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COARCTATION OF THE AORTA REPAIR

Surgical Specialty:	Cardiac
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Background:

- General Considerations
    - Coarctation of the aorta (CoA) is a common congenital cardiac condition representing up to 8% of all congenital heart disease. The area of coarctation is typically located distal to the left subclavian artery.[1,2]
    - CoA is a systemic vasculopathy that is associated with a bicuspid aortic valve. It may be associated with other vascular anomalies.
    - The classic presentation of a CoA patient is the presence of a large discrepancy between upper and lower extremity blood pressures (BP).
    - The timing of diagnosis and presentation of CoA can vary widely and typically depends on the severity of coarctation.[1,3]
        - CoA can be diagnosed prenatally or even go unrecognized into the teenage years. Unrepaired older patients may initially present with headaches and systemic hypertension.
        - Neonates may present with heart failure from decreased left ventricular function and cardiogenic shock requiring immediate medical management and urgent surgical repair. Prostaglandin infusions may be necessary to provide blood flow distal to the coarctation through the ductus arteriosus.
    - The two main treatments of CoA are surgical repair vs. transcatheter approaches.
        - This guide will focus on the surgical repair via a thoracotomy.
        - Surgical repair includes a variety of approaches:
            - End-to-End anastomosis, patch aortoplasty, and subclavian patch.[3]
            - Long-segment coarctation typically requires cardiopulmonary bypass and deep hypothermic circulatory arrest for repair.
        - Balloon angioplasty with or without stent placement is performed in the cardiac catheterization laboratory.
- Patient Considerations
    - As mentioned above, the age range for patients presenting for CoA is wide (neonate to adults).
    - Baseline health may range from an intubated patient in the intensive care unit (ICU) with heart failure to an asymptomatic, otherwise healthy teenager.

Anesthetic Planning:

- Pre-Anesthetic Evaluation
    - Additional labs/tests indicated during work-up
        - Echocardiogram, CT Angiography, ECG, CXR are standard workups.
        - Labs include type & screen, CBC, coagulation profile, lactate, and BMP (especially if the patient is on diuretics)
    - Discussions to have with surgeon/family
        - Is the patient an ECMO candidate?
- Communication
    - Good communication with the surgical team is vital for CoA repair especially as it relates to:
        - Patient's baseline status.
        - Perioperative blood pressure monitoring plan (i.e., proximal and distal to the coarctation)
        - Plan for extubation vs. postoperative ventilation and sedation plan.
        - Postoperative pain control plan.
        - Heparin dose, discontinuation of prostaglandins (if needed).
        - Aortic clamping and unclamping with core temperature goals.
        - Post-operative blood pressure goals.
- Specific or Unique Room Set-Up Requirements
    - Airway
        - Discussion with surgeon to determine if one-lung ventilation (OLV) is required.
            - In smaller patients, surgeons may be able to pack the lung with gauze and/or surgically retract the lung for surgical exposure and avoid the need for lung isolation.
            - If OLV is desired, use double-lumen endotracheal tube (ETT) in larger patients and bronchial blockers vs. right mainstem intubation in smaller patients
        - Neonates may already be intubated.
            - Be prepared to change an uncuffed ETT to a cuffed ETT.
    - Drugs/Infusions[1,2]
        - Infusion set-up at a minimum should include an inotrope (e.g., epinephrine) and a vasodilator (e.g., sodium nitroprusside)
        - Esmolol (beta-blocker) should be available.
        - Consider milrinone, especially if the patient has signs of heart failure or decreased ejection fraction (EF).
        - Consider dexmedetomidine infusion if the patient will not be extubated in operating room.
        - Certain institutions may have protocols to administer steroids for spinal cord protection.
        - In infants, a prostaglandin infusion may be started to keep the ductus arteriosus open.
            - Clarify with the surgeon regarding the timing for discontinuation of prostaglandins.
        - Postoperative nausea/vomiting prophylaxis (dexamethasone & ondansetron) in older patients who will be extubated shortly after surgery.
    - Monitors

        - Standard American Society of Anesthesiologists monitors with the addition of:
            - 1 to 2 large bore IVs
            - Central venous catheter may be required in patients with severe comorbidities and those needing vasoactive medications.
            - Right radial/ulnar arterial line (needed to accurately monitor BPs in right carotid and coronary perfusion beds during aortic cross-clamp)
                - Discuss with the surgeon the possible need for an additional lower extremity arterial line in the femoral, posterior tibial, or dorsalis pedis artery.
                - If no lower extremity arterial line is used, place the non-invasive blood pressure cuff on either lower extremity.
            - Cerebral and renal Near Infrared Spectroscopy can help guide management during aortic cross-clamping.
    - Blood Availability
        - 1 unit packed red blood cells should be immediately available
    - ICU Bed Availability
        - Plan for postoperative ICU admission for all surgical procedures.

