CASE REPORT OLGU SUNUMU

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Plastic Bronchitis: A Rare Complication After Fontan Surgery

Fontan Ameliyatı Sonrası Gelişen Nadir Bir Komplikasyon: Plastik Bronşit

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This study was presented as an oral/poster presentation at 21st National Congress of Pediatric Cardiology and Pediatric Cardiac Surgery April 27-30, 2023, Muğla, Türkiye.

ABSTRACT Plastic bronchitis is a medical emergency where obstructing bronchial casts may cause asphyxia. 9-year-old boy presented with choking cough fits, producing rubbery sputum 1 year after Fontan operation. He had right atrial isomerism, unbalanced complete atrioventricular septal defect, pulmonary atresia, and received bosentan therapy before a fenestrated Fontan operation. Catheterization at presentation revealed oxygen saturation 84%, mean pulmonary artery (PA) pressure 18-19 mmHg, and pulmonary vascular resistance 3.5 WU. Narrow PA segment between the bilateral cavo-pulmonary anastamoses was stented. Medical treatment consisted of intravenous fluconazole, ceftriaxone; oral clarithromycin, prednisolone, sirolimus; inhaler salbutamol, budezonide, pulmozyme, heparin; and middle chain triglyceride diet. There were no casts in the bronchoscopy. One year after his discharge, he is stable, with no recurrences. Elevated PA pressure and failing Fontan circulation needs to be evaluated if plastic bronchitis is seen after Fontan surgery. Urgent medical treatment and bronchoscopy for bronchial casts is very crucial in these patients. Sirolimus may be a new option in medical treatment.

Keywords: Fontan procedure; complications; bronchitis; asphyxia; therapy

ÖZET Plastik bronşit, hava yollarında oluşan sert, yapışkan mukuslu tıkaçlar nedeniyle asfiksiye neden olabilen tıbbi acil durumdur. Dokuz yaşında erkek çocuk Fontan ameliyatından 1 yıl sonra boğulma hissi veren öksürük nöbetleri ve lastik kıvamında yapışkan balgam çıkarma şikâyeti ile başvurdu. Hasta sağ atriyal izomerizm, dengesiz komplet atriyoventriküler septal defekt, pulmoner atrezi nedeniyle yapılan fenestre Fontan ameliyatından önce bosentan tedavisi almıştı. Başvuru anında oksijen satürasyonu %84, ortalama pulmoner arter (PA) basıncı 18-19 mmHg, pulmoner vasküler direnç 3,5 WU'di. Bilateral kavo-pulmoner anastamoz arasındaki dar PA segmenti stentlendi. Tıbbi tedavi intravenöz flukonazol, seftriakson; oral klaritromisin, prednizolon, sirolimus; inhaler salbutamol, budezonid, pulmozim, heparin; orta zincirli yağ asidi diyetinden oluşuyordu. Bronkoskopide tıkaç saptanmadı. Hastanın taburculuktan 1 yıl sonra genel durumu iyi ve stabildir, tıkaç oluşumu tekrarlamamıştır. Fontan ameliyatı sonrası gelişen plastik bronşitte yüksek PA basıncı ve Fontan dolaşımı yetersizliği açısından değerlendirme yapılmalıdır. Bronşiyal tıkaçlar için acil tıbbi tedavi ve bronkoskopi çok önemli ve hayat kurtarıcıdır. Sirolimus tedavide yeni bir seçenek olarak değerlendirilebilir.

Anahtar Kelimeler: Fontan işlemi; komplikasyonlar; bronşit; asfiksi; tedavi

Plastic bronchitis (PB) is characterized by the formation of sticky, fibrinous casts in the tracheobronchial branches. It is a rare complication that can occur in children after Fontan surgery.[1] PB is a medical emergency where these bronchial casts obstruct the respiratory tract, leading to life-threatening asphyxia.

We present a rare a case of PB that occurred one year after Fontan surgery and discuss its diagnosis and treatment options. The parents of the patient pro-

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vided informed consent for the anonymous publication of his data.

CASE REPORT

Nine-year-old boy presented with episodes of choking cough, during which he produced long, white, branching, rubbery sputum (Figure 1). He had no fever and showed no respiratory distress between the cough fits. Prior to his presentation, he had been evaluated at a pediatric outpatient clinic and was prescribed oral amoxicillin and inhaler salbutamol.

