Cardiopulmonary Support for Emergent Innominate Artery Repair Complicating Tracheal Surgery

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Abstract: Innominate artery rupture is a rare, but usually fatal, complication of tracheal stenosis. Although prevention is key, prompt, appropriate intervention can be life saving. Hemorrhage and airway must simultaneously be controlled. Most deaths occur from exsanguination with adequate ventilation before surgical repair can be effected. In the ideal situation, the event would occur in the operating room. We report on just such a case with concomitant respiratory failure requiring cardiopulmonary support in order to accomplish definitive therapy. Keywords: innominate artery, cardiopulmonary support, tracheal stenosis.

Blood vessel erosion and rupture is an uncommon (0.7%) complication following tracheostomy (1). Possible vessels include the aortic arch, carotid artery, thyroid artery, innominate vein, or innominate artery (IA). At 75% incidence, the IA is by far the most common (2). The IA lies anterior to, and usually in contact with, the trachea at the level of the 5th or 6th tracheal cartilage behind the manubrium (3, 4). Young women are at higher risk because of their IA being in even more intimate contact with and crossing higher on the trachea (3).

Erosion can come from different sources, depending upon tracheostomy placement and sizing. A tracheostomy placed high at the level of the 2nd or 3rd tracheal ring can cause IA erosion from the tube cuff or tip. A tracheostomy placed low at the level of the 5th or 6th ring can cause erosion from contact with the tube at the inferior portion of the stoma (5).

Prevention of IA rupture is accomplished in a multifaceted approach. Proper placement of tracheostomy stoma and tube sizing are important. The tracheostomy tube should be optimally placed, checked daily, and changed as often as possible. Neck radiographs should be obtained if there is any question of position. Bounding pulsation of the tracheostomy tube needs to be investigated promptly. Cuff inflation pressures should be minimized (4).

Treatment starts with prompt recognition. Any excessive bleeding, even if episodic should be questioned. If caused by tracheal stenosis, inflation of the tracheostomy cuff to high levels may bring bleeding under control (4, 5). If caused by the tracheal tube at the inferior stoma, withdrawing the trach tube a few centimeters and inflating the cuff could stop the hemorrhage (4). Last, digital pressure applied to the site, compressing the IA against the posterior of the manubrium should stop the bleeding (1, 4, 5). With this maneuver, the tracheal tube must be removed and an endotracheal tube placed (5).

Surgical repair is usually accomplished through median sternotomy. The IA is divided, the eroded segment removed and sewn end to end. There have been instances of prosthesis and saphenous vein grafting usually with poor results because of the contamination of the area from the long-term tracheostomy (2, 5, 6). Soft tissue interposition of various types are often used to prevent recurrence (1, 2, 7).

We report on a case of IA rupture with concomitant poor airway control and respiratory failure requiring cardiopulmonary support (CPS). A review of the literature failed to find any similar cases, except those involving aortic arch repair.

MATERIALS AND METHODS

Patient History

The patient was a 51-year-old African American female with a history of asthma and diabetes. She had a tracheostomy performed 2 years earlier. She presented to the operating room for gastric tube placement and tracheal stenosis repair.

Materials

The CPS system consisted of a portable cart containing...
a Biomedicus centrifugal pump model #540 and a Biocal heater/cooler model #370 (Medtronic, Minneapolis, MN). The circuitry consisted of a custom-made Carmeda-coated CPS pack containing a model BP-80 centrifugal pump head (Medtronic, Minneapolis, MN). In addition to the basic pump pack was a Carmeda-coated Maxima Plus PRF (Plasma Resistant Fibers) oxygenator (Medtronic, Minneapolis, MN) and a Duraflo II (heparin coated) cardiotomy (Baxter, Irvine, CA). Cannulation consisted of a 20 French, femoral arterial cannula (Research Medical, Midvale, UT) and a 21 French, 50-cm long femoral venous cannula (Medtronic, Minneapolis, MN). Ancillary equipment included a BRAT-2 autotransfusion machine (Cobe, Arvada, CO), and an ACT II Activated Clotting Time (ACT) device (Medtronic, Parker, CO).

Drainage was by kinetic assist with the pump approximately equal to patient level. The cardiotomy outlet was “Y”ed off of the venous return line to add volume rapidly but normally left clamped (Figure 1). A requested pump sucker was fashioned using a ¼-inch line to the cardiotomy, which was sealed, and vacuum applied. The vacuum was discontinued during volume additions. The system was primed with plasmalyte (approximately 1,500 cc) and de-aired. Heater/cooler lines were attached to the oxygenator and warmed to 37°C. Recirculation continued with 3 L/min sweep of oxygen at FIO2 of 1.0. The patient was heparinized at 3 mg/Kg, right femoral artery and vein were then accessed and cannulated. Each cannula was connected to the appropriate line of the system in an air-free manner.

