pCO_2 gap

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Objectives

- Physiology
- Experimental data
- Clinical data
- Everyday use

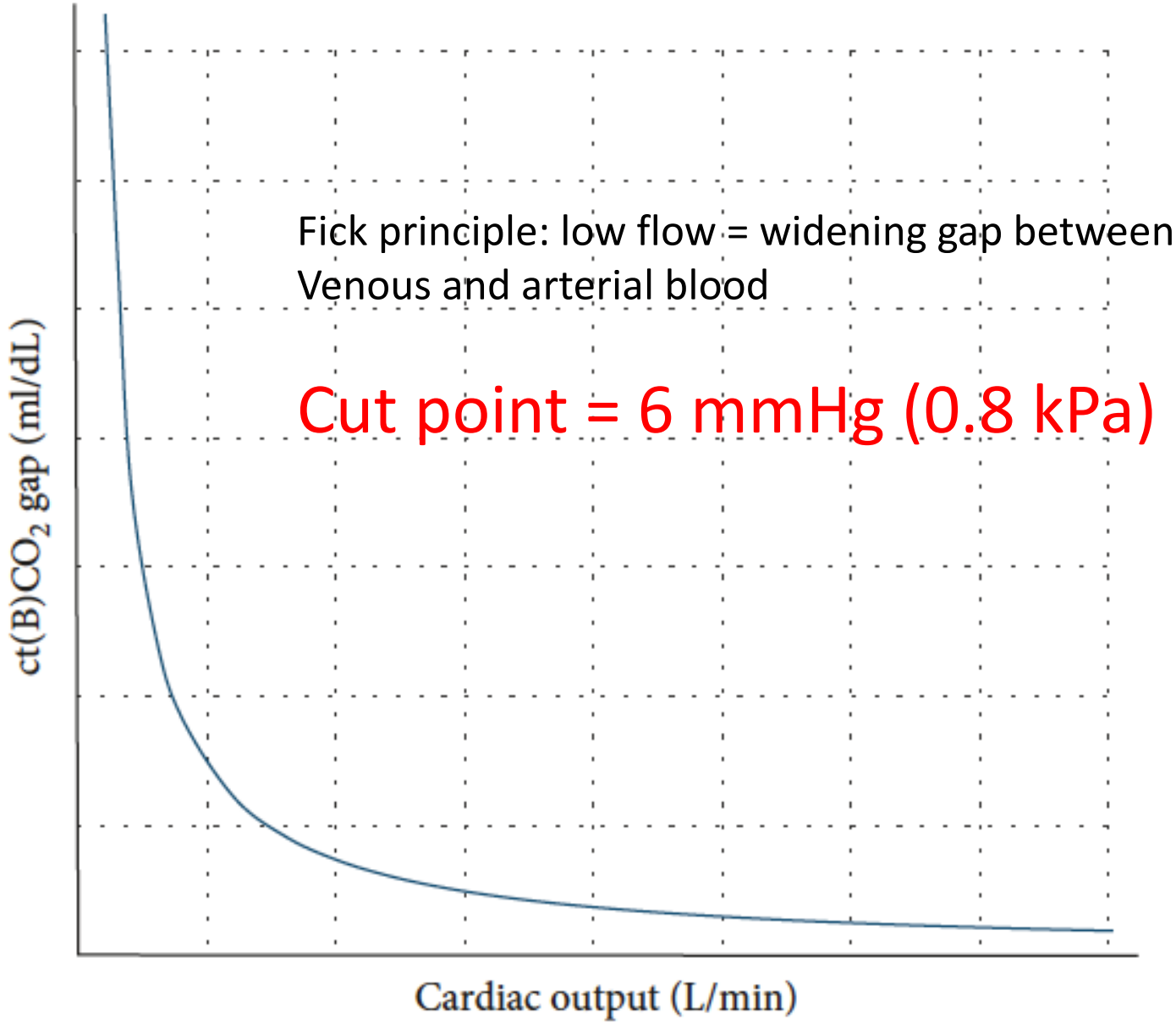
The Case

- Elderly man with good performance status
- Admitted after elective Whipples pro ampuloma
- Complicated procedure, 2L blood loss, multiple Pringles maneuvers

