QUICK LESSON

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 that 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.

ICD-9
428.9

ICD-10
I50.9

Authors

Tanja Schub, BS
Cinahl Information Systems, Glendale, CA

Obiamaka Oji, DNP, APRN, FNP-BC
Cinahl Information Systems, Glendale, CA

Reviewers

Darlene Strayer, RN, MBA
Cinahl Information Systems, Glendale, CA

Teresa-Lynn Spears, RN, MSN
Cinahl Information Systems, Glendale, CA

Nursing Executive Practice Council
Glendale Adventist Medical Center, Glendale, CA

Editor

Diane Pravikoff, RN, PhD, FAAN
Cinahl Information Systems, Glendale, CA

March 26, 2021

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 might be ordered; low hemoglobin can indicate hemorrhage
- Electrolyte panel is performed to assess for electrolyte imbalances (e.g., hyperkalemia or hypocalcemia)
- ABGs are 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 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 clinical 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 occurring after 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)
› Authors in a study of 275 participants reported that the use of global longitudinal strain(GLS)to measure left ventricular systolic function is a good predictor of LCOS post cardiopulmonary bypass in adult patients (Amabili et al., 2017)
› Researchers in a study concluded that dobutamine and milrinone are effective treatment options in preventing low cardiac output syndrome after pediatric cardiac surgery. More cost-saving is observed with the use of dobutamine, and milrinone was found to be efficient in reduction of afterload (Cavigelli-Brunner et al., 2018)

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

Note

› Recent review of the literature has found no updated research evidence on this topic since previous publication on May 11, 2018

References

1. Amabili, P., Benbouchta, S., Roediger, L., Senard, M., Hubert, M. B., Donneau, A., ... Hans, G. (2017). Low cardiac output syndrome after adult cardiac surgery: Predictive value of peak systolic global longitudinal strain. *Anesthesia And Analgesia*. doi:10.1213/ANE.0000000000002605 **(R)**
2. Burkhardt, B. E. U., Rucker, G., & Stiller, B. (2015). Prophylactic milrinone for the prevention of low cardiac output syndrome and mortality in children undergoing surgery for congenital heart disease. *Cochrane Database of Systematic Reviews*, Issue 3. Art. No.: CD009515. doi:10.1002/14651858.CD009515.pub2 **(SR)**
3. Cavigelli-Brunner, A., Hug, M. I., Dave, H., Baenziger, O., Buerki, C., Bettex, D., ... Balmer, C. (2018). Prevention of low cardiac output syndrome after pediatric cardiac surgery: A double-blind randomized clinical pilot study comparing dobutamine and milrinone. *Pediatric Critical Care Medicine*. Advance online publication. doi:10.1097/PCC.0000000000001533 **(RCT)**
4. Chandler, H. K., & Kirsch, R. (2016). Management of low cardiac output syndrome following surgery for congenital heart disease. *Current Cardiology Reviews*, *12*(2), 107-111. doi:10.2174/1573403X12666151119164647 **(RV)**
5. Ding, W., Ji, Q., Shi, Y., & Ma, R. (2015). Predictors of low cardiac output syndrome after isolated coronary artery bypass grafting. *International Heart Journal*, *56*(2), 144-149. doi:10.1536/ihj.14-231 **(R)**
6. Epting, C. L., McBride, M. E., Wald, E. L., & Costello, J. M. (2016). Pathophysiology of post-operative low cardiac output syndrome. *Current Vascular Pharmacology*, *14*(1), 14-23. doi:10.2174/1570161113666151014123718 **(RV)**
7. Hickok, R. L., Spaeder, M. C., Berger, J. T., Schuette, J. J., & Klugman, D. (2016). Postoperative abdominal NIRS values predict low cardiac output syndrome in neonates. *World Journal of Pediatric and Congenital Heart Surgery*, *7*(2), 180-184. doi:10.1177/2150135115618939 **(R)**
8. Hummel, J., Rucker, G., & Stiller, B. (2017). Prophylactic levosimendan for the prevention of low cardiac output syndrome and mortality in paediatric patients undergoing surgery for congenital heart disease. *Cochrane Database of Systematic Reviews*, Issue 3. Art. No.: CD011312. doi:10.1002/14651858.CD011312.pub2 **(SR)**
9. Machiraju, V. R. (2012). Low cardiac output syndrome. In V. R. Machiraju, H. V. Schaff, & L. G. Svennson (Eds.), *Redo cardiac surgery in adults* (2nd ed., p. 4). New York, NY: Springer. **(GI)**
10. Maganti, M., Badiwala, M., Sheikh, A., Scully, H., Feindel, C., David, T. E., & Rao, V. (2010). Predictor of low cardiac output syndrome after isolated mitral valve surgery. *Journal of Thoracic and Cardiovascular Surgery*, *140*(4), 790-796. doi:10.1016/j.jtcvs.2009.11.022 **(R)**
11. Ok, Y. J., Lim, J. Y., & Jung, S. (2018). Critical illness-related corticosteroid insufficiency in patients with low cardiac output syndrome after cardiac surgery. *The Korean Journal Of Thoracic And Cardiovascular Surgery*, *51*(2), 109-113. doi:10.5090/kjtcs.2018.51.2.109 **(R)**