Define cardiac output. (10% of marks) Outline the factors that affect cardiac output. (60% of marks) Briefly describe the thermo dilution method of measuring cardiac output. (30% of marks)

Cardiac output = Volume of blood ejected by the heart per unit time (minute) = HR x SV

HR determined by autonomic input
- Resting HR approx 60
  - Sympathetic blockade causes HR to slow to 50
    - Sympathetic output to heart governed by the medullary vasomotor area
  - Parasympathetic blockade causes HR to hasten to 110
  - Both sympathetic and parasympathetic blockade causes HR to hasten to 100
  - Electrolytes
  - Drugs

SV = Amount of blood ejected by the heart per contraction
- Governed by
  - Preload
    - Tension applied to myocyte immediately prior to contraction
      - Starling relationship
        - Optimal sarcomere length ~2.2um
        - Over-stretch inhibited by fibrous pericardium
      - Preload governed by
        - Blood volume and MSFP (increases preload)
        - RAP (decreases preload)
        - Resistance to venous return (decreases preload)
        - Negative intrathoracic pressure (aids in venous return)
        - Musculovenous pumps (aids in venous return)
        - One-way venous valves (aids in venous return)
  - Afterload
    - Load against which the ventricle must exert its contractile force
    - According to Laplace law
• Afterload \( \propto \frac{(\text{Aortic pressure} \times \text{ventricular radius})}{\text{thickness of ventricular wall}} \)

❖ Other factors affecting afterload

• Resistance
  ➢ Viscosity inversely proportional to flow
    ❖ As viscosity decreases (e.g. Hb decrease), output increases
  ➢ Flow is proportional to vessel radius to the 4th power

❖ Contractility
  ❖ Intrinsic ability of myocardium to contract at given preload and afterload

❖ Governed
  • Sympathetic increases contractility
  • Parasympathetic decreases contractility
  • Other hormones
  • Electrolytes

Thermodilution method
- Form of indicator dilution method where indicator is cold fluid
- Catheter passed into right atrium
  ➢ Known quantity of fluid of known temperature injected into right atrium
- Second catheter in pulmonary artery
  ➢ Measured change in temperature
  ➢ Change in temperature over time graphed
  ➢ Return of temperature to baseline extrapolated to zero to account for recirculation
  ➢ Average change in temperature for duration of curve calculated
  ➢ \( \text{CO} = \frac{\text{temperature of indicator}}{\text{(average change in temp} \times \text{duration of curve)}} \)
Examiners Comments:
This is a core question. It was expected candidates could provide a definition (heart rate x stroke volume) and then move on to outline factors that affect it (afterload, preload, contractility). Additional marks were awarded for descriptions of the relationship to mean systemic filling pressure and other influences beyond this. Most candidates described a thermodilution cardiac output curve but almost all described the technique as based on the “Fick equation or method” (which is used to estimate cardiac output from oxygen consumption). Very few candidates correctly identified the Stewart Hamilton equation as the integration method used to relate cardiac output (flow) to temperature change as an example of indicator dye dilution. Candidates seemed to lack depth and understanding on this topic.
58% of candidates passed this question.