The patient had a history of right atrial isomerism, unbalanced complete atrioventricular (AV) septal defect, mild AV valve regurgitation, pulmonary atresia and persistent left superior vena cava. He underwent a modified BT shunt operation on his second day of life. At 15-months old, he underwent a bilateral bidirectional cavo-pulmonary anastamosis (BCPA), after which he experienced prolonged chest tube drainage and was treated for mediastinitis. He was discharged on the 30th postoperative-day. At age 5, a major aortopulmonary collateral artery (MAPCA) was embolized with a vascular plug, and he left the catheter lab with an oxygen saturation of 80%. At age 7, he was evaluated for a Fontan operation. His preoperative pulmonary artery index, mean pulmonary artery (PA) pressure, and pulmonary vascular resistance (PVR) were 200mm^2/m^2, 16mmHg and 3.4 Woods units, respectively. He was prescribed 2mg/kg bosentan twice daily.[2] After 1 year of pulmonary vasodilator therapy his mean PA pressure decreased to 10 mmHg, with an oxygen saturation of 79% and PVR of 1.94 Woods units.

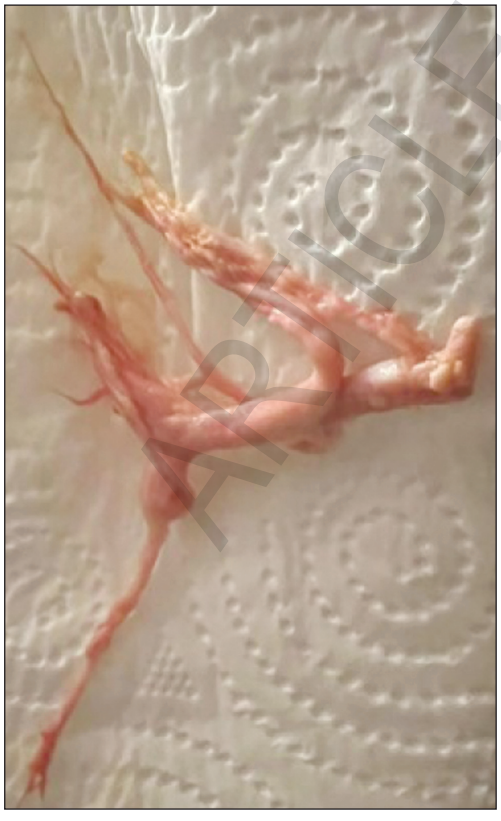

FIGURE 1: Bronchial casts expectorated by the patient

An extracardiac Fontan operation was performed using a 19 mm polytetraflouroethylene (PTFE) tube graft, fenestrated with a 6 mm ringed PTFE graft between the conduit and the right atrium. His postoperative oxygen saturation and PA pressure were 90% and 15-16 mmHg, respectively. He was discharged on the 9th postoperative day with furosemide, spironolactone, warfarin, and bosentan. Four months later, bosentan and warfarin were discontinued and aspirin was initiated.

Upon presentation, 1 year after the Fontan operation, his heart rate, respiration rate and blood pressure were normal, with an oxygen saturation of 87%. Cardiac examination revealed a single 2nd heart sound and a 2/6 soft pansystolic murmur in the 3rd left intercostal area. Lung auscultation revealed rhonchi in the right middle and basal areas. All other physical examination findings were normal.

Table 1 shows the patient's laboratory results, which revealed leukocytosis and mild increase in C-reactive protein. The gram stain of the sputum showed gram negative coccobacilli; it was hypocellular, with few mature squamous cells and alveolar macrophages. Sputum culture reported no pathogenic microorganisms. Serological tests for Adenovirus, Influenza A and B, Aspergillus (Galactomannan Ag) were negative. Beta D-glucan (fungal) was positive (160 pg/mL). Severe acute respiratory syndrome coronavirus 2 PCR and immunoglobulin G were negative. Blood culture remained sterile. Intravenous fluconazole, ceftriaxone along with oral clarithromycin (used as an anti-inflammatory agent 3 days/week), were administered. Treatment included oral pred-

TABLE 1: Laboratory results at presention		
White blood cell count	16600 cells/mm^3	62% neutrophil 13% monocytes
Hemoglobin	16.2 g/dL	
Thrombocytes	417000 cells/mm^3	
International normalized ratio	1.2	
C-reactive protein	1.83 mg/L	(n<0.79 mg/L)
Procalcitonin	0.047 ng/mL	(n<0.1 ng/mL)
Creatinine	0.46 mg/dL	
Albumin	4.4 g/dL	
ALT	27 IU/L	
AST	29 IU/L	

nisolone along with salbutamol, budezonide, pulmozyme and heparin inhalers to reduce bronchial hyperreactivity and to soften and liquefy the sticky casts. Sirolimus 1 mg/day and a middle chain triglyceride (MCT) diet were prescribed to reduce lymph production.

