Cardiovascular System

Ashish K. Khanna, M.D., FCCP., FCCM
Associate Professor & Section Head for Research
Department of Anesthesiology, Section on Critical Care Medicine
Wake Forest School of Medicine, Wake Forest Baptist Medical Center
Winston-Salem, NC 27106
akhanna@wakehealth.edu

Ricardo E. Verdiner, M.D.
Senior Associate Consultant
Department Anesthesiology
Mayo Clinic, Phoenix, AZ 85054
verdiner.ricardo@mayo.edu

Initial assessment of shock states in the ICU

A presenting clinical picture of arterial hypotension and signs of tissue hypoperfusion should prompt an algorithmic approach (Figure 1, Figure 2) to access the etiology of shock. Distributive or vasodilatory shock, which is normally a high-cardiac-output state, is the most common cause (>60%) of circulatory shock. Septic shock is a clinical subtype of high-output vasodilatory shock.

High-output vasodilatory shock (septic shock)

An initial diagnosis of septic shock, as defined by a high lactate level and an inability to maintain mean arterial pressure despite resuscitation with vasopressors, should prompt a series of interventions. These include continuing an initial crystalloid fluid bolus up to at least 30 cc/kg (or more if signs of volume depletion persist, as accessed with a combination of urinary output, central venous pressure, and serum lactate), sending blood cultures, rechecking an initial lactate, and administering broad-spectrum antibiotics (all within the first 3 hours of presentation if possible). These patients should have an indwelling central venous line, especially if they are on escalating high doses of vasoactive medications and need a significant amount of volume. Hemodynamic stability is critically important in these patients.(1) A search for the source of infection and controlling of the source of infection either medically or surgically should be concurrently continued. Steroids (hydrocortisone up to 200 mg/day in divided doses, at a point where there is an escalation to higher doses, i.e. >10 mcg/min of norepinephrine and or the addition of a second vasopressor), should be supplemented as needed. The surviving sepsis guidelines recommend adding vasopressin or additional epinephrine, in case an inability to maintain mean arterial pressure (MAP) >65 mmHg exists, and consequently decreasing the amount of norepinephrine needed to do so.(2) Dobutamine is reserved for septic shock with an additional element of '"pump-failure'" (also see COVID-19 cardiogenic shock). Angiotensin II (utilized as a second-line or third-line vasopressor) has shown good benefit in the management of septic shock. (3) Glycemic control (120-180 mg/dl), stress ulcer prophylaxis, and deep vein thrombosis (DVT) prophylaxis should be initiated. Early enteral nutrition should be considered in intubated and mechanically ventilated patients if they meet the criteria for stability (consult the ICU team). Septic shock on high-dose vasopressors (total vasopressor need >0.2-0.3 mcg/kg/min norepinephrine or norepinephrine equivalents) may benefit from adjuncts such as ascorbic acid and or thiamine.

COVID-19-related high-output vasodilatory shock (septic shock)

Critically ill patients with diagnosed COVID-19 sepsis may quickly escalate to septic shock. These patients (especially those meeting the clinical criteria for instability) should be monitored in an ICU environment, and consideration should be given for early resuscitation, invasive lines, intubation, and mechanical ventilation. Most general principles of the management of COVID-19 septic shock are the same as those for non-COVID-19 septic shock (see above).

Specific considerations for these patients

1. Consider the judicious use of volume resuscitation, since these patients present with early and significant lung injury, which may be worsened with excessive fluids. Using additional data such as stroke volume variation (SVV) with an arterial line to guide fluid resuscitation (SVV >12% will generally respond to volume) is prudent.
2. In the context of point number 1, due consideration should be given to the early initiation of single or early multi-modal combination vasopressor therapy.
3. The discontinuation of ACE inhibitors and or ARBs is not currently recommended, although it should be strongly considered in cases of septic shock needing vasopressors.(4)
4. The early initiation of hydroxychloroquine and or azithromycin for source control may be considered. Clinical trials are ongoing, and some initial data have been encouraging. Please also see section under infectious disease.
5. Angiotensin II as a front-line vasopressor also merits consideration in these patients, because it may compete with the virus for binding sites on cardiac ACE2 and may in addition down-regulate cardiac ACE2 activity.(5, 6) The virus has been shown to have a strong affinity for the ACE2 enzyme.(7)
6. Steroids as supplements to reverse hemodynamic instability may be provided, although cautious use and short-term treatment regimens are suggested.

