CARDIAC TAMPONADE/ PERICARDIAL EFFUSION

Surgical Specialty:	Cardiac Anesthesia
Authors:	Eric Zhang, MD; Andrew Giustini, MD, PhD Oregon Health and Science University

Background:

- General Considerations
  - The diagnosis of pericardial effusions relies on clinical presentation and imaging studies with evidence of fluid within the pericardial sac[1].
  - Effusions may cause cardiac tamponade when pericardial pressure increases enough to nearly equalize atrial and ventricular end-diastolic pressures and pressure within the pericardial sac, thereby preventing adequate ventricular filling and reduced ventricular preload, leading to decreased stroke volume and decreased cardiac output. As stroke volume is limited, cardiac output becomes rate-dependent. Pericardial tamponade is a clinical diagnosis based on the interpretation of physiologic and imaging data[1].
  - Increased contractility, increased heart rate, and increased systemic vasoconstriction are sympathetic compensatory mechanisms for tamponade; general anesthesia and positive pressure ventilation may further impede preload.
  - Definitive treatment is pericardiocentesis or a surgical pericardial window, frequently with a pericardial drain left in place.
  - Severe hypotension and high end-diastolic ventricular pressure will produce a low coronary perfusion pressure; tachycardia is associated with a shortened diastolic phase and causes inadequate time for perfusion, which can precipitate myocardial ischemia and exacerbate systemic hypotension and increase end-diastolic pressure.
- Patient Considerations
  - Disease Specific Considerations
    - Any process that results in pericardial effusion, once reaching a critical pressure within the pericardial space, can cause tamponade physiology, which compromises hemodynamic stability.
    - In adult-size patients, rapid accumulation of as little as 50-100cc of fluid within the pericardial space can compromise ventricular filling.
    - Chronic pericardial effusions may grow slowly and may grow as reach several hundred milliliters to one liter before causing tamponade.
      - One must keep in mind similar concerns of hemodynamic instability when providing anesthesia to patients with non-tamponade effusions.
    - Electrocardiogram frequently shows electrical alternans.

        - Pericardial effusion in pediatric patients has a wide range of etiologies, including pericarditis (infectious and non-infectious), post-surgical or post-procedural changes, and malignancy.
        - Diagnosis is usually made clinically.
        - Typical symptoms are dyspnea, diaphoresis, and chest pain.
        - Tamponade physiology can be visualized via echocardiography; common findings include usually a significant pericardial effusion, right atrial and right ventricular collapse, and a dilated inferior vena cava.
        - Other important echocardiographic findings of tamponade physiology include loss of inferior vena caval respiratory variation, increase of interventricular dependence with respiration, and respiratory variation of mitral, aortic, or tricuspid inflow peak velocity of 25%[2].
    - Associated Comorbidities/Syndromes
        - Systemic lupus erythematosus is frequently associated with pericarditis and pericardial effusion which can lead to tamponade
        - Myocardial inflammation from myocarditis may lead to pericardial effusion and thereby tamponade
        - Other common causes include infection, malignancy, iatrogenic (post-surgical inflammation or hemopericardium), or post-infarct effusion[1]

Anesthetic Planning:

- Pre-Anesthetic Evaluation
    - Echocardiography to determine the degree of diastolic right ventricular collapse, systolic right atrial collapse, respiratory changes in atrioventricular valve inflow velocities, and estimate of effusion volume, location, and presence of loculation[2].
    - ECG to evaluate for arrhythmias or ischemia; may be able to see electrical alternans.
    - Pulsus paradoxus may be used to evaluate and trend the degree of tamponade physiology[3].
    - Beck Triad (venous distention, hypotension, and diminished heart sounds) is the classic constellation of physical exam findings. Venous distension can be seen on exam as elevated jugular venous pressure (JVP) and there is likely to be sinus tachycardia and hypotension with narrow pulse pressure.
    - In pediatric patients, a decrease in pulse-oximeter waveform amplitude > 25% upon inspiration is highly predictive of tamponade.
    - Note that patients who have non-acute effusions may have received NSAIDs, colchicine, and/or steroids recently and may have a recurrence of effusion after previous drainage attempts.
        - With recurrence, more invasive treatments, such as pericardial window, may be needed to prevent recurrence.
    - Discussions to have with surgeon, family, and ICU team:
        - Code Status
        - ECMO candidacy
        - Pediatric procedures, especially in young patients, are typically done under general anesthesia. Depending on the severity of physiologic derangement, it may not be safe to perform pericardiocentesis under general anesthesia. It is important to discuss with families that the patient may need to be awake

during the procedure and may remember parts of the procedure, which can lead to physical discomfort and psychological trauma.

