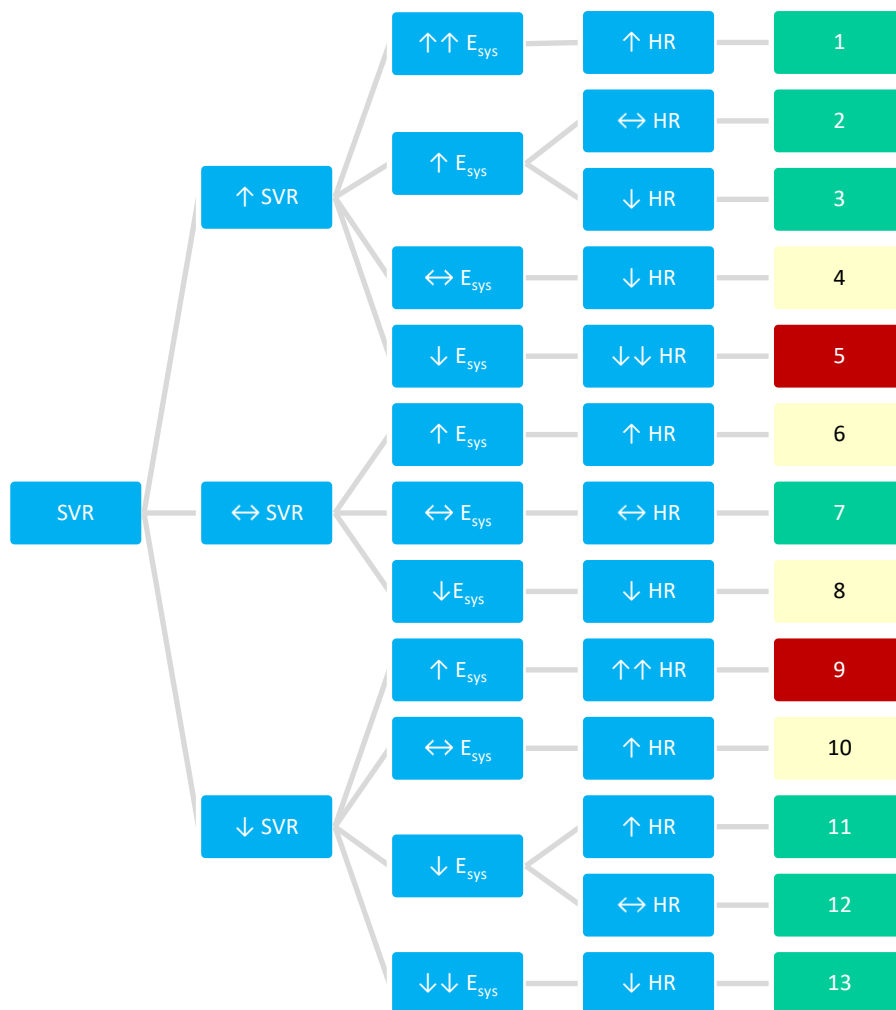


Supplementary Material

1 Permutations of systemic vascular resistance (SVR) and systemic elastance (E_{sys})

There are 13 permutations of systemic vascular resistance (SVR) from a reference point, when expressed in terms of systemic elastance (E_{sys}) and heart rate (HR) (16).

In two permutations (permutation 5 and 9, colored red), SVR and E_{sys} trend in opposite directions. In four permutations (permutations 4, 6, 8 and 10, colored yellow), E_{sys} or SVR is stable while the other parameter is increasing or decreasing. In six permutations, E_{sys} and SVR trend in the same direction although at different magnitudes (permutations 1-3 and 11-13, colored green). Trends in SVR and E_{sys} will be equivalent where HR is constant (permutation 7, colored green), e.g., where the heart is paced.



2 Derivation of the pressure field equation from Sunagawa's effective arterial elastance equation

Effective arterial elastance (E_a) is a pulsatile measure of afterload developed by Sunagawa (21). By rearrangement and by substituting CVP for Sunagawa's downstream pressure (P_d):

$$E_a = \frac{(LVESP - P_d)}{SV} \approx \frac{(MAP - P_d)}{SV} \quad \begin{array}{l} \text{(1) Sunagawa's effective} \\ \text{arterial elastance} \\ \text{equation} \end{array}$$