COVID-19-related Myocardial Injury (Cardiogenic Shock)

The usual presentation of this syndrome includes an acute onset of chest pain, ST changes, T wave inversion, arrhythmia, reduced LVEF <50%, elevated troponin, cardiomegaly on chest x-ray, and new or worsening heart failure. (Figure 2) Wang and colleagues reported an incidence of 16.7% for arrhythmia and an incidence of 7.2% for evidence of acute cardiac injury in a cohort of 138 critically ill COVID-19 patients.(8)

Initial laboratory testing reveals an elevated C-reactive protein (CRP an early detector), interleukin (IL)-6 (results take hours), B-type natriuretic peptide (BNP) and troponin levels. Instead of drawing conclusions on single values, clinicians should consider trending them over time to estimate a trajectory. The *H score* should be calculated to estimate reactive hemophagocytic syndrome if the early use of Tocilizumab (anti IL-6) is being considered prior to obtaining the results of IL-6 levels.(9,12,15) Monitoring should include regular ECGs for arrhythmias, ST changes and QTc. Hydroxychloroquine/Chloroquine and azithromycin both cause QT prolongation.(10,11) QTc >500 indicates an increased risk for polymorphic ventricular tachycardia (Torsade de Pointes). Echocardiography is an important modality which can help distinguish between COVID-19 related acute coronary syndrome (ACS) and myocarditis.

Specific echocardiographic findings include:

1. **Regional Hypokinesis**: A selective portion of the LV or RV shows reduced contractility. This normally follows the pattern of ECG to coronary distribution to myocardial location. For example, Leads II,II,AVF=RCA=RV; Leads V1,V2=Prox. LAD=Septal; Leads V3-V5=LAD=anterior LV; Leads I,AVL,V5,V6=CFX=lateral LV. Ischemia can result in isolated LV or RV dilation.
    a) In the setting of COVID-19, ACS can be secondary to hypoxia from acute respiratory distress syndrome or increased metabolic demand.
    b) Follow ACS management protocol. Reduce beta blocker dose if chloroquine/hydroxychloroquine are being used. (Both cause a reduction of CYP2D6 inhibition which will potentiate the effects of beta blockers.)
    c) Consult interventional cardiology for risk-benefit analysis of catheterization.
    d) Conduct risk-benefit analysis for extracorporeal membrane oxygenation (ECMO). (Please refer to the specific section on ECMO for greater detail.)

2. **Global Hypokinesis**: The entire heart shows reduced contractility. It is not unusual to find that both the RV and LV are dilated. “Basketball” appearance of the heart on echocardiogram is commonly seen.
    a) Global hypokinesis is suggestive of myocarditis in the presence of COVID-19. SARS-COV-2 is a cardiotropic virus.(13,14)
    b) **No role for NSAIDS exists.** They may also exacerbate heart failure.
    c) Steroids are not recommended for this specific situation at this time.
    d) Insufficient data are available to support ACE/ARB continuation.
    e) Beta blocker dose should be reduced if chloroquine/hydroxychloroquine are being used.
    f) Sustain supportive care to maintain cardiac performance. Use inotropic agents.
    g) LVEF<20% requires anticoagulation if not present already.
    h) If CRP level or H score is significantly high, consider an anti IL-6 inhibitor.
    i) Conduct a risk-benefit analysis for ECMO.
    j) A potential role exists for intravenous immunoglobulins (IVIG).