- O/E: A + B stable, major concern is lac 2.8…7.9mM and raising noradrenaline requirements (0.8 ug/ml), UO 60ml/min, echo: hypercontractile LV, PLRT negative, given 2xfluid challenges no effect
- CRT normal, ScvO2 71.3%, Hb 121 g/L

Back to basics

- Clinical signs
- Waveforms
- Echo + monitors
- Lactate
- Fick-principle derived indices
  - ScvO2
  - pCO_2 gap = $PcvCO_2 - PaCO_2$



Squara *Critical Care* 2014, **18**:579
http://ccforum.com/content/18/5/579

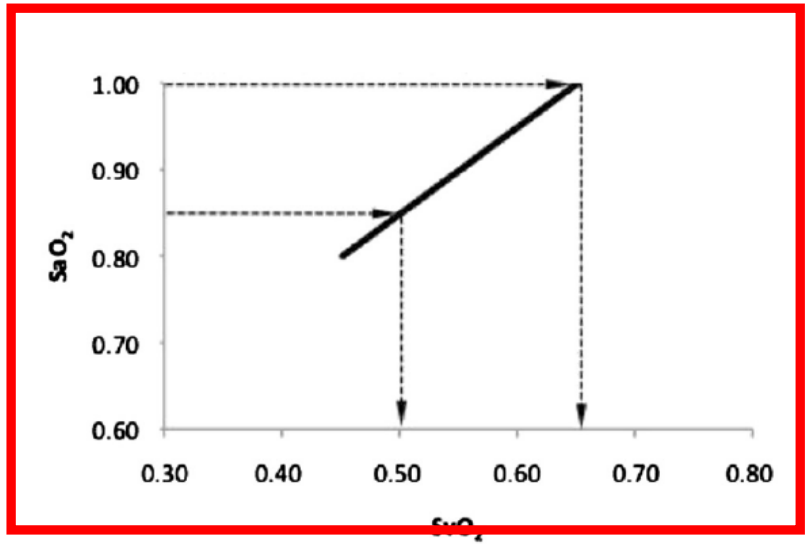
CRITICAL CARE

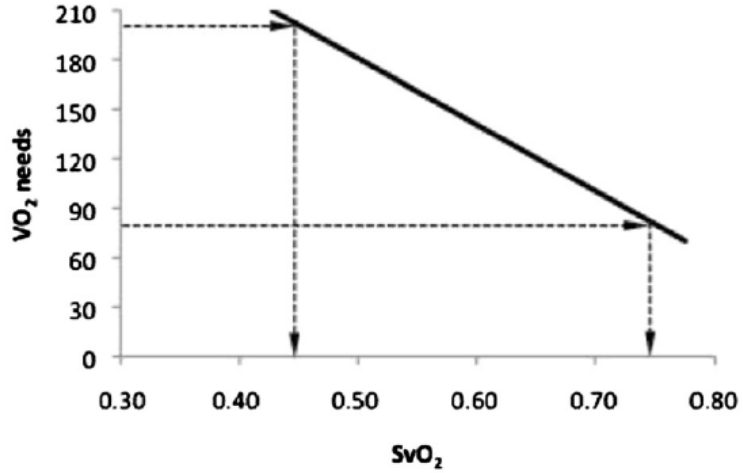
REVIEW

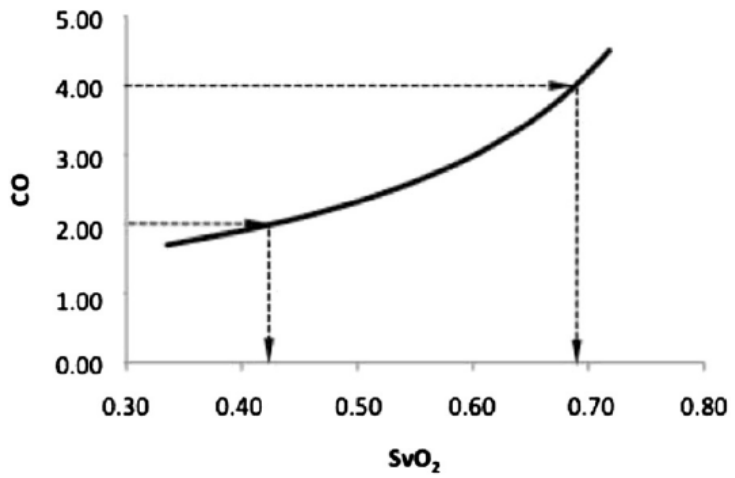
Central venous oxygenation: when physiology explains apparent discrepancies