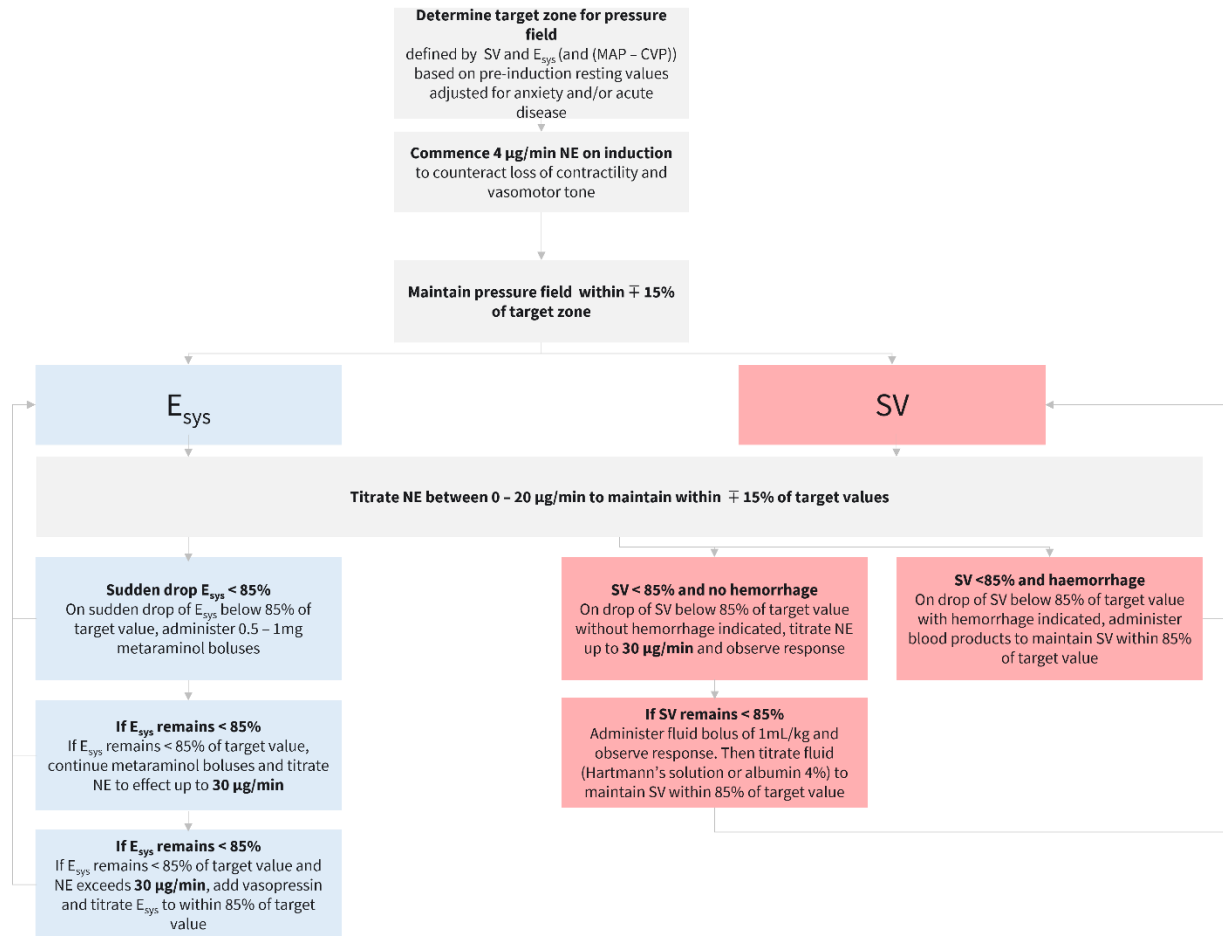
$$E_a \approx \frac{(MAP - CVP)}{SV} \quad \text{Substituting CVP for } P_d$$

$$(MAP - CVP) \approx SV \times E_{sys} \quad \begin{array}{l} \text{By rearrangement,} \\ \text{(2) Pressure field equation} \end{array}$$

where E_a = effective arterial elastance, LVESP = left ventricular end-systolic pressure, P_d = downstream pressure, MAP = mean arterial pressure, SV = stroke volume, CVP = central venous pressure, and E_{sys} = systemic elastance.

3 The AHM+PF management algorithm

The AHM+PF management algorithm is summarized below.



Abbreviations: E_{sys} , systemic elastance; MAP, mean arterial pressure; CVP, central venous pressure; NE, norepinephrine; SV, stroke volume.

4 Table: Additional cases of hemorrhage

The six additional cases of hemorrhage are summarized below. For the five patients in the AHM group who suffered post-operative hemorrhage, the graphs display the period of post-operative ICU monitoring prior to and during hemorrhage. For the one case of operative hemorrhage in the AHM+PF group, the operative period prior to and during exsanguinating hemorrhage is displayed.