Intraoperative Considerations:

- General
    - Intraoperative blood pressure control with aortic cross-clamping and unclamping is the main physiologic surgical change.
    - Large increase in afterload during aortic cross-clamping.
- Induction
    - Mask vs. IV induction at the discretion of anesthesiologist depending on the patient comorbidities.
    - Be cautious and avoid propofol for induction in patients with decreased ejection fraction (EF) or additional congenital cardiac abnormalities.
    - In patients with heart failure, an opioid-based induction method may be preferred.
    - Use of neuromuscular blockade is recommended.
- Positioning
    - Right lateral decubitus position for thoracotomy.
- Pain Control[4]
    - Thoracic surgery is extremely painful and warrants a multimodal approach to pain management.
    - Erector spinae plane (ESP) block vs. thoracic epidural may be performed after positioning but prior to incision.
        - Single shot ESP for smaller patients (< 10kg) may be easier to perform
        - Consider ESP catheter insertion vs. thoracic epidural in larger patients
            - If the surgeon requests a large heparin dose, consider forgoing thoracic epidural placement.
        - Typically performed at the beginning of the case in the right lateral position
    - If the maximum limit of local anesthetic dosing has not been used, the surgeon may inject additional local anesthetic at the surgical site.
    - Intravenous acetaminophen
    - Opioids as a continuous infusion or PRN boluses
- Maintenance
    - Either inhalational or total intravenous anesthesia is acceptable
        - Easier to titrate sevoflurane to adjust for BP changes during the procedure.
- Temperature Control[1,2]

    - Permissive hypothermia (not less than 35 C) has been suggested to decrease the risk of spinal cord injury during aortic cross-clamp.
- Hemodynamic/Physiologic goals[1,2]
    - Prior to aortic cross-clamp
        - Maintain normal hemodynamics
        - Discuss with the surgeon the dose of heparin to be administered and if there is a target activated clotting time (ACT)
            - Surgeon may not request an ACT but will wait for 2-3 minutes after heparin administration and then proceed with aortic cross-clamp.
    - During aortic cross clamp
        - Expect increases in systemic vascular resistance (SVR) after aortic cross-clamping.
        - Aortic cross-clamp time is typically less than 20 minutes.
        - Titrate anesthetic depth and administer narcotics to maintain goal BP.
    - After aortic unclamping
        - Immediate: Be prepared for hypotension or hypertension.
        - Consider checking an arterial blood gas with a lactate level
        - Rebound hypertension (HTN):
            - Typically develops 5 to 10 minutes after cross clamp removal
                - Mechanism potentially from an increased sympathetic response in lower extremities after increased blood flow and reflex vasoconstriction[2]
            - Treat HTN with sodium nitroprusside and/or esmolol. Other vasodilators, such as nicardipine, may be needed.
            - Rewarm the patient to normothermia
        - Hypotension: Can be secondary to bleeding, cardiogenic shock, decreased SVR due to medications, etc.).
            - Consider PRN boluses of phenylephrine if decreased SVR is the likely cause and adjust vasoactive medications and anesthetic depth.
    - Surgical Considerations
        - Blood loss is typically minimal with no need for a blood transfusion. However, since the surgery is close to large blood vessels, a massive transfusion may be needed at short notice.
- Emergence/Disposition
    - All patients will require ICU care post-operatively.
    - The decision to extubate otherwise healthy patients in the operating room is institution dependent. Much of this depends on the comfort level of the ICU for recently extubated patients and the desire to have blood pressure under control prior to extubation.
    - Patients with preexisting heart failure, other significant comorbidities (lung disease) or neonates will be kept intubated and sedated and transferred to the ICU.
- Postoperative Pain
    - For patients with ESP catheters or thoracic epidurals, the acute pain service should be consulted for postoperative pain management.
    - Poor pain control and inadequate sedation while patients are intubated exacerbate postoperative HTN.
- Postoperative HTN
    - Systemic HTN is common post-operatively despite adequate pain control and may be paradoxical in nature.

- Even after repair, these patients have an increased risk for systemic HTN and aneurysms.

Case Specific Complications/Pitfalls

- The baseline status of these patients varies widely from neonates with heart failure to otherwise healthy teenagers where the diagnosis was incidental.
- Placement and removal of aortic cross-clamp
  - Be prepared for sudden changes in BP.
  - Good communication with the surgical team is imperative.
- Be prepared to treat HTN during closing and transfer to the ICU.
- Thoracotomies are painful.
  - Have a plan in place for postoperative analgesia.

References

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