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Case Report

A Newborn with Isolated Tracheal Agenesis: Unfolding a Diagnostic Dilemma

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Abstract

Tracheal agenesis is an extremely rare entity characterizing the complete or partial absence of the trachea. Commonly it is found in association with other congenital malformations however isolated TA cases have also been identified. Without prenatal identification such respiratory embarrassment creates a diagnostic dilemma requiring emergency tracheostomy and detailed broncho-esophagoscopy under anaesthesia. The case report will further contribute to the literature and highlight the importance of prenatal recognition of symptoms and increasing cognizance of this rare entity to prepare us to take appropriate postnatal measures including surgical reconstruction.

Keywords: *Tracheal Agenesis (TA); Dilemma; Broncho-Esophagoscopy; Tracheostomy*

Introduction

Tracheal agenesis (TA) is a rare condition with an incidence of 1:50,000 live births and is a potentially lethal congenital defect affecting the airway with a male-to-female ratio of 2:1 [1,2]. TA is characterized by the complete or partial absence of trachea below the larynx with or without tracheoesophageal fistula. Not many cases of TA have been reported in the literature worldwide. It is commonly found in association with other congenital malformations; however, some, isolated tracheal agenesis cases have been identified. The prognosis is very grave and often incompatible with life. These newborns typically present with severe respiratory distress soon after birth and prompt diagnosis and ventilation through the oesophagus is the only immediate survival measures [3]. Although appropriate reconstructive surgery for tracheal agenesis is not well established and the prognosis after surgical measures is unsatisfactory [4], recent advances in surgical measures and tissue engineering for the possible correction of TA are imminent. Hence, prenatal MRI in the background of polyhydramnios associated with other congenital anomalies of TA becomes critical to provide a definitive diagnosis. We present a female newborn postnatally diagnosed as Floyd's type-2 tracheal agenesis, further contributing to the literature to emphasize the importance of prenatal acknowledgment of symptoms and diagnosis for appropriate postnatal measures, including preparation of surgical reconstruction.

Case Presentation

An out born female newborn weighing 1800 grams, with a gestation age of 33+4 weeks, was delivered to a healthy 28-year-old primigravida through the emergency cesarean section given a leaking membrane for approximately 10 hours and non-reassuring CTG. The pregnancy was complicated by Polyhydramnios; however, no anomalies were detected in a routine 2nd trimester anomaly scan. The baby was born limp with no respiratory efforts, and required positive pressure ventilation with coordinated chest compressions. Apgar scores at 1, 5, and 10 minutes were 3,5 and 6 respectively. Endotracheal intubation was attempted, glottis was visualized but intubation was unsuccessful, multiple such attempts were futile eventually necessitating extensive resuscitation with 3 doses of adrenaline. Cord blood gas was also suggestive of severe respiratory and metabolic acidosis with (pH 6.7, HCO_3 -15.9, BE -20, pCO_2 of 125 mmHg). Oxygen saturation of 91 - 95% was achieved with nasal CPAP but severe suprasternal retraction with desaturations occurred after a brief period. Urgent consultation with otorhinolaryngologist was sought, and an emergency tracheostomy was performed. The baby was placed on mechanical ventilation (SIMV with PS mode of ventilation: rate 50/minutes, Ti 0.4 seconds, FiO_2 30%, PIP 18, and PEEP 5) and transferred to our hospital (Tertiary level 3 NICU) for further management.

On initial assessment at our hospital, the baby was well perfused, normothermic, and euglycemic with some intercoastal and suprasternal retractions, receiving mechanical ventilation via a tracheostomy tube. She was continued with the mechanical ventilator on the same settings, and the adrenaline infusion continued. The following day, the baby experienced severe bradycardia and desaturation, requiring chest compression, suction, and positive pressure ventilation. Hourly suction was advised due to excessive secretions, causing an airway blockage.

Investigations

Blood gas done revealed severe respiratory acidosis with CO2 retention. Consultation from the pediatric surgeon and otorhinolaryngologist were sought. Video laryngoscopy showed that even the smallest size 2 mm endotracheal tube could not be passed. A CT neck revealed nearly 7.2 mm craniocaudal discontinuity in the laryngotracheal air column, leading to the diagnosis of subglottic stenosis (Figure 1). Head ultrasound revealed gross cerebral edema suggestive of perinatal asphyxia, while abdominal ultrasound and KUB study were unremarkable. 2D-ECHO in the previous hospital showed normal cardiac structure and function except for borderline PA pressure. Gastroenterology consultation led to upper GI endoscopy demonstrated wide ulceration of the upper esophagus with a tracheostomy tube, suspected iatrogenic perforation, compressing the esophagus, and preventing further scope progression (figure 2). A few days later another upper GI Endoscopy examination was done in OT under general anesthesia, confirming, orogastric and tracheostomy tubes together in the esophagus with the carina and esophagus separated from the same tube with no tracheal cartilage in the lower part, supporting the diagnosis of tracheal agenesis (Floyd's type 2) (figure 4).

