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# Case Reports

## Diagnosis of Inadvertent Cannulation of the Azygos Vein During Cardiopulmonary Bypass

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**Abstract:** Cardiac surgery with cardiopulmonary bypass demands diligence and attention to detail to prevent neurologic injury. Arterial and venous cannulae are used to facilitate cardiopulmonary bypass. The assessment of adequate decompression of the venous circulation is an essential duty of the cardiac surgical team. Modalities for the assessment of adequate regional venous drainage are limited, however communication between the team and increased awareness of certain pathologic states can be useful. These modalities include cerebral oximetry and superior vena caval pressure monitoring, which were employed during a case with bicaval venous cannulation. Malposition of the superior vena cava cannula was detected after a series of events alerted the team that superior vena cava drainage may be compromised. **Keywords:** azygos vein, superior vena cava, cardiopulmonary bypass, cerebral oximetry. *JECT. 2010;42:235–237*

Open cardiac procedures involving the right side of the heart require cannulation of both the inferior vena cava (IVC) and superior vena cava (SVC) to facilitate "total" cardiopulmonary bypass (CPB). Once the SVC and IVC are cannulated, caval snares prevent venous drainage to the right atrium and divert blood flow to the CPB circuit.

The azygos vein is a blood vessel of the thoracic venous system that drains the ascending lumbar vein as it travels superiorly and empties into the posterior SVC (Figure 3). In patients with congestive heart failure and volume overload the size of the azygos vein is often underappreciated. Inadvertent cannulation of the azygos vein and subsequent "snaring" of the SVC can cause severe cerebral and upper extremity venous congestion.

Cerebral perfusion pressure (CPP) is the effective pressure across the cerebral capillary and is normally the difference between mean arterial pressure (MAP) and intracranial pressure (ICP). During CPB, ICP may be replaced with SVC pressure monitoring to calculate CPP with the formula CPP = MAP – SVC. SVC pressure monitoring (via the side port of the Swan-Ganz catheter) combined with cerebral saturation monitoring may be helpful for identifying cerebral venous congestion, reduced CPP, and subsequent cerebral hypoperfusion (1). The Foresight® oximeter (CAS Medical Systems, Inc., Branford, CT) can be used to non-invasively monitor absolute measurements of cerebral tissue oxygen saturation ($SctO_2$%). Using a laser, four wavelengths of near infrared light are projected through the scalp and skull and into the frontal lobe of the brain to measure bi-frontal regional saturation of the tissues. The goal is to maintain right and left $SctO_2$% greater than 55% (2).

### DESCRIPTION

The patient is a 39-year-old male, who weighed 95 kg and stood 185 cm (body surface area = 2.2 $m^2$), with congestive heart failure secondary to a severe mitral perivalvular leak and tricuspid valve regurgitation. He had a past medical history of three prior cardiac valve operations for rheumatic heart disease. He presented to our institution for a

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fourth-time re-operative mitral valve repair and tricuspid valve replacement with a 33 mm St. Jude Medical mechanical heart valve.

The cardiopulmonary bypass circuit was selected to achieve flows of 5.3 L per minute for a normothermic cardiac index of 2.4 L per minute/m$^2$. The A-V loop was comprised of a ⅜″ arterial line and ½″ venous line. A Terumo RX25 open cardiotomy/venous reservoir with an integrated oxygenator was used without vacuum assisted drainage. Pre-cardiopulmonary bypass hemoglobin/hematocrit was 7.5 g/dL and 23%, respectively.

The right internal jugular vein was cannulated with an 8 Fr introducer and Swan-Ganz catheter for right heart pressure monitoring. The pressures at the side port of the introducer were monitored to identify changes in SVC pressure during the initiation of CPB. Our expectation is to keep the SVC pressure at or below zero during CPB. Decreases in venous drainage or congestion of the SVC will present as an elevation in the side port pressure. In addition, Foresight® disposable sensors were applied to the patient's forehead to monitor cerebral saturations throughout the procedure. The baseline cerebral saturations on the left and right were 69% and 62%, respectively.

