Low Cardiac Output Syndrome

Description/Etiology

Low cardiac output syndrome (LCOS) is a transient complication of a disease process (e.g., third-degree heart block, sepsis, hemorrhage, hyperkalemia) or cardiac surgery in which the cardiac output (CO) is insufficient to meet the oxygen delivery requirements for metabolic function. Postoperative LCOS has been reported after repair of congenital cardiac anomalies, valve surgery, and coronary artery bypass grafting (CABG) and typically develops 4–6 hours after cardiopulmonary bypass (a technique which requires use of a machine to perform the function of the heart and lungs, circulating oxygenated blood throughout the body while bypassing the heart).

CO is the volume of blood ejected from the heart into the systemic circulation every minute and is a function of the heart rate (HR) and stroke volume (SV; i.e., CO = HR x SV). A healthy heart can adjust CO to meet the needs of increased demands (e.g., exercise), but cardiac surgery or any condition that affects preload, afterload, or myocardial contractility can impair the heart's ability to provide an adequate CO.

› Preload is the volume of blood in the ventricles before each contraction. Atrial or central venous pressures are indicators of preload. If there is not enough blood returning to the heart (e.g., due to hemorrhage, sepsis, or cardiac tamponade), SV will decrease. If preload is too high (e.g., excessive fluid administration) the ventricle can be overstretched, decreasing contractility and CO.

› Afterload is the resistance (e.g., vasoconstriction) the heart must overcome to eject blood. Over time, increased afterload leads to hypertrophy that is associated with decreased contractility. The most common condition causing increased afterload is hypertension.

› Contractility is the ability of the heart to efficiently contract. Ejection fraction is an indicator of contractility and is typically measured by echocardiogram. Contractility can be impaired by hypoxia, hypoglycemia, and electrolyte imbalances (e.g., hyperkalemia or hypocalcemia).

The treatment of LCOS aims to address all three of these components in addition to maintaining an adequate heart rate and rhythm. Intravenous fluids and blood products are often administered to maintain an adequate preload. Inotropic agents (e.g., DOPamine, DOBUTamine, and/or milrinone) can be administered to improve contractility and decrease afterload. Antiarrhythmics (e.g., amiodarone) can be administered to treat arrhythmias. Electrolyte imbalances can require the administration of sodium bicarbonate.

If medical treatment is not effective, mechanical intervention (e.g., use of an intra-aortic balloon pump [IABP], extracorporeal membrane oxygenation [ECMO], or ventricular assist device [VAD]) can be necessary to maintain adequate perfusion. If LCOS is apparent before the patient leaves the operating room, delayed sternal closure (DSC) is another technique that can be used to manage LCOS. Patients with DSC require mechanical ventilation and prophylactic antibiotics until the incision is closed.

Facts and Figures

LCOS occurs in up to 25% of young children following surgery to repair congenital heart defects.
Risk Factors
Cardiac surgery with cardiopulmonary bypass is the primary risk factor for LCOS, but any condition that affects preload, afterload, or contractility can lead to LCOS. Risk factors for postoperative LCOS include age > 70 years, left ventricular ejection fraction (LVEF) < 30%, prolonged QRS interval, increased time on a cardiopulmonary bypass machine, reoperation, female sex, both hypo- and hyperthermia, systemic inflammation, residual cardiac lesions, electrolyte imbalances, diabetes mellitus, and significant coronary artery disease.

Signs and Symptoms/Clinical Presentation
Signs and symptoms of LCOS include tachycardia, hypotension, increased capillary refill time, decreased peripheral pulses, cool extremities, and decreased urine output.

Assessment
› Laboratory Tests
  • CBC is typically performed; a low hemoglobin can indicate hemorrhage
  • Electrolyte panel is typically performed to assess for electrolyte imbalances (e.g., hyperkalemia or hypocalcemia)
  • ABGs are often ordered to assess perfusion and for metabolic disturbances (e.g., acidosis)
  • Serum lactate levels are measured serially from the time of admission as an indication of perfusion and should decrease with treatment
› Other Diagnostic Tests/Studies
  • Echocardiogram is typically ordered to measure the ejection fraction
  • Arterial or central venous pressures are routinely monitored to assess preload

Treatment Goals
› Minimize Oxygen Consumption
  • Assess temperature, heart rate and rhythm, and pain level
    – Monitor core vs. peripheral temperature. If the peripheral temperature is at least 3 °C lower than the core temperature, notify the treating clinician
    – Notify the treating clinician of any arrhythmias
  • Maintain normothermia
  • Administer prescribed analgesics (e.g., morphine) and antiarrhythmics (e.g., amiodarone); monitor treatment efficacy and for adverse effects
  • Adjust mechanical ventilation settings per clinician orders
› Promote Healing and Reduce Risk for Complications
  • Assess capillary refill time, peripheral pulses, and warmth
  • Monitor arterial or central venous pressures per clinician orders
  • Monitor and record intake and output
  • Administer prescribed medications, fluids, and blood products (e.g., packed red blood cells, albumin, dobutamine, milrinone, sodium bicarbonate); monitor treatment efficacy and for adverse effects
  • Perform skin care and turn the patient every 2 hours to prevent skin breakdown
  • Review laboratory results (e.g., CBC, serum lactate, electrolytes, ABGs) and report abnormalities to the treating clinician
› Provide Emotional Support and Education
  • Assess patient/family anxiety level and coping ability
  • Educate and reassure family members regarding the treatment plan
  • If appropriate, request clinician referral to a mental health clinician for supportive counseling

Food for Thought
› In a study published in 2015, impaired left ventricular function, on-pumpCABG, emergent cardiopulmonary bypass, and incomplete revascularization were identified as predictors of LCOS following CABG surgery (Ding et al., 2015)
› Cochrane reviewers found insufficient evidence to determine the effectiveness of prophylactic milrinone or levosimendan (a calcium sensitizer), in preventing LCOS or death in children who undergo surgery for congenital heart disease (Burkhardt et al., 2015; Hummel et al., 2017)
Researchers found that near-infrared spectroscopy (NIRS)—a noninvasive tool for monitoring regional oxygenation—could be used to predict LCOS in neonates undergoing cardiac surgery. NIRS values of < 58% predicted LCOS with a sensitivity of 100% and a specificity of 69% (Hickok et al., 2016).

**Red Flags**
- Low urine output is a sign of cardiogenic shock and should be immediately reported to the treating clinician.
- A peripheral temperature that is at least 3 °C lower than the core temperature is a sign of poor perfusion and the treating clinician should be notified.

**What Do I Need to Tell the Patient/Patient’s Family?**
- Educate about LCOS and its transient nature, risks and benefits of treatment, and discharge instructions.

**References**