Treatment

The baby was continued on mechanical ventilation through a tracheostomy tube and antibiotics were started empirically. After stabilization, baby was started on trophic feeds, which led to repeated respiratory arrest, which compelled us to insert gastrostomy and jejunostomy tubes. Baby still manifested frequent massive gastroesophageal reflux episodes, which prevented us from building up the feeds, and the baby was continued on TPN for the entire duration of the hospital stay. Since the reconstructive surgery/tracheal transplant procedure was unavailable at our institution; prompting the transfer of the baby to a higher center for further management.

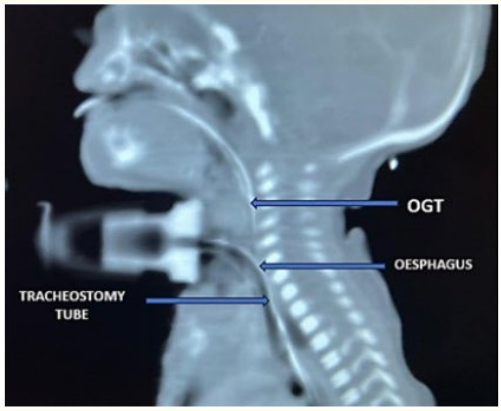

Figure 1: *CT neck revealed a tracheostomy tube and orogastric tubes (OGT) in the esophagus. Additionally, there was posterior displacement of the tracheostomy tube due to the absence of the trachea, with the tube actually positioned within the esophagus.*

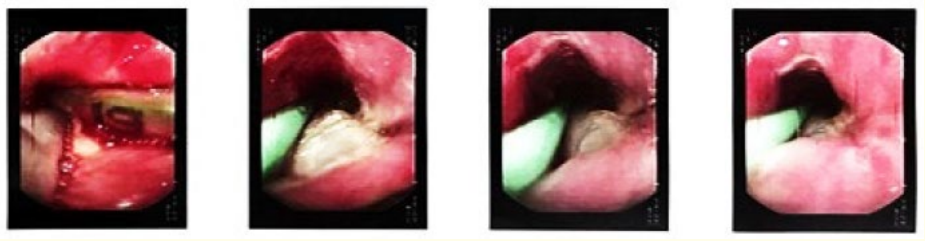

Figure 2: *upper GIT endoscopy showed wide ulceration of the upper esophagus with a tracheostomy tube, suspected iatrogenic perforation with tracheostomy tube compressing the esophagus.*

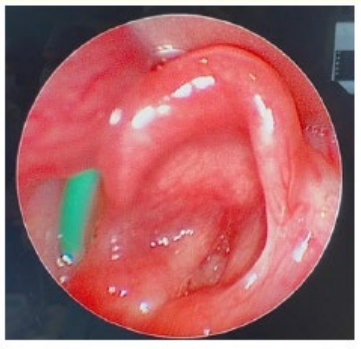

Figure 3: *upper laryngoscopy showed sever sub laryngeal stenosis*

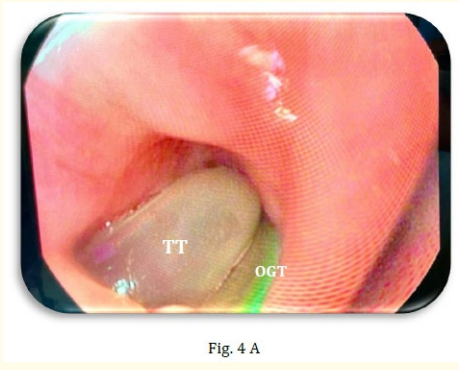

Fig. 4 A

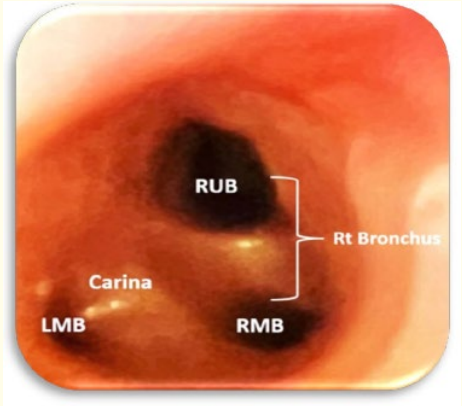

Fig. 4B

Figure 4 : *fig.4 A Upper GI endoscopy reveals the presence of both an orogastric tube (OGT) and a tracheostomy tube within the esophagus, with the trachea being absent. Fig. 4B showed the distal end of oeophagus with opening of Rt and Lt bronchus , The opening of the esophagus appears stenotic, preventing further progression.*

