

Clinical Case Study PICU 1: USCOM in the Pediatric Intensive Care Unit

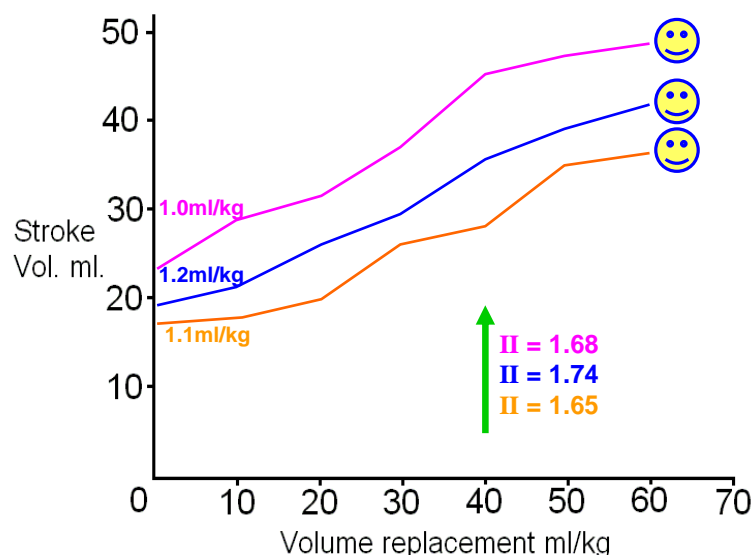


Septicemia with hypotension.

In intensive care, we have to look at the patient's cardiopulmonary system as a whole rather than looking at individual parameters; it is all too easy to focus on one parameter but miss the big picture.

Septicemia in children is associated with considerable hypovolaemia in some cases. The current Surviving Sepsis Campaign guidelines advocate rapid and considerable volume expansion in any child with septic shock. Volumes of 40 or even 60 ml/kg body weight in the first hour are advised. But is this all we need to worry about from the hemodynamic viewpoint. The USCOM suggests that there is a much bigger picture we need to look at.

This figure shows three children presenting with septic shock, with their stroke volumes (expressed as ml/kg) and response to fluid replacement therapy.



The Smith-Madigan Inotropy Index¹ (SMII), a measure of inotropy (myocardial contractility) was calculated from their USCOM data after 40 ml/kg of fluid replacement (normal is >1.4 watts/m²). All three children did well clinically and survived. The pediatric literature tells us that there are "responders" who improve

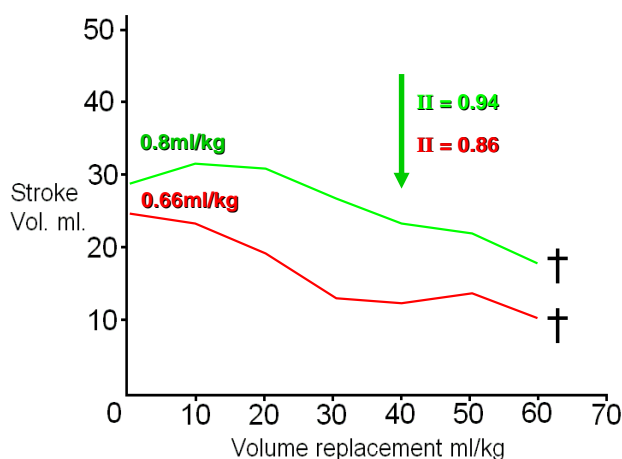


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with volume replacement, and “non-responders” who do not. Can the USCOM tell us why?

In this figure we see two further children who were “non-responders”. They died.



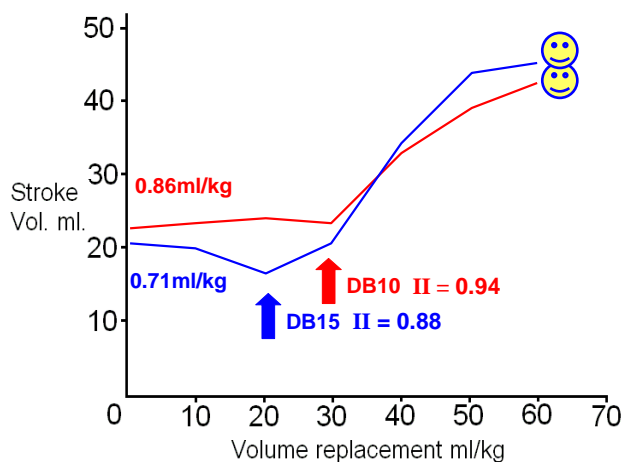
We can see that they have stroke volumes below 1 ml/kg on presentation and that this does not increase with volume loading. But just look at the SMII after 40 ml/kg. In both cases it is below 1.0 W/m². These children have left ventricular failure. The USCOM also showed that in both the responders and the non-responders the SVR was very high, i.e. they were markedly vasoconstricted. Low myocardial contractility should respond to an inotrope, but which one to use? The SVR is already high, so a vasodilating inotrope would seem appropriate.

In the figure below, we see the effect of adding dobutamine at 10 mcg/kg/min and 15 mcg/kg/min in two apparent non-responders after 30 ml/kg and 20 ml/kg respectively.

In both cases the stroke volume on presentation was under 1.0 ml/kg and both had SMII values below 1.0 W/m². Following the dobutamine, both showed rapid improvement.



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After 60 ml/kg of volume replacement the SMII values were 1.62 and 1.84. SVR values had reduced to the upper end of the normal range in each case. The dobutamine was weaned slowly over 24 hours in each case. Both children survived.

The USCOM data is used to calculate the SMII, and when this is taken together with preload and SVR data, we can make a rational choice of which inotrope to use. Repeat measurement guides dosage and duration of inotrope support. We can only do this if we consider the full hemodynamic picture.

¹The Smith-Madigan Inotropy Index calculates the effective inotropy of the heart from the external work it performs in generating each stroke volume and the time taken to eject the stroke volume. The SMII is calculated using the formula

$$SMII = \frac{(BPm \times SV \times 10^{-3})}{7.5FT} + \frac{(D \times Vm^2 \times SV \times 10^{-6})}{2FT} \quad \text{Watts/m}^2$$

Where BPm = mean blood pressure (mmHg), SV = stroke volume (ml), D = blood density (Kgm/m³), Vm = mean ejection velocity (m/s), FT = Flow Time (s), BSA = body surface area (m²). The factors 7.5, 10⁻³ and 10⁻⁶ are required to convert mmHg for BP and ml for SV to kPa and m³ respectively, to conform with SI units.