- Specific or Unique Room Set-up Requirements
  - Airway
    - Plan for spontaneous ventilation with natural airway if possible.
    - If endotracheal intubation is warranted, the non-depolarizing neuromuscular blockade can help lessen maintenance anesthetic dose and reduce the sympatholytic burden of general anesthesia.
    - Always be prepared for the loss of cardiac output and the possible need for increased preload and inotropic support (typically epinephrine) with intubation and/or muscle relaxation.
    - Emergency intubation equipment must be available.
  - Drugs/Infusions
    - Ensure the patient is adequately hydrated and consider fluid boluses with a balanced crystalloid solution to optimize volume status and preload to avoid hemodynamic collapse in tamponade physiology.
    - Have 5% albumin available to infuse to replete intra-vascular volume in the event of rapid re-accumulation of pericardial fluid
    - Ketamine may be a favorable induction agent given its sympathomimetic properties in many patients. For patients who are catecholamine-depleted, however, ketamine may worsen cardiac function and require vasoactive medications.
    - If intubating, etomidate may be the most physiologically stable induction medication, though patients may still lose cardiac output due to positive pressure ventilation. If etomidate is chosen, patients may need exogenous steroids if adrenal suppression occurs and is clinically significant[1].
    - Be ready to start vasoactive boluses or infusions, typically norepinephrine and/or epinephrine.
  - Monitors – Standard ASA & invasive blood pressure monitoring
    - In some cases, invasive blood pressure monitoring may not be required, but this should be discussed with interventionalists and surgeons prior to the procedure.
    - Code cart immediately available with defibrillator.
  - Blood Availability – blood must be available, especially if concern for hemopericardium.
  - ICU Bed Availability – All patients with tamponade must be monitored in an intensive care unit. In many institutions, all patients with pericardial drains will be monitored in an intensive care unit. Pericardiocentesis is sometimes performed in the ICU, especially in emergencies.
  - Typically, drainage of pericardial fluid should relieve symptoms of tamponade. If high concern that drainage will be difficult, consider whether ECMO standby is needed.
  - Drainage can be done by needle decompression or subxyphyoid pericardiocentesis, or via surgery if drainage is anticipated to be difficult, such as in the case of loculated effusions.
  - Recurrence can be common and may need management with more invasive means, such as a pericardial window.

Intraoperative Considerations:

- General techniques
    - Local anesthesia with natural airway and spontaneous breathing – this is the preferred anesthetic technique in patients with severe tamponade physiology.
    - Be aware that hypoxemia and hypercapnia may occur while the patient is breathing on spontaneously without appropriate ventilatory support.
    - Small boluses of ketamine (0.2-0.5 mg/kg/bolus titrated to effect) with natural airway, combined with local anesthetic will be sufficient for many patients. Patients with tamponade physiology will often need less than a full induction dose to tolerate pericardiocentesis.
    - If intubation is required due to patient comorbidities, a balanced induction with slowly titrated in combinations of fentanyl, ketamine, and etomidate will likely be best tolerated. Volatile anesthetic is likely to be poorly tolerated, as is propofol, due to lower systemic vascular resistance and preload.
    - Consider nondepolarizing neuromuscular blockade on induction to reduce the sympatholytic burden of general anesthesia.
    - Patients with tamponade have limited ability to modify stroke volume so cardiac output will largely be heart rate dependent; therefore, medications that decrease heart rate such as dexmedetomidine are likely to be poorly tolerated.
    - (already addressed this above)If possible, avoid positive pressure ventilation if possible because it decreases preload and can cause catastrophic hypotension.
        - If spontaneous ventilation is not possible in intubated patients, ventilation with lower tidal volumes is preferred to minimize intrathoracic pressure.
- Induction – This is the highest-risk period for developing catastrophic hypotension and adverse cardiac events.
    - High risk of catastrophic hypotension upon induction of general anesthesia due to blunting of sympathetic compensation for decreased preload in tamponade.
    - Maintenance of natural airway and spontaneous negative-pressure respiration may be ideal
    - Must consider the patient's clinical history as ketamine may cause myocardial depression in patients who are maximally sympathetically stimulated.
    - Must be ready to perform PALS.
- Positioning – If possible, avoid positions that further reduce preload, like upright or reverse Trendelenburg.
- Maintenance
    - Repeated ketamine and small opioid boluses.
    - Volatile anesthetics and propofol are likely to be poorly tolerated due to their effects on SVR and preload.
- Hemodynamic/Physiologic goals
    - During drainage, maintain cardiac output by maximizing preload with volume, maintaining a high heart rate, and avoiding agents that decrease contractility and systemic vascular resistance. Arrhythmias are especially poorly tolerated in this population so sinus rhythm must be maintained.
- Procedural or Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
    - Pericardiocentesis is typically done under transthoracic echocardiographic guidance from a subxyphoid approach[5].
    - Placement of the guidewire for drainage can cause transient arrhythmias as it contacts cardiac tissue.

