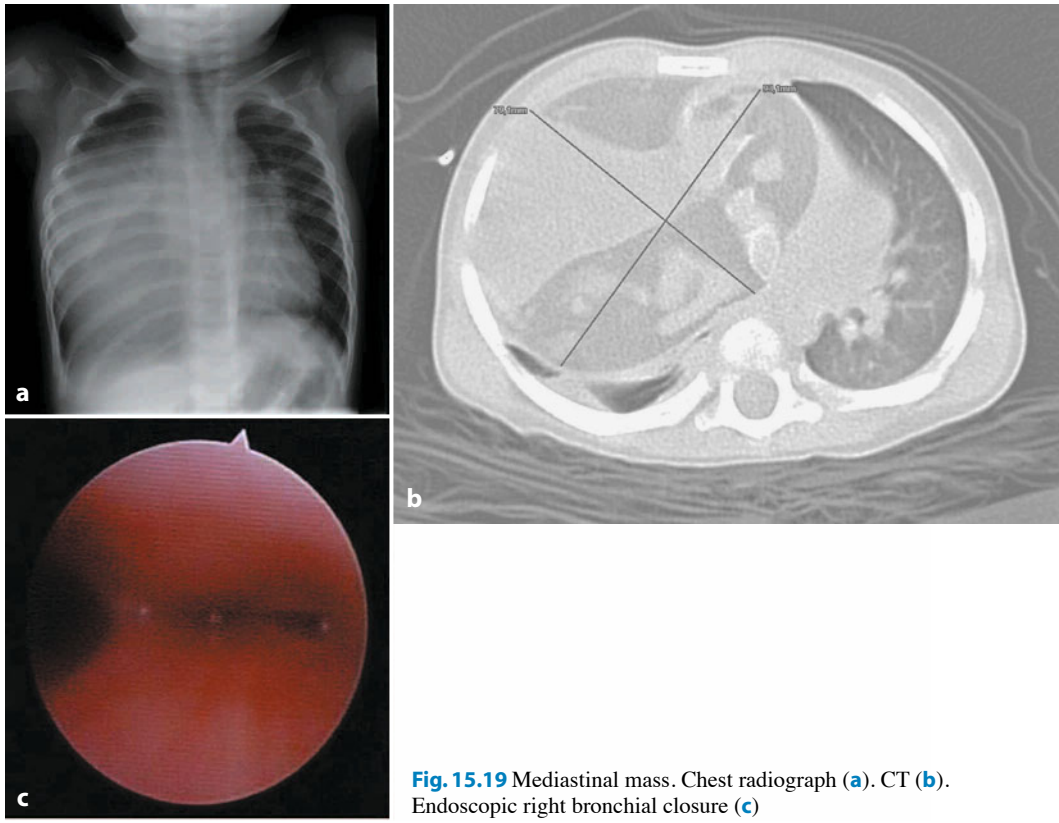

Fig. 15.19 Mediastinal mass. Chest radiograph (**a**). CT (**b**). Endoscopic right bronchial closure (**c**)

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