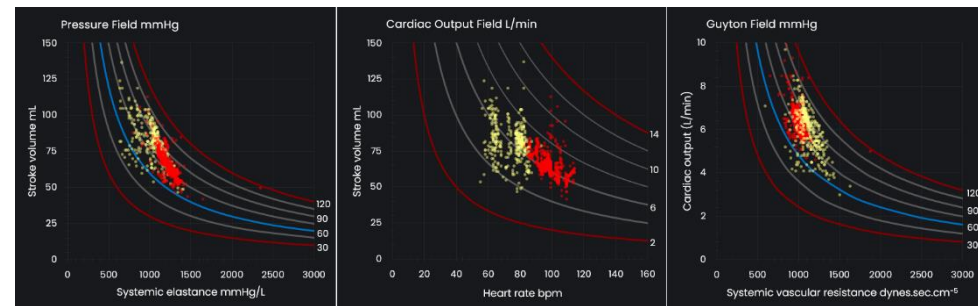
AHM management ■ ICU ■ Evolved hemorrhage

3. Post-op AVR, est 4L blood loss

63-year-old 120kg male with chronic liver disease. On-pump AVR, admitted post-op to ICU. Assessed as ‘likely bleeder’.

15 hrs hemorrhage before OR return. 4L estimated blood loss, NE titrated to 20 mcg/min, 12L fluid and blood products administered prior to OR return. Lowest ABE -2.7, Hb 79, pH 7.29. Postoperative recovery prolonged with acute kidney injury. Discharged home at 21 days.

Pressure field indicates patient hypodynamic and vasoconstricted. Guyton field indicates CO and SVR preserved.

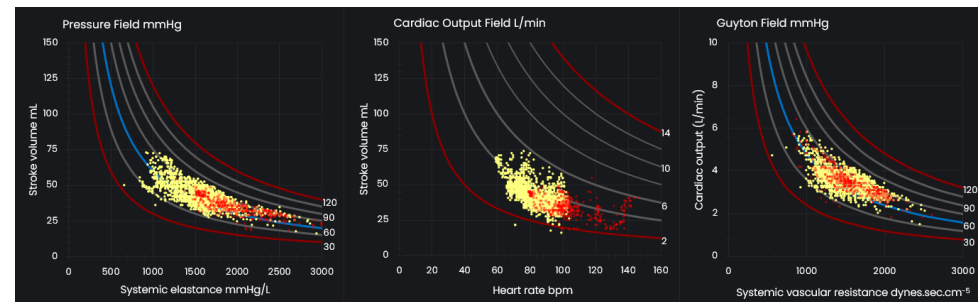


4. Post-op paraoesophageal hernia repair, est 3L blood loss

89-year-old 64kg female, large paraoesophageal hernia repair. 6 hours after post-op ICU admission, tachycardia with distended abdomen.

15 hr delay in OR return for evacuation of large bleed, repair of falciform ligament bleeder due to surgical skepticism. 3L estimated blood loss, NE titrated to 20 mcg/min, 7L fluid and blood products prior to OR return. ICU stay prolonged by 3 days with acute kidney injury. Discharged home.

PF indicates patient hypodynamic and vasoconstricted. GF indicates CO and SVR preserved



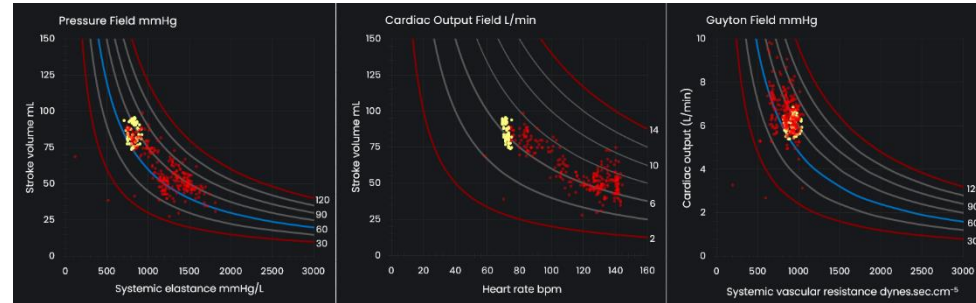
AHM management (continued)

5. Post-op (on-pump) CABG, est 3L blood loss

75-year-old 77kg male. On-pump CABG, post-op ICU admission, ventilated.

Blood pressure decreased 7 hours after ICU admission, NE 40mcg/min. 3L est blood loss, 6.5L fluid and blood products prior to OR return. 5-hr delay in return to OR return. ICU stay prolonged by 3 days with acute renal failure. Discharged home.

PF indicates patient hypodynamic and vasoconstricted. GF indicates CO preserved to high, and SVR preserved to low.