Sternotomy was performed and pericardial adhesions were lysed to mobilize the right heart. The patient was heparinized and a single 28 French venous cannula was passed into the IVC. A 7.0 mm arterial cannula was inserted into the ascending aorta for arterial perfusion. CPB was instituted with the single IVC cannula draining enough to achieve a cardiac index of 2.2 L/min/m2. Due to the severe fluid overload, the cardiotomy reservoir was noted to be filled with 3800 mL of venous blood. A single 24 French venous cannula was placed through pursed string sutures in the SVC and presumed to be draining the SVC. Upon snaring the SVC and IVC cannulae, the side port pressures increased from 0 mmHg to 26 mmHg (Figure 2). The cerebral oximeter alarmed and displayed an acute desaturation from 69–57% on the left side and 62–47% on the right side over 2 minutes (Figure 1). The superfluous volume in the cardiotomy reservoir masked the decrease in venous drainage from the SVC. The surgeon was notified and attention was given to the SVC snare that was then released. There was immediate decompression of the SVC and normalization of side port pressures. Cerebral saturations also returned to near-baseline levels. Further examination of the cannulation site and palpation of the SVC revealed the "bullet style" tip of the SVC cannula had entered a posterior IVC vascular structure, presumed to be an enlarged azygos vein. The SVC cannula was repositioned into the SVC proper and snares were again applied. The aortic cross clamp was applied, patient was systemically cooled and the operation was completed without further incident.

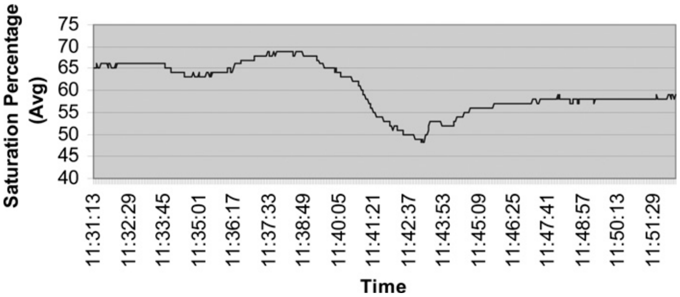


**Figure 1.** Acute cerebral desaturation.

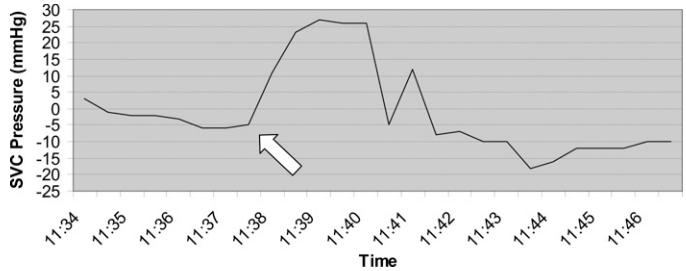


**Figure 2.** Acute SVC pressure elevation.

## COMMENT

Neurologic injury continues to be a relatively common complication in cardiac surgery with consequences ranging from subtle deficits to brain death. The most severe of these complications is stroke, which occurs in 9.7% of patients undergoing multiple valve surgery (4). Neurocognitive dysfunction is even more common with an incidence of 50% at discharge for patients undergoing cardiopulmonary bypass (5). The mechanism of these injuries are likely similar and are related predominantly to ischemia caused by either embolism (62.1%) or hypoperfusion (8.8%) (6). Furthermore, it is likely the same mechanisms of ischemia occur in other major end organs and are associated with complications of those organs.

Recent studies have highlighted the utility of non-invasive cerebral saturation monitoring and intervention to minimize the incidence of end-organ injury in cardiac surgery (7–10). Murkin and colleagues (9) randomized 200 patients to either cerebral saturation monitoring with treatment or a control group with blinded monitoring and no intervention. The most common interventions were increasing mean arterial pressure, increasing CPB flow, and normalizing $pCO_2$. The authors concluded the control group experienced significantly longer periods of desaturation and suffered more major end organ injury and mortality. In a retrospective study comparing

