Management of Anesthesia for Bronchoscopic Removal of an Airway Foreign Body in a Fontan Patient

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Objectives:

1. Understand the anatomy, physiology and long term consequences of the Fontan operation
2. Identify key considerations in the anesthetic management of the Fontan patient for non-cardiac surgery
3. State the anesthetic considerations inherent to the retrieval of an airway foreign body
4. Prioritize the considerations of both objective #2 and #3

As you are finishing the last case of the day, you are informed that a patient with a foreign body (FB) aspiration has been added on for flexible and rigid bronchoscopy. The patient is an 11 year old boy with a hypoplastic heart who had several cardiac surgeries in early childhood. Over the past 3 days the patient has developed progressive tachypnea and dyspnea at rest, as well as coughing, rhinorrhea and a slight fever.

1. Preoperative assessment and interventions

> ***Questions****: Describe the palliation of single-ventricle patients. What is the natural clinical progression after Fontan surgery? What morbidities are associated with the Fontan operation? What are the typical modes of death? What specific information needs to be obtained in order to clarify his history of congenital heart disease?*

The most recent cardiology note (8 months ago) describes his past cardiac history as follows:

- Double-outlet right ventricle with a small left ventricle, secundum muscular ventricular septal defect without any arterial commitment, pulmonary stenosis.
- Status post pulmonary artery band as infant.
- Right femoral venous occlusion and stenosis of the inferior vena cava at the junction of the hepatic veins.
- Status post bidirectional cavopulmonary shunt at age 2.
- Status post failed biventricular repair at age of 4.
- Status post takedown of biventricular repair and cardiac Fontan surgery with adjustable fenestration (20 mm aortic homograft) and modified Damus-Kaye-Stansel operation.
- Last cardiac cardiac catheterization (4 years ago) revealed normal pulmonary artery and Fontan pressures.
- Echocardiogram showed unobstructed flow in the Fontan pathway, normal ventricular function, and no fenestration.
- Clinically doing well.

Upon further discussion, the mother reports that the patient is usually able to play and run, but cannot exercise as much as the other children in his class. Over the past couple of weeks he has been more tired and spent most of the time playing video games and sleeping. His oxygen saturation prior to the current event was reported as 94%. He denies paroxysmal nocturnal dyspnea, orthopnea, syncope, palpitations, weight gain.

He has a history of stroke and blood clots in the femoral vein. His medications are Lasix, Enalapril, Digoxin and Aspirin. There are no known allergies. On physical exam, he has diminished breath sounds in the left apex, a quiet precordium, and pulses equal and palpable in all limbs. Vital signs are heart rate (HR) 105, blood pressure (BP) 91/45, respiratory rate 28, temperature 38.1° C, with pulse oximeter saturation (SpO2) reading of 91% on 3L of oxygen by nasal cannula. Room air SpO2 is noted to be 87%. His weight is 41.9 kg. He last ate 12 hours ago. An intravenous (IV) line with maintenance fluids running was placed 6 hours ago.

> ***Questions:*** *What is your differential diagnosis of his low SpO2 reading? How would you determine whether the Fontan physiology is failing in this patient? Do you need further studies? Given the urgent nature of this case, would you delay the procedure in order to obtain an echocardiogram (ECHO)?*

The chest x-ray shows a new foreign body consistent with a BB pellet in the left hilum, and a segmental opacity in the left upper lobe. The chest CT describes a pellet measuring 4.8 mm located in the proximal left upper lobe bronchus, an area of consolidation in the left upper lobe, and possibly, an intracardiac thrombus. Hemoglobin is 12.9, WBC 9.2. Platelet count and CHEM7 are WNL. A preoperative transthoracic ECHO shows unobstructed flow in the Fontan pathway, moderate ventricular dysfunction, a fenestration with right to left shunt, and no intracardiac thrombi or vegetations.

> ***Questions:*** *What significance has the presence of fenestration and the direction of flow? What additional challenges would have an intracardiac thrombus created?*

2. Intraoperative management

> ***Questions:*** *What are the goals of the anesthetic management in Fontan patients? What are the goals of the anesthetic management in patients with foreign body aspiration? What are the advantages and disadvantages of spontaneous versus controlled ventilation? What anesthetic technique will induce the least amount of physiologic perturbation while providing the conditions required for safe removal of the foreign body? Which operative technique (flexible versus rigid bronchoscopy) would be more advantageous in a patient with Fontan circulation?*
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> *Would you premedicate this patient? What are the risks and benefits of administering a bolus of fluid prior to induction? Is it necessary to give antibiotic prophylaxis?*

What monitors would you use? If you decide to use an arterial line, does its location matter? Would you place one before induction? Would you place a central line? How about if the patient were to undergo a procedure in which significant fluid shifts were anticipated? Are there any alternatives to placing a central line? Would you consider placing a cerebral oximeter? A Bispectral Index (BIS) monitor?