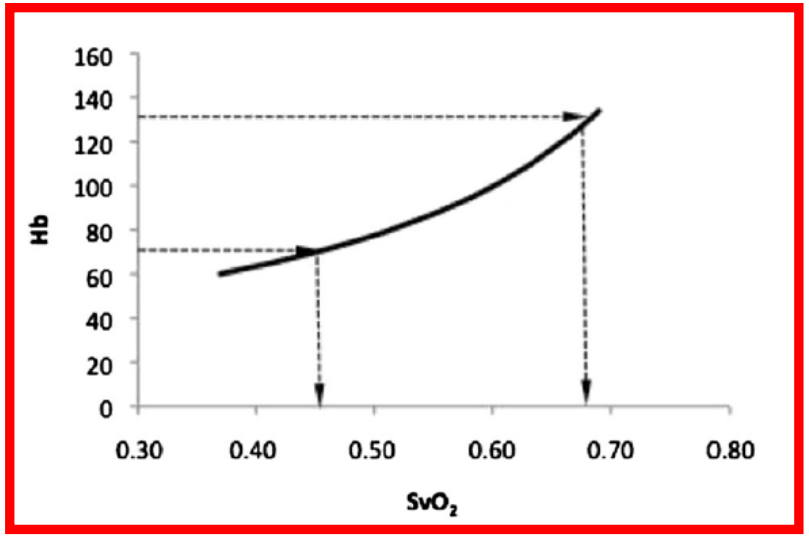
Pierre Squara

ScvO2 will depend on SaO2, Hb and in situations where an O_2 diffusion barrier exists (e.g. non-functional and obliterated capillaries)