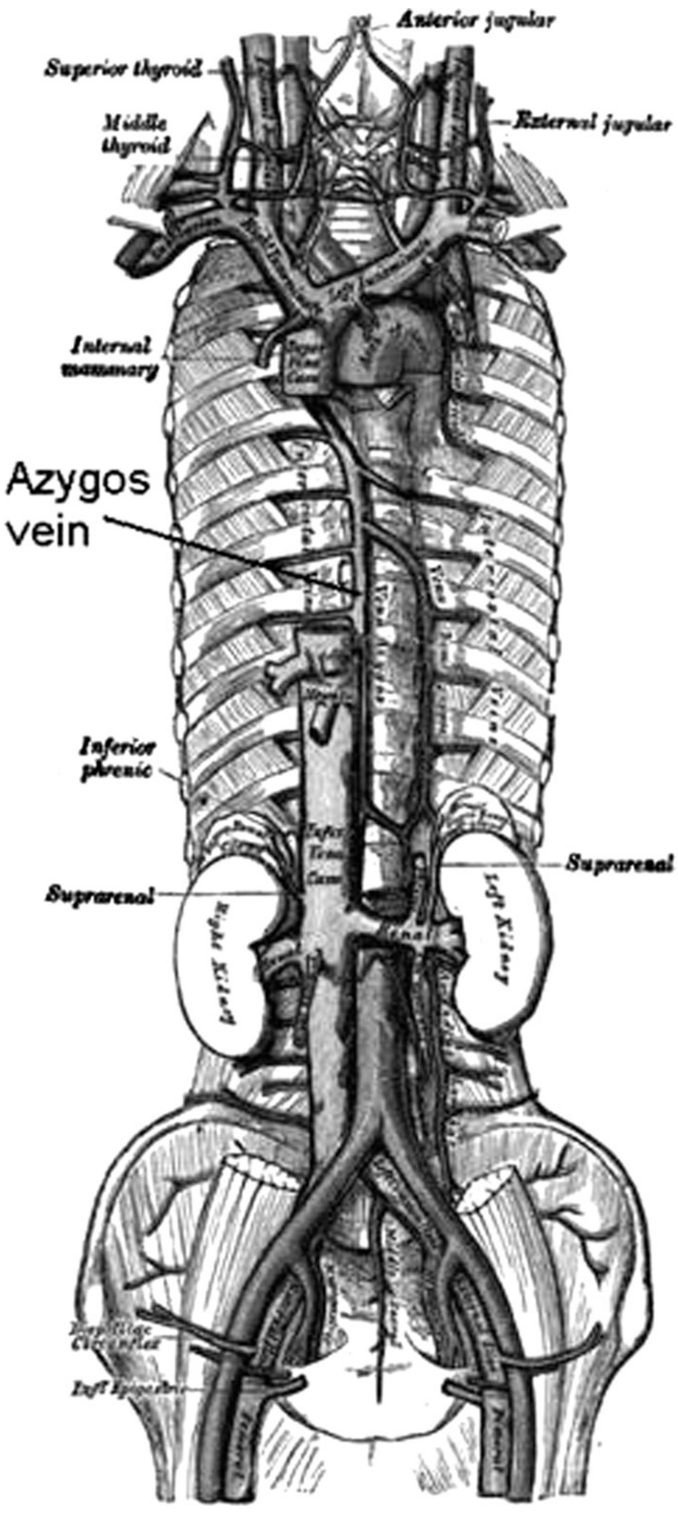


**Figure 3.** The venæ cavæ and azygos veins, with their tributaries (3).

monitored and treated patients with unmonitored patients, Goldman and colleagues (8) found a significant reduction in the incidence of stroke in the monitored and treated group.

In this case report, given the complexity of the patient's disease state, including severe chronic venous congestion, minor decreases in venous return relative to the cardiotomy volume had masked the inadvertent azygos cannulation. Diagnosis and correction of inadvertent azygos cannulation while on CPB was achieved by utilizing previously reported pressure monitoring techniques as well as cerebral saturation monitoring. These monitoring techniques alerted the surgical team of an acute SVC occlusion that may have otherwise been unappreciated. Correction of the SVC occlusion reduced the side port pressure and improved cerebral saturations and may have avoided end organ injury. These and future advances in monitoring technology as well as a commitment to better understand the mechanisms associated with end organ injury secondary to cardiac surgery can help to improve patient outcomes.

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