Given the respiratory findings were stable, elective bronchoscopy was planned, and the patient was taken to the catheter lab for evaluation of the Fontan circulation. His oxygen saturation, mean PA pressure, Qp/Qs, and Pulmonary Vascular Research Institute were 84%, 18-19 mmHg, 0.98, and 3.5 Woods units, respectively. The fenestration was patent, but left PA segment between the bilateral cavo-pulmonary anastomoses was narrow, so a 2.8cm/8zig CP stent was implanted using a 14X30mm balloon (Figure 2). Sildenafil 1mg/kg/day 3 times daily was added to the treatment regimen.[3] No casts were observed during the bronchoscopy a week later. The patient was discharged on aspirin, sildenafil, sirolimus, prednisolone and inhalers (salbutamol, budezonide). One year after his discharge, he remains physically and hemodynamically stable, with no recurrence of symptoms.

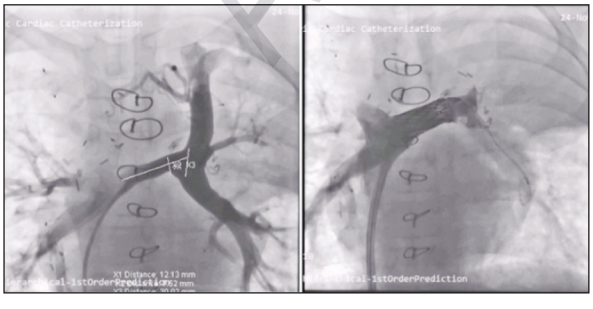

FIGURE 2: Stent implantation in the left pulmonary artery in a patient with Fontan operation

DISCUSSION

In PB, the patient's cough produces a characteristic sticky, fibrinous sputum containing intrabronchial casts shaped like bronchial branches. The condition may be mistaken for pneumonia due to associated symptoms like fever, productive cough, wheezing, respiratory distress, and side pain. The most critical manifestation is the occlusion in the middle and distal airways by casts, which can lead to asphyxia and death.[4] Early recognition of these secretions is crucial for timely diagnosis and intervention in this life-threatening condition.

The heterogeneous etiology of PB is summarized in Table 2. It is more commonly seen in adults and is often related to pulmonary infections, chronic inflammatory processes, or abnormal lymphatic drainage. In children, PB is rarely observed and is primarily associated with congenital heart defects, most notably following Fontan surgery.[4] The lifetime cu-

TABLE 2: Heterogeneous etiology of plastic bronchitis		
Infectious etiology	Bacterial	Mycoplasma
	Viral	Adenovirus influenza A/B
	Fungal	Aspergillosis
Inflammatory etiology	Asthma	
	Idiopathic chronic eosinophylic pneumonia	
	Primary ciliary dyskinesia	
	Cystic fibrosis	
Abnormal lymph drainage/ obstruction	Congenital anomaly	
	Sickle cell anemia	
	Tumor obstruction	Kaposi sarcoma in HIV infection
		LAP in silicosis
After cardiac operation	Congenital heart disease	Fontan surgery
		Glenn/BCPA
		Operated Fallot tetralogy
		Arterial switch for TGA
	Adult acquired disease	3-vessel bypass for non-ST MI

HIV: Human immunodeficiency virus; LAP: Lymphadenopathy;
BCPA: Birectional cavo-pulmonary anastamosis; TGA: Transposition of the great arteries;
MI: Myocardial infarction

mulative incidence of PB after Fontan surgery is reported to be up to 4%, with most cases occurring within 1-3 years postoperatively. The 5-year mortality rate after diagnosis can be as high as 50%.[5,6]

Pathophysiologically 2 types of casts have been identified: Type 1, which contains inflammatory components (e.g., neutrophils, eosinophils, Charcot-Leyden crystals), is associated with infective/inflammatory etiologies and decreased mucociliary clearance. Type 2, which is seen after Fontan surgery, contains acellular proteinaceous lymph material and is associated with inadequate lymphatic drainage. Our patient exhibited Type 2 casts, suggesting this etiology.[4]

Treatment varies depending on the underlying cause, but the primary goal is to remove obstructive casts and prevent the formation of new ones. Urgent intervention is necessary, as casts can cause asphyxia and death. Bronchoscopy is the mainstay of the treatment, allowing for mechanical removal of obstructive casts and the collection of material for etiological examination. Cryoextraction method has also been used as an alternative method.[7] To facilitate cast removal, inhalers containing pulmozyme, heparin, tissue plasminogen activator, or N-acetylcyctein are often administered prior to bronchoscopy.[4] Therefore we also prescribed pulmozyme and heparin inhalers to our patient. Even if the etiology is not infectious or inflammatory, oral and/or inhaled steroids, bronchodilators, oral macrolide antibiotics are typically prescribed to suppress secondary bronchial inflammation and decrease cast production. Any accompanying secondary infections should be identified and treated.

