



Online Appendix

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Appendix to: Jones D, Carty P, Karalapillai D. A four-step model to aid teaching, clinical assessment and communication of circulatory disorders among junior clinicians. *Crit Care Resusc* 2022; doi: 10.51893/2022.4.POV.

Table 1: Summary of history, examination, chart information and charted investigations for various causes of circulatory disorders.

| Patho-physiol. cause | History | Examination | Charts | Targeted Investigations |
|-------------------------|---|---|--|--|
| Hypovolemia | Thirsty. Vomiting or high NGT aspirates, diarrhoea Rarely polyuria. Abdominal surgery – 3 rd spacing | Cold, poor cap return, tachycardic, weak pulse, low JVP and dry mouth, third spacing, high drain outputs. Chest clear. Obvious source of fluid loss (NGT, IDC, stool) | Negative fluid balance, poor input, high outputs | Tests to look for cause – stool, imaging High U/Cr ratio |
| Haemorrhage | Thirsty (may not be if very acute) Obvious source of loss from gut, drains, intra-abdominal, wound. | Cold, poor capillary return, tachycardic, weak pulse pale conjunctiva. low JVP, chest clear. Source of bleeding – drains, abdomen, GIT (rectal examination). | High drain outputs | Urgent FBE and x-match (NB Hb on ABG) High U/Cr ratio if GIT bleed Investigations for source |
| Epidural related | More likely to be if higher thoracic epidural (Sympathetic nerves) Recent bolus or increased rate | Warm and well perfused Check level of sensory block Make sure T1 motor intact | Recent bolus or increased rate | Discuss with pain services Trial reduced rate |
| Cardiogenic | Known history of IHD or CCF or coronary RFs. Current chest / jaw /arm pain or palpitations, N + V, SOB | Cold and shut down, weak pulses Raised JVP, murmur if valvular related Crepitation in chest. <u>±</u> peripheral oedema | Chest pain Positive fluid balance | Urgent ECG, CXR Cardiac enzymes <u>±</u> echo |
| Pulmonary embolism (PE) | History of Cancer, trauma, OCP/HRT, prior DVT/PE, immobilisation symptoms = SOB, chest pain, palpitations, calf pain | Increased RR, low grade temp Cold and shut down, weak pulses Raised JVP, right parasternal heave and loud P2. | | V-Q scan CTPA |
| Sepsis | Hot, flushed, sweats Source = cough, sputum, dysuria, pain in surgical site, headache, nasal pain (if NGT) | Warm and well perfused, brisk cap return Bounding pulse, variable JVP Source of sepsis → chest, abdomen, IV sites, devices, urine | Temp chart Drains | Pan-culture Urinalysis Imaging to find suspected source CRP, ESR |
| Tension Pneumothorax | Trauma Tall thin male Attempt at CVC Removal of ICC | Cold and shut down. Likely increased RR Tracheal deviation away from side, reduced expansion, hyper-resonant PN, reduced breath sounds | N/A | Medical emergency = needle decompression 2 nd inter-costal space mid-clavicular line |
| Tamponade | Cardiac surgery Trauma Recent URTI/LRTI Symptoms suggesting malignancy | Cold, poor cap return, tachycardic, weak pulse. High JVP, soft heart sounds (low BP, raised JVP, soft heart sounds) | Drain from chest drains when in | Urgent CXR and TTE Check serial CXRs |

NGT = nasogastric tube; IHD – ischemic heart disease; CCF = congestive cardiac failure; RF = risk factors; SOB = shortness of breath; OCP = oral contraceptive pill / HRT = hormone replacement therapy; DVT = deep venous thrombosis; CVC = central venous catheter; ICC = intercostal catheter; URTI = upper respiratory tract infection; LRTI = lower respiratory tract infection; IDC = indwelling catheter; JVP = jugular venous pressure; IV = intravenous; RR = respiratory rate; BP = blood pressure; U = urea; Cr = creatinine; ECG = electrocardiogram; CXR = chest X-ray; CRP = c-reactive protein; ESR = erythrocyte sedimentation rate; TTE = trans-thoracic echo

| Modality | Measure cardiac performance | Measure of how full | Measure of end organ perfusion |
|-----------------------------|------------------------------------|----------------------------|---------------------------------------|
| Clinical examination | | | |
| Central line | | | |
| PiCCO | | | |
| Pulmonary arterial catheter | | | |
| Echocardiography | | | |

Table 2: Measures of cardiac output, endo organ perfusion, and pre-load obtained from clinical examination and commonly used ICU monitoring devices

| Technique | Cardiac output / Stroke volume | End organ perfusion (concern) | Marker of pre-load |
|--|---|---|--|
| Clinical examination ¹ | Strength and volume of pulse | Capillary refill time (> 4 sec) Warmth of periphery (Cold) Conscious state (Reduced) Urine output (Oliguria) | Jugular venous pressure Fluid balance |
| Arterial line ² | Visual inspection of waveform and area under curve | Serum lactate (> 3 mmol/L) Serum HCO ₃ (<20 mmol/L) | Systolic pressure variation Pulse pressure variation Delta down |
| Central venous line ³ | | Central venous oxygenation (S _{cvO₂}) (< 55%) Serum lactate (> 3 mmol/L) Serum HCO ₃ (<20 mmol/L) | Central venous pressure |
| Echo cardiography ⁴ | “Eyeball” assessment Fractional shortening LVOT VTI ± Estimated CO Regional wall motion abnormality Right ventricular dilatation Pericardial fluid | | Left ventricular end-diastolic area (LVEDA) Atrial size and Interatrial septal motion Inferior vena-caval dimension and collapsibility |
| Pulse Contour analysis ⁵ | Transpulmonary cardiac output Pulse contour cardiac output Cardiac function index | Serum lactate (> 3 mmol/L) Serum HCO ₃ (<20 mmol/L) | As per arterial line Stroke volume variation Intra-thoracic blood volume index Global end diastolic index |
| Pulmonary artery catheter ⁶ | Thermo-dilutional cardiac index | Mixed venous oxygenation (MvO ₂) (< 55%) | Pulmonary artery occlusion pressure Pulmonary artery diastolic pressure |

ICU = Intensive Care Unit; sec = seconds; LVOT VTI = Left Ventricular Outflow tract velocity time integral, CO = cardiac output
Shown in red are the values that should raise concern

References

- 1 Hariri G, Joffre J, Leblanc G, et al. Narrative review: clinical assessment of peripheral tissue perfusion in septic shock. *Ann Intensive Care* 2019; 9: 37.
- 2 Marik PE, Cavallazzi R, Vasu T, Hirani A. Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: a systematic review of the literature. *Crit Care Med* 2009; 37: 2642-7.
- 3 Marik PE, Baram M, Vahid B. Does central venous pressure predict fluid responsiveness? A systematic review of the literature and the tale of seven mares. *Chest* 2008; 134: 172-8.
- 4 Perera P, Lobo V, Williams SR, Gharahbaghian L. Cardiac echocardiography. *Crit Care Clin* 2014; 30: 47-92.
- 5 Monnet X, Teboul JL. Transpulmonary thermodilution: advantages and limits. *Crit Care* 2017; 21: 147.
- 6 Bootsma IT, Boerma EC, de Lange F, Scheeren TWL. The contemporary pulmonary artery catheter. Part 1: placement and waveform analysis. *J Clin Monit Comput* 2022; 36: 5-15.