Discuss the determinants of venous return to the heart.

Factors that determine venous return back to the heart

The factors that influence VR are captured in 2 formulae: VR = CO, and VR = (MSFP - RAP) / Venous Resistance.

The three variables that influence venous return are:

- Mean Systemic Filling pressure (MSFP)
  - MSFP is the theoretical pressure present in the systemic circulation at equilibrium
  - MSFP is the main driving pressure moving blood back towards the RA – It is the MAIN factor determining venous return (and thus CO)
  - MSFP can be used to assess the degree of filling of systemic circulation: It is normally 7 mmHg (0-20 mmHg)
  - Two factors influence MSFP:
    - Blood volume \(\uparrow\) \(\Rightarrow\) MSFP
    - Venomotor tone (venous capacitance) \(\uparrow\) \(\Rightarrow\) MSFP
- RA pressure
- Resistance to venous return
Therefore, the factors that affect venous return influence one or more of the aforementioned variables:

- **Blood volume**
  - Blood volume is proportional to MSFP and thus venous return

- **Venomotor tone**
  - Increased venomotor tone (Eg. due to SNS activity) decreases vein compliance and capacity, which increases MSFP and venous return
  - Decreased venomotor tone (Eg. due to SAB) increases vein compliance and capacity, which decreases MSFP and venous return
  - This has a greater effect on venous return when (i) venous pressures are normal, and (ii) veins are circular (not collapsed and contain large volumes of blood)

- **Venous valves**
  - Veins have one-way valves that prevent retrograde flow

- **Skeletal muscle pump**
  - Alternating contraction and relaxation of limb skeletal muscle forces blood out of the veins towards the heart (thus, increasing MSFP) – During contraction, veins compress to expel blood towards the heart, then during relaxation, veins distend and fill with blood
  - With exercise, this pump function enhances net venous return

- **Respiratory pump**
  - During inspiration, venous return is increased due to (i) fall in RAP (associated with fall in PINTRAPLEURAL), and (ii) increased IAP (due to diaphragmatic contraction)
  - During expiration, the effects are reversed
  - Note that if RAP is < 0 mmHg, the respiratory pump will NOT have any effect on venous return as the thoracic veins would have collapsed at subatmospheric pressures

- **Posture**
  - Posture has an effect on blood pooling in the venous capacitance system – When going from supine to erect, there is reduced venous return due to venous pooling in the lower extremities
  - Normally, there is reflex vasoconstriction to prevent this BUT this reflex is delayed and less effective in the elderly

- **Effect of ventricular contraction and relaxation**
  - During rapid ejection phase of ventricular systole, atrial pressure falls sharply (to zero or −ve values) as the ventricle contraction pulls the atrioventricular fibrous ring downwards and increases the atrial volume – This causes net blood flow into atria and increases venous return
  - During early diastole, ventricles fill rapidly causing both ventricular and atrial pressures to decline – This facilitate blood flow into atria and increases venous return

- **Intrapericardial pressure**
  - Increased intrapericardial pressure (Eg. tamponade) can increase RAP, thus impeding venous return

- **Afterload**
  - Changes in the dimension of the resistance vessels (arterioles) has a small effect on MSFP as only 2% of blood volume is in arterioles (cf. venous capacitance vessels) – Instead, it has an impact on “Resistance to venous return”
  - Decreased afterload (such as decreased SVR due to arteriolar vasodilation) decreases resistance to venous return, thus increasing venous return
Increased afterload (such as increased SVR due to arteriolar vasoconstriction) increases the resistance to venous return, thus decreasing venous return.

**Examiner Comments:**
67% of candidates passed this question.
The factors that influence VR are captured in 2 formulae; VR = CO, and VR = (MSFP-RAP) / Venous Resistance. Candidates that used these as the backbone structure of their answer scored well. Quite a few candidates failed to consider factors that affect left heart CO also effect VR. Recognising that CO does = VR appeared to elude some candidates.