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Successful surgical management of airway perforation in preterm infants

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ABSTRACT

Traumatic airway perforation during endotracheal intubation is an uncommon but life-threatening complication in preterm infants. Death usually occurs at the time of the injury, but in rare cases where the infant survives the initial resuscitation, therapeutic options include conservative versus surgical management. We describe three cases of airway perforation treated successfully with surgical intervention and without lung resection, utilizing novel graft material and cardiopulmonary bypass to facilitate repair. In preterm infants who survive the initial injury we advocate for early identification and surgical management with cardiopulmonary bypass when feasible.

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Airway perforation is an under recognized complication of endotracheal intubation, especially in premature newborns and contributes to unsuccessful delivery room resuscitation. The incidence of airway perforation is likely higher than published due to underreporting and the injury not being recognized. Death usually occurs at the time of injury and the diagnosis of airway rupture is seldom confirmed. However when suspected, with aggressive non-surgical management including; chest tube placement for air leak, positioning with the affected side down, high frequency ventilation, the use of extracorporeal membrane oxygenation (ECMO) therapy in older children and inotrope administration for hemodynamic instability, some premature infants are able to be stabilized. Once stabilized, therapeutic options include conservative management or surgical repair. Historically in published reports non-surgical conservative management is commonly employed with an 88% mortality rate [1–8].

There are only 12 reported cases of iatrogenic tracheobronchial injuries in neonates [1–11]. Injury to the trachea or mainstem bronchi most commonly occurs secondary to endotracheal tube (ETT) suctioning or as the ETT is advanced during intubation, particularly if an ETT stylet is used and extends beyond the distal end of the tube [1–9]. The sites of airway injury reported include; proximal trachea, carina, right and left mainstem bronchi and one report documents the injury at the site of a tracheoesophageal fistula repair [1–11]. More recent reports have described surgical interventions, with extensive resection of normal lung parenchyma and improved survival [1]. Overall reported mortality for iatrogenic airway perforation remains significant at 55% [1–11].

This report describes the successful outcome of three premature infants with tracheobronchial perforation, managed surgically without lung resection utilizing; novel graft material, BioGlue© (Cryolife, Kennesaw, GA), CorMatrix© (ECM technologies, Roswell, GA) and azygos vein graft material and intraoperative cardiopulmonary bypass (CPB) to facilitate repair.

1. Methods

After Institutional Review Board approval, a retrospective chart review was performed to identify patients with iatrogenic airway

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Table 1
Patient characteristics.

	Patient 1	Patient 2	Patient 3
Birthweight	1570 g	1600 g	615 g
Gestational age	28 weeks	32 weeks	27 weeks
Diagnosis	Prematurity	Prematurity	Prematurity
	Beckwith Weidemann	CDH	Twin gestation IUGR
Mechanism of injury	Tube exchanger	Intubation in delivery room	Intubation or suction injury
Age at injury	60 days (36 wks PCA)	Birth (32 wks PCA)	3 days (27 wks PCA)
Diagnosis	CT scan intra-operative flexible bronchoscopy	Bedside flexible bronchoscopy	Bedside flexible bronchoscopy
Site of injury	Right lower lobe bronchus	Right mainstem bronchus	Right mainstem bronchus

This table describes patient characteristics, mechanism and timing of airway injury, diagnostic studies and site of injury.
CDH, congenital diaphragmatic hernia; IUGR, intrauterine growth restriction; PCA, post-conceptional age.

perforation managed at our institution. During September 2009–December 2012 3 patients were identified, however the true incidence of airway injury at our institution was likely higher, as during the same period several preterm infants died around the time of attempted intubation, and airway perforation was suspected as the cause of unsuccessful resuscitation. Data collected on the three patients who survived initial resuscitation included patient characteristics (Table 1), surgical management (Table 2) and post-operative course (Table 3).

2. Results

Three premature infants with iatrogenic airway injury survived initial resuscitation. In patient 1 conservative management was initiated and failed due to patient instability. All patients ultimately underwent surgical intervention and survived to discharge. Results are presented in Tables 1–3.

