perioperative right atrial and right ventricular chamber values obtained by direct needle measurements. Our case is unique among reported cases of TRALI in its management with extracorporeal oxygenation. Maximal ventilatory support instituted immediately after the initial cessation of bypass was insufficient to maintain oxygen saturation. Without the timely reinstitution of bypass, the patient would not have survived. After 893 min of cardiopulmonary bypass, ventilation was reinstituted and the patient then maintained adequate arterial oxygen saturation. It appears that this period of bypass was sufficient to allow pulmonary function to recover sufficiently to allow mechanical ventilation, which nevertheless had to be continued for a further 7 days. Other treatments that have been used for TRALI include high-dose steroids and plasmapheresis. There is no evidence that steroids are effective in established disease. Plasmapheresis has been reported in a single case and was associated with clinical improvement 6 days after the initial insult. As most cases show recovery at 24–48 h, it seems likely that plasmapheresis will only be valuable when the antibody titre is very high and there is evidence of continuing damage. At present, it does not form part of the routine management of TRALI. This case has implications for the management of TRALI in general, as current interventions do not routinely go beyond mechanical ventilation. The fact that this was a cardiac case was fortuitous as it allowed the patient to continue to be supported by extracorporeal oxygenation through the acute episode. Extracorporeal membrane oxygenation has, however, been used in clinical practice for a number of years. It has been used successfully in the management of acute reversible pulmonary failure, such as post-lung transplantation acute respiratory failure. The use of extracorporeal oxygenation may be particularly valuable in severe cases of TRALI, as it is a transient condition and the patient is expected to make a full recovery after the acute episode. We therefore recommend that, where facilities exist, extracorporeal membrane oxygenation or cardiopulmonary bypass should be considered seriously in the management of patients with TRALI when conventional treatment is proving insufficient.

References

Welded tracheal stent removal in a child under cardiopulmonary bypass


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Metallic tracheal stents have been used in the treatment of paediatric tracheomalacia for more than a decade. We describe a case in which critical airway obstruction occurred during removal of a welded tracheal stent using a rigid bronchoscope under general anaesthesia. Life-saving cardiopulmonary bypass was instituted urgently, and the welded stent was then removed successfully by directly opening the trachea.

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Use of balloon-expandable metallic stents (Palma stents) for the treatment of tracheobronchial stenosis in paediatrics has gained popularity.1-6 Several of the reports on stent insertion for treatment of tracheomalacia have focused only on its effectiveness in relieving airway stenosis. However, there are possible risks in removing difficult stents through a rigid bronchoscope under general anaesthesia. We present a case in which critical airway obstruction occurred during the removal of a welded tracheal stent using a rigid bronchoscope. Urgent cardiopulmonary bypass (CPB) was used to manage the situation successfully.

Case report
A boy aged 1 yr and 11 months, weighing 10 kg, presented with stridor and respiratory distress. He had a history of a double aortic arch complicated by collapse of the lower third of his trachea, which was treated successfully with surgical correction and tracheal stenting (Palma stent) at the age of 6 months. However, partial loosening of the stent had occurred, with recurrent granulation tissue growing over it (Fig. 1). This had resulted in obstruction of the tracheal lumen despite repeated balloon dilatation. As stent removal by flexible fibreoptic bronchoscope had failed, removal by rigid bronchoscope under general anaesthesia was scheduled.