TT : Tracheostomy tube , OGT orogastric tube (green tube) , LMB : Left Main Bronchus , RUB: Right Upper Bronchus , RMB: Right Main Bronchus

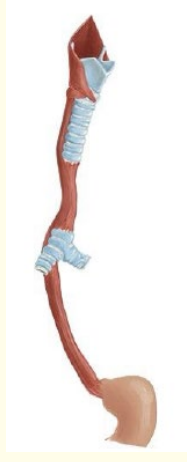

Figure 5: *Drawing of the patient's native malformation, which is characterized by a common segment involving both the middle esophagus and distal trachea*

Discussion

The precise etiology of tracheal agenesis is not known except for some genetic predisposition [5]. However, the proposed theory suggests that around eight weeks of gestation at the ventral aspect of the primitive foregut, the respiratory diverticulum leads to the development of a trachea-pulmonary complex. This complex matures into the carina and bronchopulmonary tree in the caudal direction, while the trachea and infra glottic structures evolve from cephalad elongation of the respiratory diverticulum. Failure of this normal elongation resulted in tracheal agenesis (Type 1) while arrested elongation with fusion to form carina gave rise to type 2 and with no fusion to form type 3 [6,7].

Floyd., *et al.* have formulated the anatomic classification of tracheal agenesis, categorizing it into three types (1, 2, and 3), and accepted worldwide [8]. Type 1 TA involves the absence of complete tracheal length except a short caudal segment with normal carina and a trachea-oesophageal fistula connects the distal trachea with the oesophagus (figure 6 A). Type 2 TA, features a complete absence of trachea and both the main bronchi join at the carina in the midline with a fistulous connection between the carina and esophagus, in most of the cases (figure 6 B). Type 3 TA exhibits, the complete absence of trachea and carina, with the two main bronchi independently originating from the oesophagus (figure 6 C).

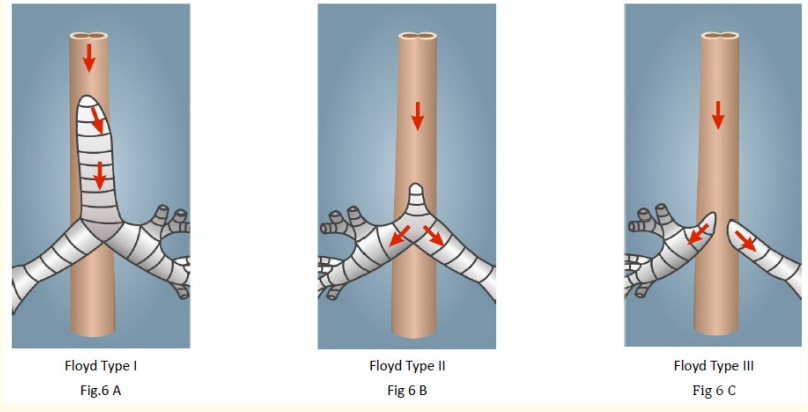

Figure 6: *Floyd classification of congenital tracheal agenesis.*

The incidences of type 1, 2, and 3 are 13%, 65%, and 22%, respectively. A more complex classification of TA was described by Faro., *et al*. in 1979 [9]. It has seven types; complete tracheal agenesis is type A, TA with main two bronchi arising directly from oesophagus is type B, TA with fused main bronchi and fistulous opening between bronchi and oesophagus is type C, TA with distal trachea and larynx connected by an atretic strand that has a fistulous communication with the oesophagus in type D, upper TA with large tracheoesophageal connection in type E, proximal tracheal agenesis with normal distal trachea with no fistula in type F, only short segment TA is found in type G. this classification is less commonly used nowadays.

Isolated tracheal agenesis is quite rare and is commonly associated with the malformations of other organ systems such as cardiac, musculoskeletal, gastrointestinal, and urogenital systems. TA may be a part of some poly malformities syndrome such as VACTERL (Vertebral anomalies, anal atresia, cardiovascular anomalies, tracheo-oesophageal fistula, renal anomalies, and limb defects) and TARCD syndrome (tracheal agenesis, radial anomalies, cardiovascular malformations, and duodenal atresia [10-12].