In all three patients the ETT was stabilized proximally in the trachea as the injuries were distal to the carina. In patient 1 initial attempts at conservative management with high frequency oscillatory ventilation (HFOV), positioning, antibiotics and multiple chest tube (CT) placements, failed to seal the air leak and ongoing clinical instability prompted surgical treatment. Surgery was performed 10 days post injury, with significant instability and marked anasarca. Patient 2, was initially misdiagnosed with an esophageal injury from naso-gastric tube placement due to a contained posterior mediastinal air collection. Although stable form a cardiopulmonary standpoint, once the airway injury was confirmed, patient 2 was treated surgically due to the concern for rupture of the posterior mediastinal air collection, the development of a broncho-pleural fistula, impairment of gas exchange and exacerbation of the underlying pulmonary hypertension. The repair was facilitated with the use of CPB, allowing for intra-operative bronchoscopy, stable hemodynamics and gas exchange, adequate time to complete and reinforce the repair and the advantage of resting the lung during the repair, preventing exposure of the surgical site to ventilator induced injury. Patient 3 was stabilized with HFOV, CT placement and positioning with the affected side down. Urgent flexible bronchoscopy was performed, followed by surgery once the diagnosis of airway perforation was confirmed. Conservative management was not attempted due to the aggressive nature of the air leak, which prevented lung inflation on the affected side. This exacerbated the degree of respiratory support needed with the contralateral lung exposed to excessive ventilator pressures. Despite initial stabilization, the size of the air leak resulted in frequent episodes of tension pneumothorax, with marked clinical deterioration and instability.

Intra-operative surgical findings in all three patients confirmed the preoperative diagnoses of airway perforation. All 3 patients were placed in the left lateral decubitus position and a lateral posterior right thoracotomy was performed through the fifth intercostal space. In patient 1, at the time of surgery severe anasarca with abdominal ascites and pericardial fluid were present, necessitating a pericardial window and peritoneal dialysis catheter for drainage. On entering the chest, multiple adhesions were noted which were released, freeing up the lung. Multiple air leaks were noted, the largest of which was a large right lower lobe broncho-pleural fistula. Primary closure of the airleaks and larger broncho-pleural fistula were achieved using 6-0 PDS suture, subsequently reinforced with BioGlue. Three 14 French chest tubes were placed and the chest closed in standard fashion. In patient 2, on entering the chest, a very large posterior pneumomediastinum reinforced with parietal pleura and under significant tension was noted, with a 2×7 mm tear in the membranous portion of the right mainstem bronchus beginning at the carina. The incision was extended anteriorly and the pericardium, opened allowing for cannulation of the ascending aorta with a 8 French Bio-Medicus cannula and the right atrium with a right angle 12 French cannula. After CPB was initiated, mechanical ventilation was terminated and the lungs rested. The mediastinal pleura was opened, and the azygous vein divided where it exits the back of the superior vena cava. A pleural flap was preserved on either side of the azygous vein to use to cover the injury site. On exposing the injury, the bronchoscope was passed to confirm and verify the proximal extent of the injury. The size of the injury prevented a primary closure due the concern of significant airway narrowing and CorMatrix was used to patch the defect, secured with interrupted 7-0 PDS sutures around the length of the injury. The bronchoscope was then used to verify patency of the airway, it was easily passed beyond the site of injury into the distal right lung. Mechanical ventilation was reinitiated and the

Table 2
Management.

	Patient 1	Patient 2	Patient 3
Definitive Management	Initial conservative, then surgical without CPB	Surgical with CPB	Surgical without CPB
Conservative management	HFOV, positioning, CT placement	None	None
Mode of ventilation	HFOV	CMV	HFOV
Surgical indication	Patient instability	Elective	Patient instability
Age at repair	70 days (38 wks PCA)	12 days (34 wks PCA)	8 days (28 wks PCA)
Time from diagnosis to repair	10 days	2 days	2 days
Weight at repair	3200 g (anasarca)	1800 g	675 g

This table describes the management of the three infants.
CMV, conventional mechanical ventilation; CPB, cardiopulmonary bypass; CT, chest tube; HFOV, high frequency oscillatory ventilation; PCA, post-conceptional age.

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