After obtaining informed consent from the parents, midazolam 0.05 mg kg\(^{-1}\) and atropine 0.01 mg kg\(^{-1}\) were given i.v. when the patient arrived in the anaesthesia area. Standard monitoring including ECG, pulse oximeter, non-invasive arterial pressure and a capnograph was used. Anaesthesia was induced with sevoflurane 6% in oxygen 100% by facemask and maintained with sevoflurane 4-6% with oxygen 100% under considerable pressure. Anaesthesia was induced with sevoflurane 6% in oxygen 100%. Body temperature was maintained around 37°C with a heat lamp and a warm blanket. When deep anaesthesia had been achieved, lidocaine 2% 1 ml was sprayed onto the laryngotracheal region, and a rigid bronchoscope (Storz, 3.5 \(\times\) 26) was inserted. Granulation tissue was seen over the stent, resulting in partial tracheal obstruction. The opening through the stent was about 1 mm. Removal of the stent using long forceps was attempted by the surgeon. However, the tracheal stent became deformed and almost completely occluded the trachea after manipulation. Positive-pressure ventilation was impeded by the deformed stent. The airway pressure was higher than 60 mm Hg and no breath sounds were heard. The oxygen saturation decreased progressively to 40%. The sevoflurane was turned off and the patient was ventilated with oxygen 100% under considerable pressure. Fortunately, the patient resumed spontaneous breathing about 90 s later and the oxygen saturation gradually returned to 75-80% and finally to 95% within 2 min. However, the stent was still firmly imbedded in the tracheal wall and caused increasingly severe tracheal occlusion after several attempts to extract it. Left radial artery cannulation was performed and blood gas analysis showed \(Pa_O_2\) 15.8 kPa, \(Pa_CO_2\) >13.3 kPa, base deficit –2.4 mmol litre\(^{-1}\) and pH 7.02. The cardiovascular surgeon was called and CPB was instituted urgently. About 30 min later, the deformed stent (Fig. 2) was removed by directly opening the trachea under partial CPB assistance. A tracheostomy tube was inserted through the surgical opening to ensure a patent airway. The patient was then weaned from CPB uneventfully and breathed spontaneously with oxygen 4 litre min\(^{-1}\) through a tracheostomy tube in the intensive care unit. The patient was discharged without sequelae 2 weeks later.

Discussion
Tracheal stenting has been described as the procedure of choice for children with tracheomalacia, as the clinical outcome is similar to an aortopexy but the procedure is less invasive.3 Metallic stents, unlike the silicone tube stent, are preferred in children to relieve airway stenosis because of less stent migration and better epithelial growth.7-8 However, metallic stents may stimulate ingrowth of granulation tissue,3 5 7 8 and are prone to collapse.8 Growth of granulation tissue may recur even after repetitive scraping and balloon compression,7 and may obstruct the airway, as it did in this patient. The stent is apt to collapse from external pressure, such as from an enlarging tumour mass, a thoracic aortic aneurysm, or a vigorous cough.8 When these complications occur, the stent may need to be removed.

The majority of stents can be removed through a fibroscope. However, once the stent has been incorporated into the mucosa, it becomes more difficult to remove,8 especially when it has been there for a long time. Filler and colleagues3 described a child who died from an attempt to remove a tracheal stent that had become ‘welded’ into the tracheal wall by fibrous tissue. Attempts to free stents from the tracheal wall may cause stent deformity and resultant critical airway obstruction. If the stent is located in the subglottic area, urgent tracheostomy may be an alternative method of restoring a patent airway. Successful removal of large laryngotracheal foreign bodies impacted in the subglottic area through a tracheostomy has been reported.9 In our case, however, the ‘welded’ stent was located in the
lower third of the trachea and could only be removed under CBP.

Complicated stent removal is a high-risk procedure, so preoperative discussion about the anaesthetic with the surgeon is important. The anaesthetist should be aware of all the possible complications of difficult stent removal, such as critical airway obstruction during manipulation. During general anaesthesia, spontaneous respiration is preferable, with assisted ventilation; it may be life saving when near-total occlusion of the airway occurs. An inhalation agent with a low blood/gas coefficient which causes little airway irritability is chosen, because rapid awakening with spontaneous respiration and reduced airway resistance are desirable. This was well demonstrated in this patient. Moreover, muscle relaxants should be avoided. In order to maintain an adequate depth of anaesthesia, local anaesthetic sprayed on the larynx and trachea may be a useful adjunct to inhalation agents.

In such complicated stent removal, arterial cannulation for blood pressure monitoring and frequent arterial blood gas analysis should be performed in addition to standard monitoring. Emergency tracheostomy equipment and CBP or extracorporeal membranous oxygenation facilities should be readily available.

In conclusion, welded stent removal by rigid bronchoscopy under general anaesthesia should be regarded as a dangerous, possibly life-threatening, procedure. Preoperative evaluation, well-planned anaesthetic management and preparation of life-saving facilities in advance, especially CPB, are necessary to minimize operative morbidity and mortality.

References

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Fig 1 Chest radiograph showing the meshform tracheal stent (Palmaz stent) before extraction.

Fig 2 The welded tracheal stent shown from two different angles after removal under cardiopulmonary bypass. The stent became deformed after manipulation and nearly caused complete airway obstruction.