In the presence of CHAOS (Congenital High Airway Obstruction Syndrome), establishing a prenatal diagnosis of tracheal agenesis with no tracheooesophageal fistula is reasonably common. CHAOS is characterized by hyperechogenic enlarged lung due to intrapulmonary fluid retention because of TA, fluid-filled dilated trachea and bronchi, flattened diaphragm and massive ascites. In the presence of TOF, intrapulmonary fluid gets evacuated and CHAOS fails to develop, however unexpected polyhydramnios due to defective fetal fluids swallowing with lung hyperechogenicity can create a high index of suspicion of tracheal anomalies especially if the condition is associated

with other congenital anomalies. Fetal MRI is an excellent diagnostic modality and assumes a critical role in establishing a prenatal diagnosis of tracheal anomalies, especially in such circumstances. Once a diagnosis is made, In-Utero transfer of the expected mother to such facilities where a multidisciplinary team specialized in managing these conditions along with the availability of EXIT procedure can provide the best possible outcome and offer a fortuity of survival.

In most reported cases including ours, the diagnosis of TA was not made prenatally and presented as a respiratory emergency. In newborns with severe respiratory distress with failed intubation despite good visualization of the vocal cord and no audible cry, a high index of suspicion of TA is crucial for stabilizing cardiopulmonary condition and planning further investigation and management goals. Bag and mask ventilation and Emergency oesophageal intubation are the most vital steps to provide ventilation, however, the precarious position of the tube causes gaseous escape into the stomach which leads to abdominal distension, further aggravating the respiratory distress. Video laryngoscopy, bronchoscopy, esophagoscopy, and CT scan set forth the anatomical diagnosis of tracheal agenesis and assist in planning the palliative surgeries required to provide nutritional support.

Palliative surgical procedures are the same for all three types consisting of oesophageal ligation distal to trachea-oesophageal fistula, double lumen oesophagostomy for salivary drainage and intubation, and gastrostomy formation for enteral feeding. The major concern after the formation of pseudo trachea formation is the nature of the epithelial lining, lacking ciliary respiratory mucosa failing to clear secretions leading to recurrent respiratory infections [12]. External supportive stents were also utilized to prevent collapse but no ideal material has been identified, making this approach discouraging [13].

The first Tracheal transplant using human tracheal allograft was performed in 2008 [14]. Subsequent attempts faced challenges such as anastomotic leak, stenosis, collapse, infection, and haemorrhages. Long-term survival is limited with just ten reported cases and the longest survivor reported in the year 2021 [15-17]. Survival beyond one year required externally supported oesophageal airway reconstruction [18-21]. Three-dimensional (3D) printing is now an emerging modality in tissue engineering. Bioresorbable materials like Polycaprolactone (PCL) and Polytetrafluoroethylene (PTFE) have succeeded as airway splints offering potential benefits such as tracheal cartilage-like strength and lower infection risk. 3D-printed PCL splints have additional advantages over PTFE as being less stiff and smooth-walled exteriors, have shown promise [22]. Bioprinting technology imparts other advantages to incorporate living stem cells and chondrocytes during the production of artificial trachea [23-25]. A case in 2021 demonstrated success with a 3D-printed PCL tracheal implant, highlighting the need to establish this modality as a viable option [26].

Conclusion

Tracheal agenesis is an exceedingly rare condition, documented in approximately 200 cases within the existing literature. Failing to prenatally diagnose it, particularly when CHAOS (Congenital High Airway Obstruction Syndrome) is absent, results in severe perinatal asphyxia due to challenges in establishing an advanced airway and unpreparedness for surgical intervention. This lack of timely diagnosis significantly contributes to adverse outcomes.

A heightened suspicion for tracheal anomalies is crucial when a newborn exhibits severe asphyxia, strong respiratory efforts, inaudible cry, and multiple failed intubations despite clear glottis visualization, especially in the context of polyhydramnios. In cases where tracheal agenesis is suspected, early implementation of esophageal ventilation with gastric decompression in the neonatal golden hour proves beneficial. Diagnostic tools such as CT scans, direct laryngoscopy, and broncho-esophagoscopy are vital in confirming the diagnosis.

If tracheal agenesis coexists with other congenital anomalies, performing standard karyotyping and comparative genomic hybridization microarray (Array-CGH) is prudent to detect microdeletions and duplications in the genome. Surgical reconstruction options, including extra-esophageal stenting procedures, gastric pull-ups, small intestinal or colonic interpositions, tracheal allografts, and cutting-edge 3D bioprinting technology for artificial trachea creation, have been reported for type 1 and type 2 tracheal agenesis.

The prognosis for this condition is exceptionally poor, especially when major malformations and hypoxic brain injury are present. However, prenatal diagnosis, appropriate postnatal care, access to well-equipped facilities, and proficiency in meticulous tracheal reconstruction significantly enhance the chances of survival for these newborns.

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