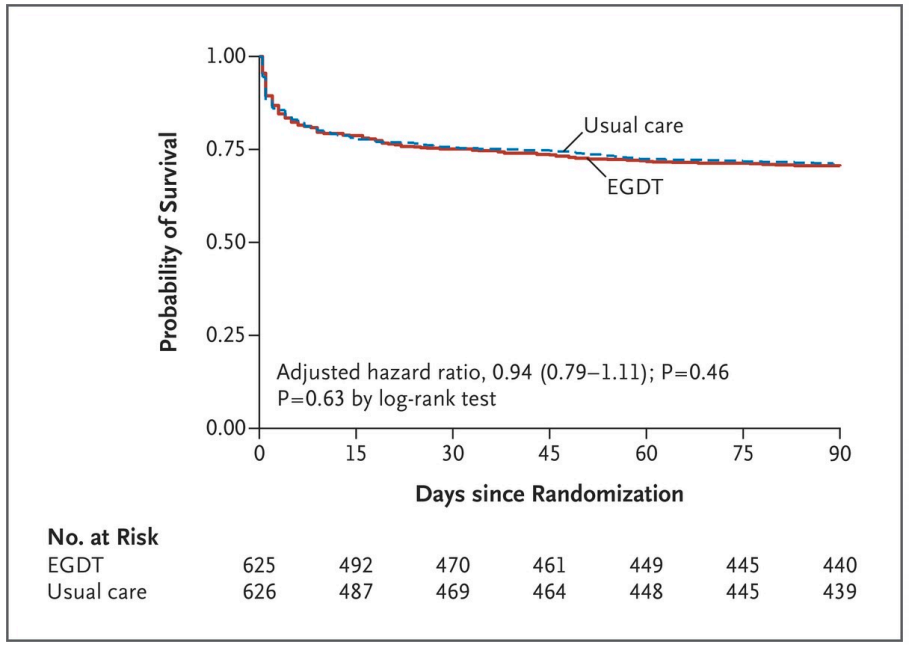


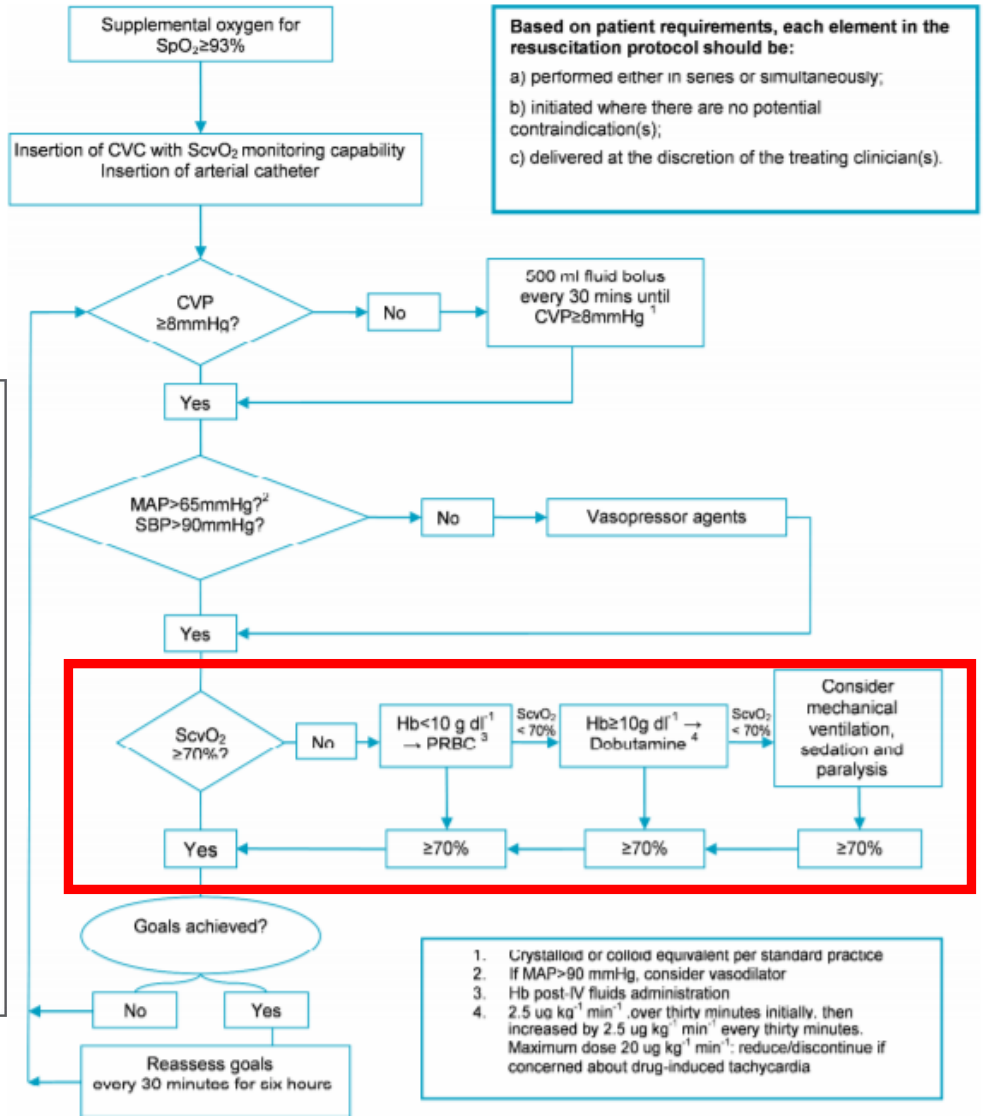
ProMISe Trial, NEJM 2015

ORIGINAL ARTICLE

Trial of Early, Goal-Directed Resuscitation for Septic Shock

Paul R. Mouncey, M.Sc., Tiffany M. Osborn, M.D., G. Sarah Power, M.Sc., David A. Harrison, Ph.D., M. Zia Sadique, Ph.D., Richard D. Grieve, Ph.D., Rahi Jahan, B.A., Sheila E. Harvey, Ph.D., Derek Bell, M.D., Julian F. Bion, M.D., Timothy J. Coats, M.D., Mervyn Singer, M.D., J. Duncan Young, D.M., and Kathryn M. Rowan, Ph.D., for the ProMISe Trial Investigators*





In patients with septic shock who were identified early and received intravenous antibiotics and adequate fluid resuscitation, hemodynamic management according to a strict EGDT protocol did not lead to an improvement in outcome.