    - Attention must be paid to the needle during the procedure to avoid catastrophic damage in the form of ventricular or coronary laceration, and hemo/pneumothorax.
        - If the drain is inadvertently placed in the ventricle, there will be continuous aspiration of frank blood, ventricular dysrhythmias, and evidence of worsening (instead of improving) cardiac output with continued drainage.
    - If reopening of the sternum after surgical repair is necessary, patients will likely need to be intubated and large-bore IV access is required to allow for rapid transfusion of blood and balanced crystalloid.
- Emergence/Disposition
    - Patients with tamponade should always be cared for post-operatively in an ICU.
    - Patients with simple pericardial effusion without tamponade may be cared for in the ICU or on an inpatient unit, depending on comorbidities, institutional practice, the volume of pericardial fluid removed, and presence of a drain[5].
- Post-op Pain
    - Pericardial drains are typically well tolerated with local anesthesia. If no concerns for bleeding and no evidence of renal injury, may consider NSAIDS (such as ketorolac) in patients older than 6 months if no hemopericardium.

Case-Specific Complications/Pitfalls

- Hemodynamic collapse upon induction of general anesthesia – providers must be prepared to perform PALS and give vasoactive agents to resuscitate the patient.
- The risks of positive pressure ventilation and muscle relaxation typically exceed the risks of aspiration, except for surgical re-exploration.
- For patients with evidence of tamponade, avoid any maneuvers that can significantly change the patient's hemodynamics (administration of anxiolysis, sedation, paralysis, alterations in ventilation) until necessary equipment for pericardial drainage and a proceduralist are present as small derangements in hemodynamics can cause cardiovascular collapse. With cardiovascular collapse, immediate drainage of the pericardial effusion will likely be necessary to achieve return of spontaneous circulation.
- In a case series by Rawlinson and Bagshaw (see citation below), one-third of patients with pericardial effusion suffered complications during anesthesia, of which one-third were major complications. Preoperative hypoxia, tachypnea, and echocardiographic findings consistent with tamponade were associated with major complications[6].

References

1. Goldstein, J. A. (2004). Cardiac tamponade, constrictive pericarditis, and restrictive cardiomyopathy. *Current problems in cardiology*, *29*(9), 503-567. PubMed Link
2. Alerhand, Stephen, and Jeremy M. Carter. "What Echocardiographic Findings Suggest a Pericardial Effusion Is Causing Tamponade?" *The American Journal of Emergency Medicine* 37, no. 2 (February 2019): 321–26. PubMed Link
3. Ammozgar H, Ghodzi H, Borzoee M et al. Detection of pulsus paradoxus by pulse oximetry in pediatric patients after cardiac surgery. Pediatr Cardiol 2009; 30: 41–45. PubMed Link
4. Pérez-Casares, Alejandro, Sergi Cesar, Laia Brunet-Garcia, and Joan Sanchez-de-Toledo. "Echocardiographic Evaluation of Pericardial Effusion and Cardiac Tamponade." *Frontiers in Pediatrics* 5 (2017): 79. PubMed Link
5. Hoit, B. D. (2007). Pericardial disease and pericardial tamponade. *Critical care medicine*, *35*(8), S355-S364. PubMed Link
6. Rawlinson E, Bagshaw O. Anesthesia for children with pericardial effusion: a case series. Paediatr Anaesth. 2012 Nov;22(11):1124-31. PubMed Link

---

Reviewed by:

Reviewer #1: Chinedu Otu, M.D., Texas Children's Hospital

Reviewer #2: Wenyu Bai, M.D., University of Michigan

Reviewer #3: Destiny Chau, M.D., Arkansas Children's Hospital

---

Created: Date; Last revised: 8/31/23