6. Post-op Ivor-Lewis esophagectomy, est 7L blood loss

79-year-old 91kg male underwent Ivor-Lewis esophagectomy for adenocarcinoma. Extubated with working epidural and admitted post-operatively to ICU.

2 hours after ICU admission, SV decreased with associated HR increase. NE titrated to 30mcg/min. 7L est blood loss, 14L fluid and blood products prior to OR return. Lowest ABE -18.8, Hb 56, pH 6.74. 7+ hour delay in OR return. Patient died after 5 months hospitalization, due to anastomotic failure, and chronic abdominal sepsis. Also experienced acute renal failure and infection.

PF indicates patient hypodynamic and vasoconstricted. Guyton Field graph indicates CO largely preserved with SVR decreased, that is vasodilation



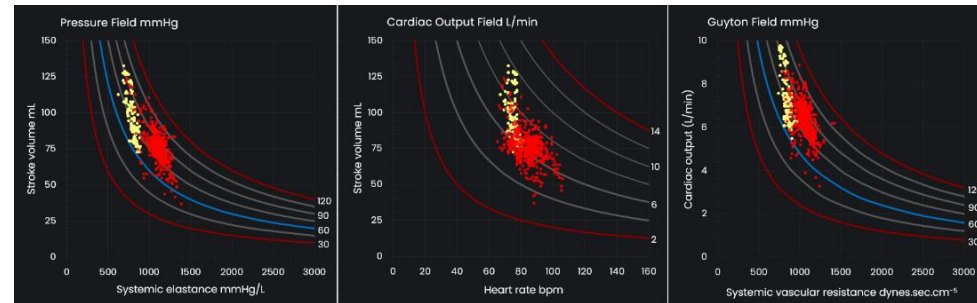
7. Post-op Ivor-Lewis esophagectomy, est 3L blood loss

70-year-old 68 kg male underwent Ivor-Lewis esophagectomy for adenocarcinoma; admitted to ICU ventilated.

5 hours after ICU admission, had sustained reduction in SV that could not be increased with fluid. NE titrated to 15 mcg/min to maintain blood pressure. 3L est blood loss, 6.5L fluid and blood products prior to OR return. Lowest ABE -2.7, Hb 79, pH 7.29. 5-hour delay in return to OR.

Patient required re-ventilation with rapid AF/pulmonary edema on Day 3 post-surgery. Post-operative infection. Prolonged ICU stay, discharged home.

PF indicates patient hypodynamic and vasoconstricted. GF indicates similar but less pronounced pattern.



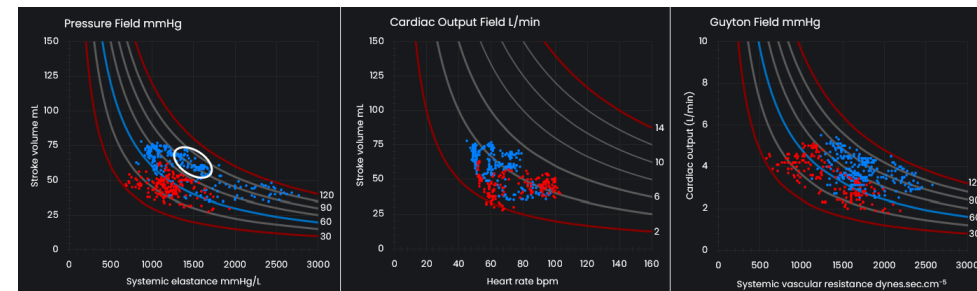
Pressure field management ■ Surgery pre-hemorrhage ■ Hemorrhage

8. Radical prostatectomy, est 5L blood loss

73-year-old 75kg male underwent radical prostatectomy with spinal plus general anesthetic. Unexpected bleeding with most of the 5L blood loss occurring over 45 minutes. Patient managed to pre-induction pressure field (see white oval) but this was challenging to maintain in view of response to spinal anesthesia and rapid hemorrhage. NE titrated to a maximum of 23 µg/min to maintain blood pressure. 4.5L albumin 4%, 6 units packed red cells, and 1L Hartmann's administered. Lowest ABE -10.2, Hb 67 g/L, pH 7.18, lactate 0.7 mmol/L

Patient extubated at end of surgery. Full recovery and discharged on postoperative day 5.

PF and GF both indicated decrease in volume/flow. Similar trends as maintenance of volume led to absence of tachycardia



Abbreviations: ABE, actual base excess; AF: atrial fibrillation; AVR, aortic valve replacement; CABG: coronary artery bypass graft; CO, cardiac output; est, estimated; GF, Guyton field; Hb, hemoglobin; ICU, intensive care unit; NE, norepinephrine; OR, operating theatre; post-op, postoperative; PF, pressure field; SV, stroke volume; SVR, systemic vascular resistance.

