Optimum PEEP

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.

Here is a typical example of a common problem that we all see regularly in ICU regarding the interaction between ventilation and circulation.

Presentation

The patient is a 67 year old female with pneumococcal pneumonia leading to bibasal consolidation.

USCOM exam

On the left her hemodynamics on SIMV with an inspired oxygen concentration of 70%:

- PEEP was at 5cm H_2O
- SpO_2 was just 85%
- PaO_2 of 58mmHg
- $PaCO_2$ was normal

We have a number of choices:

a) Increase her FiO_2?

b) Increase her PEEP?

c) Leave well enough alone?

Most of us would opt for increasing PEEP from 5 to 10 or even to 15cm H_2O? Our aim is to titrate PEEP to achieve the optimum result.

But what exactly is meant by "optimum" or "best PEEP"?

In most ICUs the measure of improvement would be an increased SpO_2 / SaO_2, but with the USCOM 1A we can do better. We can look at oxygen delivery (DO_2), in real time. The prime function of the heart and lungs is to deliver oxygen to the body, so why not measure it?

The right hand panel shows what happened when her PEEP was increased to 12cm H_2O. Although saturation certainly improved, this is not the only thing that matters. Whilst the SpO_2 has risen by a little over 10%, (with a commensurate rise in her PaO_2), the cardiac output (CO) has decreased by > 35%. The net result of this is that her DO_2 has fallen by 20%.
The pulse oximeter and arterial gases may suggest that she's better on the higher PEEP, but the USCOM 1A tells the real story. In fact, the 'optimum PEEP', in this patient, was just 5cm H_2O, a result that surprised us all.

Incidentally, if you also thought that the CO, cardiac index (CI) and Peak velocity (Vpk) were high, whilst Systemic Vascular Resistance (SVR) seemed low at 623, especially as she is 67 years old, then you were quite right. This is a classical high-output, low SVR septicemia.
What you weren't told is that increasing her PEEP from 5 to 12cm H_2O also dropped her blood pressure from 114/60 to 85/48, despite increasing her norepinephrine infusion rate from 400mcg/min to 700mcg/min.
We normally aim at a DO_2 of ≥12ml/kg/min. This patient weighed 68kg. The minimum DO_2 we would like to see is 816ml/min. On 5cm H_2O PEEP we can just about achieve this, but on 12cm H_2O we fall short. You may not be surprised to learn that her lactate level rose from 0.7 to 3.2 when the higher PEEP was used. Her tissue oxygenation was inadequate, despite the better SpO_2 / SaO_2!

Conclusion

The search for 'optimum PEEP' can be easy and rapid when you have the appropriate tools to measure the response to your manipulations. USCOM 1A told us the truth about her cardiopulmonary system.

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