In Fontan circulation, chronically elevated systemic venous pressure and non-pulsatile pulmonary flow may lead to lymph stasis, bronchial lymph leakage and cast formation.[1,4] Therefore, any issues with the Fontan circulation that lead to increased systemic venous pressure should be investigated. Our patient already had elevated PA pressure before the Fontan operation, which became favorable only after pulmonary vasodilator therapy and the use of a fenestrated Fontan operation.[2,3] After the Fontan operation, the left PA branch was mildly stenosed, necessitating stenting to ensure unobstructed Fontan circulation. These factors contributed to chronically increased systemic venous pressure, leading to abnormal bronchial drainage.

Schumacher et al. reported that prolonged chest-tube drainage after BCPA or Fontan surgery, a history of chylothorax, ascites, and significant aortopulmonary collaterals were associated with a higher risk of developing PB.[1] They suggested that prolonged chest-tube drainage might identify patients with a pathological inflammatory response that may prompt airway cast formation later on. Our patient had prolonged chest drainage after BCPA, which was complicated by mediastinitis. Additionally, at age 4, a MAPCA was embolized to reduce pulmonary overflow, further increasing his risk of developing PB.

In persistently symptomatic PB cases, lymphatic system may be evaluated using conventional or magnetic resonance imaging dynamic lymphangiogram to identify congenital or postoperative obstructions in the thoracic duct. In such cases, stenting the obstruction or redirecting lymphatic drainage to another location, along with reducing lymph production through embolization, may be effective treatment options.[8-10] Meanwhile an MCT diet or octreotide also reduce chyle production and help control symptoms.

Sirolimus (rapamycin), an mTOR-inhibitor approved by the FDA for lymphangioleiomyomatosis, has recently emerged as a potential treatment for PB. Its use is based on its anti-inflammatory, antiproliferative, and lymphangiogenic properties, which can be particularly beneficial for patients who develop PB after the Fontan operation. Sirolimus, by reducing inflammation, can help decrease the formation of bronchial casts. Additionally, by affecting the growth and permeability of lymphatic vessels, it helps manage underlying lymphatic dysfunction and reduce chyle formation. As an immunosuppressant, it modulates the abnormal immune response that is thought to occur after Fontan surgery.[1,4] In our case, treatment with sirolimus contributed to the eradication of the patient's symptoms.

With prompt and aggressive treatment, some patients may experience significant relief from symptoms. However, others may continue to suffer from

chronic respiratory issues. Unfortunately, PB tends to be a chronic condition with a risk of recurrence, even after successful initial treatment. PB carries an increased risk of mortality, which can be as high as 50% within 5 years, especially if associated with other complications of Fontan physiology.

CONCLUSION

As survival rates following congenital heart surgery have improved for even the most complex lesions, the management of rare morbidities has become more challenging. In children who have undergone staged Fontan surgery, PB is a rare but life-threatening complication. Correct diagnosis and prompt treatment are crutial.

Although the pathophysiology of PB following Fontan surgery remains largely unclear, elevated PA pressure and failing Fontan circulation should be evaluated in all patients to identify and treat any correctable issues. Urgent medical treatment and bronchoscopy are critical. Given the complexity and potential severity of PB, a multidisciplinary approach involving pediatric cardiologists, pulmonologists, interventional radiologists, and surgeons is often necessary. Treatment is highly individualized, based on the severity of the condition and the underlying cause.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Canan Ayabakan, Ayla Oktay;* ***Design:*** *Ayla Oktay, Canan Ayabakan, Abdullah Doğan, Rıza Türköz;* ***Control/Supervision:*** *Canan Ayabakan;* ***Data Collection and/or Processing:*** *Ayla Oktay, Abdullah Doğan;* ***Analysis and/or Interpretation:*** *Canan Ayabakan, Rıza Türköz;* ***Literature Review:*** *Ayla Oktay;* ***Writing the Article:*** *Canan Ayabakan, Ayla Oktay;* ***Critical Review:*** *Ayşe Sarıoğlu, Tayyar Sarıoğlu, Rıza Türköz;* ***Materials:*** *Abdullah Doğan, Ayla Oktay.*

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