RESULTS

The patient's IA was injured during tracheal stenosis repair. During the dissection around the trachea, an IA laceration was created. It was impossible to control the hemorrhage with anything other than direct digital pressure. This, unfortunately, failed to allow adequate CO2 elimination for the patient. Emergency CPS offered the only means of providing adequate gas exchange while simultaneously controlling the hemorrhage. The tracheostomy tube had been removed, and a 7.0-mm oral endotracheal tube (ETT) was placed. Airway control was poor because of the inability to place the ETT past the stenosis in light of the digital pressure being applied. A median sternotomy was performed, but the digital pressure necessary for hemostasis continued to interfere with ventilation ability.

CPS was instituted to assist gas exchange using femoral artery and vein cannulation after 3 mg/Kg heparinization. The patient was 80 Kg and 170 cm yielding a 1.9 body surface area (BSA). Flows ranged from 2.7–3.0 L/min for an assisted cardiac index (CI) of approximately 1.5. The activated clotting time (ACT) was 418 seconds on CPS.

The IA was clamped proximally and distally and repaired. CPS was then discontinued after successful succioning of the ETT. Protomine 250 mg was given to reverse the heparin. ACT was then 104. A right chest tube and mediastinal tube were placed. Post CPS arterial blood gas (ABG) showed very low PO2 and chest X-ray revealed a left pneumothorax with ETT in the right main stem bronchi. A left chest tube was placed and ETT pulled back into the trachea. ABG then improved (Table 1).

During the case, eight units of packed red blood cells (PRBC) were given, five of which were administered through the CPS circuit. Four units of fresh frozen plasma (FFP) and eight units of platelets were also given. Three 250-cc bowls from the autotransfusion machine were processed and reinfused by anesthesia. Estimated blood loss (EBL) was 5,800 cc. The time from IA laceration until repair was completed was approximately 90 minutes.

On day 3, an aortogram revealed good flow with small residual stenosis just proximal to the right internal carotid artery. On day 11, the patient returned to surgery for placement of a foam cuff tracheostomy tube. The rest of the hospital course was unremarkable with several febrile episodes. Some consideration was being given to transfer to another institution for surgical revision with possible bypass graft. The patient was discharged on day 21.

DISCUSSION

With the need for rapid setup, we discovered some shortcomings of our multiprocedure custom pack. Some

![Figure 1. Schematic diagram of CPS circuit.](https://example.com/figure1.png)

Table 1. Selected arterial blood gas results.

<table>
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<th>ABG #</th>
<th>Time</th>
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<th>PCO2</th>
<th>PO2</th>
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<td>7.28</td>
<td>43</td>
<td>303</td>
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revisions were made to facilitate a quicker assembly. Connectors and tubing lengths were changed to accommodate easier oxygenator and cardiotomy insertion. Emergency support situations were deemed too rare an event at our institution to warrant a dry setup at all times.

Airway and ventilation control were difficult. Perfusion and anesthesia personnel need to communicate continuously, especially in the face of a hectic emergency situation. As can be seen by the blood gas table, an extremely elevated PCO₂ existed pre-CPS. Perfusion failing to realize its gravity began with an initial blood flow/gas flow ratio of 1/1 (3 L/min). As a result, the initial ABGs on pump were worse than before. At that point, the sweep was increased to 14 L/min, and an overcompensation occurred bringing the carbon dioxide level well below normal while improving oxygenation (Table 1). Fortunately, the pH was not made severely alkalotic. When partial patient life support is from two disciplines simultaneously each must apprise themselves of the other’s situation on an ongoing basis. In addition in retrospect, we should have transfused through the pump sooner. The dilutional hematocrit was later calculated at 20 grams %, and the patient was actively bleeding.

Although not a technically complex perfusion, this case does point out the need to be prepared to respond quickly to aid other disciplines when needed. Our emergency occurred at noon in the operating room with two morning open hearts just finishing up. Our experience was similar to other successful case reports of this kind with the terms “fortuitous” (3) and “luck” (2) figuring prominently. With an exsanguination of this magnitude, there is no substitute for good fortune. In addition to good old-fashioned luck; forethought, planning, and good communication go a long way.

REFERENCES