Figure 1: Initial Assessment of Shock Etiology in a Critically Ill Patient

Figure 2: COVID-19-Associated Myocardial Injury

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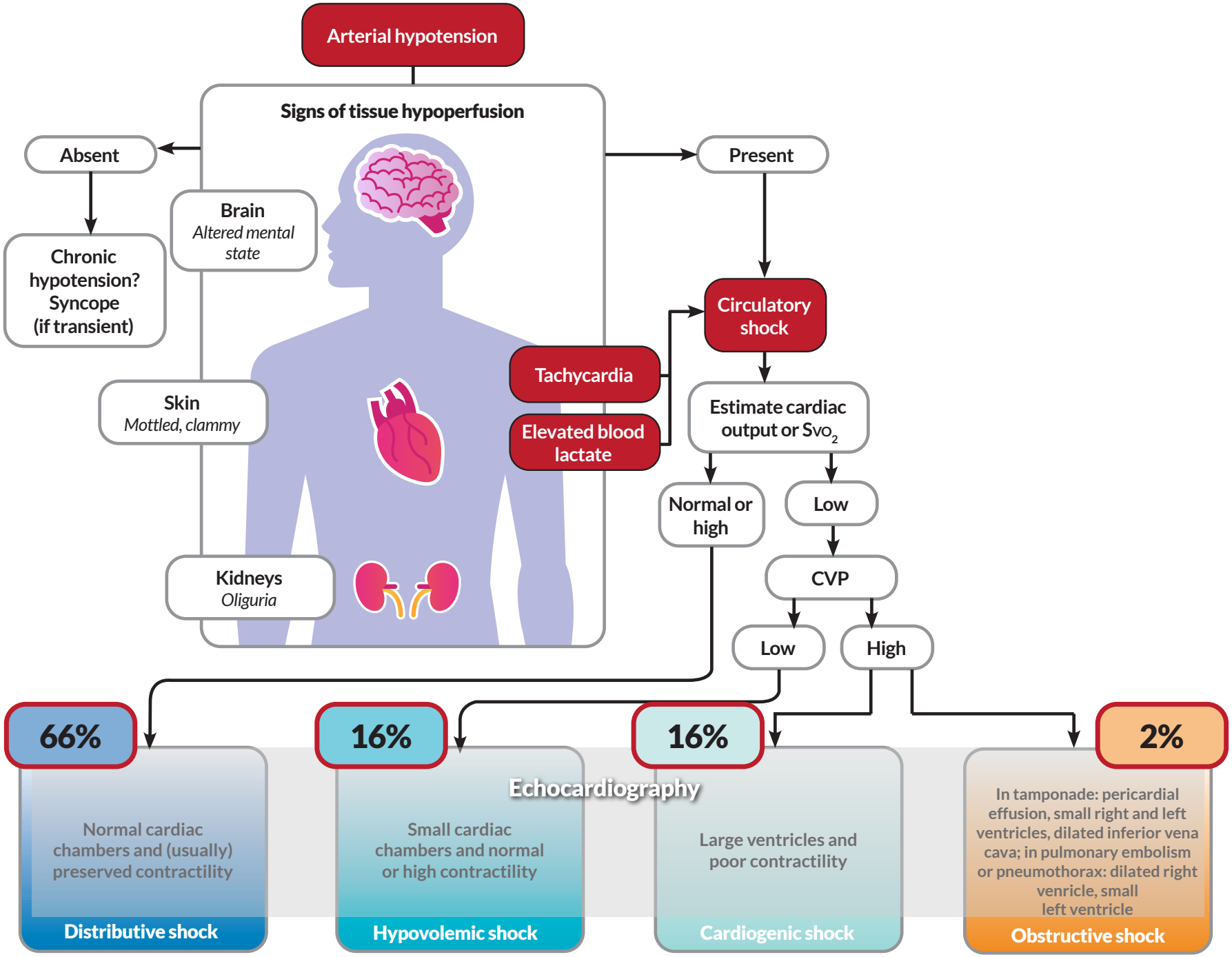
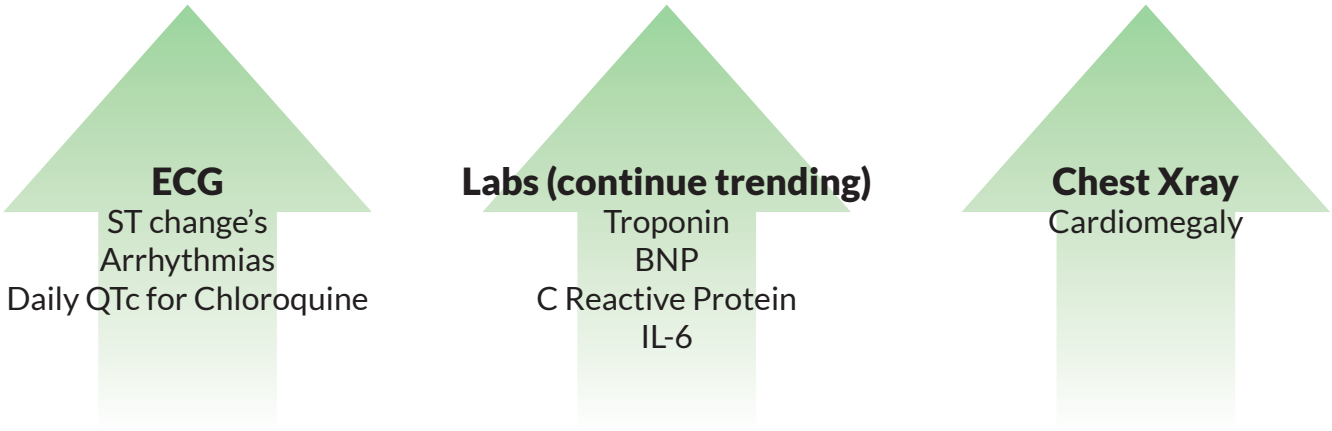
Initial Assessment of Shock Etiology in a Critically Ill Patient



COVID Activated Emergency Scaling of Anesthesiology Responsibilities (CAESAR) ICU | Content developed and sourced in collaboration with ASA, SOCCA, SCCM and APSF
Dated: 03/30/2020

COVID-19 associated Myocardial Injury



Echocardiography

Regional Hypokinesis

- Potential for Acute coronary syndrome secondary to Hypoxia and/or increase metabolic demand
- Follow ACS management protocol
- **Reduce beta blocker dose if on chloroquine/hydrochloroquine (CYP2D6 inhibition)**
- Consult Interventional Cardiology for risk-benefit analysis
- Consider ECMO

VS

Global Hypokinesis

- Suggestive of myocarditis
- Elevated Troponin, BNP, CRP, IL-6
- **NSAIDs not advised. May also exacerbate heart failure!**
- No role for steroids
- Insufficient data to support ACE inhibitors/ARB at this time
- **Reduce beta blocker dose if on chloroquine/hydrochloroquine (CYP2D6 inhibition)**
- Support care to maintain cardiac performance
- If CRP ↑ or "H" score is high consider anti IL-6
- Consider ECMO
- Consider IVIG

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