A decision is made to attempt FB removal via flexible bronchoscopy.

Questions: *Would you choose to intubate the trachea or place a supraglottic airway (SGA)? Does the type of SGA matter? What agents would you use to maintain anesthesia?*

Anesthesia is induced with etomidate 12mg intravenous push. The initial SGA insertion is difficult due to inadequate jaw relaxation. The patient starts gagging and coughing, and his SpO2 reading decreases rapidly to 79%. The BP and HR drop to 78/45 and 81, respectively.

Questions: *What would you do next? Retrospectively, would you have done anything differently to prevent this incident?*

A small dose of intravenous succinylcholine is administered, and the patient is stabilized. The SGA is placed successfully. Fiberoptic bronchosopy commences and anesthesia is maintained with an infusion of dexmedetomidine and remifentanil, while the patient is breathing spontaneously with additional pressure support. BP and saturation are stable. However, due to difficulties in removing the pellet with the flexible scope, conversion to rigid bronchoscopy is required. The anesthesia depth is increased due to coughing, and the patient becomes apneic. Controlled ventilation is instituted; however the blood pressure decreases again gradually to 70/42 as the SpO2 decreases from 90s to 80s, necessitating the removal of the rigid scope. The ABG shows 7.26/82/127/-6/89%, lactic acid 2.4.

Questions: *What would you do next? What pressors would you use? Would you consider nitric oxide? You recall that the patient was taking an ACE inhibitor preoperatively. Would you administer Phenylephrine or Vasopressin?*

3. **Postoperative management**

The patient improves and eventually the pellet is removed.

Questions: *Would to extubate the patient? Where should the patient recover? Postoperatively the patient develops sinus bradycardia (HR in the 60s). How would do manage this complication?*

Discussion:

Single-ventricle lesions are congenital heart anomalies in which one of the two ventricular chambers is either absent or so severely hypoplastic that a biventricular repair is impossible. The atrioventricular valve and/or arterial outflow valve associated with the hypoplastic ventricle may also be affected. The goal of palliative surgery is to convert the circulation from a parallel to a series arrangement via a complete cavo-pulmonary anastomosis (Fontan procedure) in which vena caval blood is rerouted directly into the pulmonary circulation.

Despite improving survival rates, Fontan patients often have significant morbidity. The most common complications following Fontan operation include congestive hepatopathy, the development of pulmonary and venous collaterals, protein losing enteropathy, plastic bronchitis, thromboembolic disease, and arrhythmias. Findings suggestive of a failing Fontan are fatigue, weight gain, palpitations, syncopal episodes, oxygen saturations below 90%, dyspnea, cardiomegaly, and pleural effusions.

In Fontan physiology, the pulmonary blood flow is passive and determined by the difference between central venous pressure and systemic ventricular end-diastolic pressure (transpulmonary gradient). Determinants of the efficacy of the Fontan circulation include systemic venous pressure and volume, pulmonary vascular anatomy, pulmonary vascular resistance (PVR), atrioventricular valve function, cardiac rhythm, and the function of the systemic ventricle.

The clinician caring for a Fontan patient presenting emergently with an airway foreign body must appreciate the challenges of maintaining adequate pulmonary blood flow within single-ventricle physiology during a procedure that affects ventilation and oxygenation. Maintenance of reduced PVR with periods of apnea and suboptimal ventilation and/or oxygenation is difficult. Similarly, maintenance of spontaneous ventilation may be more advantageous; however, the depth of anesthesia required to tolerate the intense stimulation of bronchoscopy may result in significant cardiovascular depression.

The discussion will address the choice of anesthetic techniques that induce the least amount of physiologic perturbation to the Fontan physiology, preoperative preparation (liberalized NPO guidelines?) and testing (polycythemia?), management of intraoperative hypotension and hypoxia (inotropes?), need and type of invasive monitoring (arterial line, central venous line?), surgical technique (flexible versus rigid bronchoscopy), and management of postoperative complications (postoperative bradycardia) and disposition (home, floor, ICU).

Improved survival after a univentricular palliative procedure has led to a progressive increase in the number of patients who present for noncardiac surgical interventions with Fontan physiology. The perioperative management of these high-risk patients is complex and requires careful (albeit expeditious in emergent cases) preparation, as well as good communication between all members of the surgical team.

References:

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