Can pCO_2 gap outperform $ScvO_2$ in detecting low flow states?

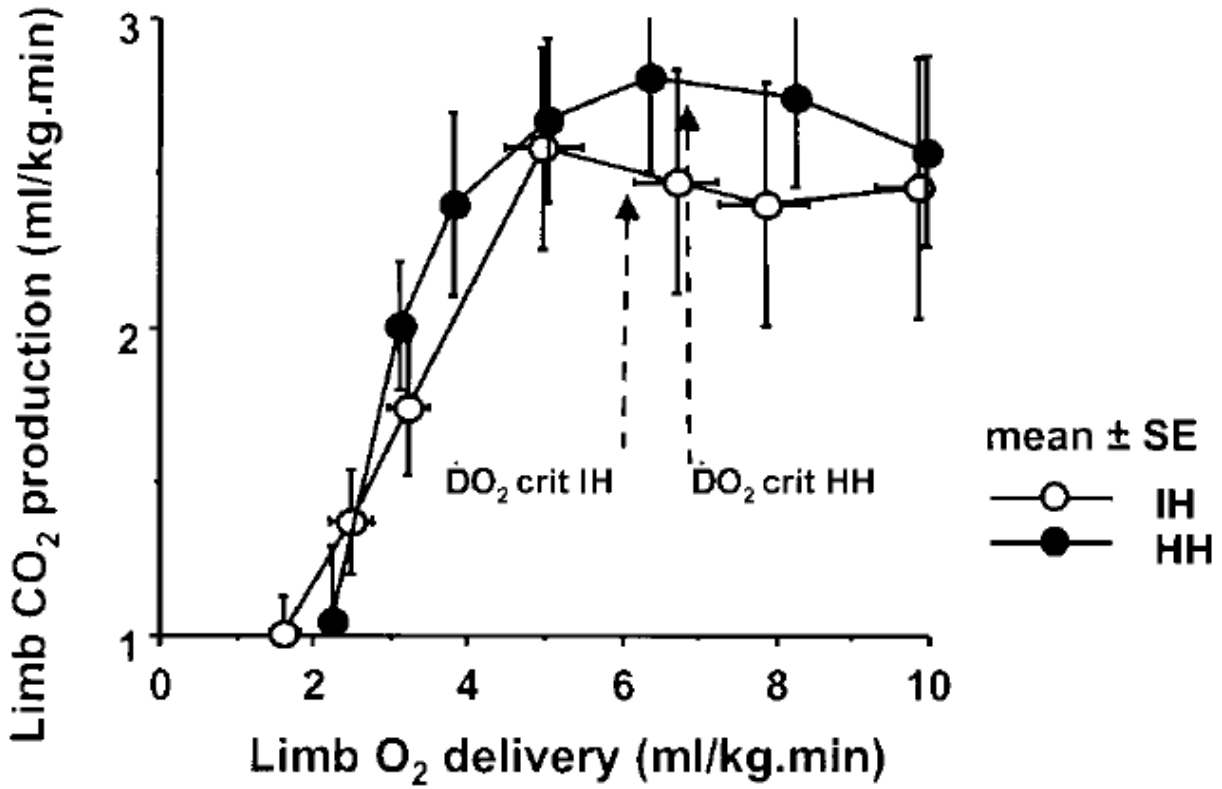
Physiology

- CO_2 production
  - Aerobic = decarboxylation Krebs cycle
  - Anaerobic = transient if ↓pH ”Coca-cola effect”
- RQ = VCO_2/VO_2
  - Normally depends on substrates oxidised
  - Oxygen limitation will also stop aerobic CO_2 production, but RQ will rise above one due to Coca Cola effect

Venoarterial CO_2 difference during regional ischemic or hypoxic hypoxia

J Appl Physiol
89: 1317–1321, 2000.

BENOIT VALLET,[1] JEAN-LOUIS TEBOUL,[2] STEPHEN CAIN,[3] AND SCOTT CURTIS[4]



Any type of tissue hypoxia will reduce CO2 production by the tissue (along with the reduction of oxygen use)

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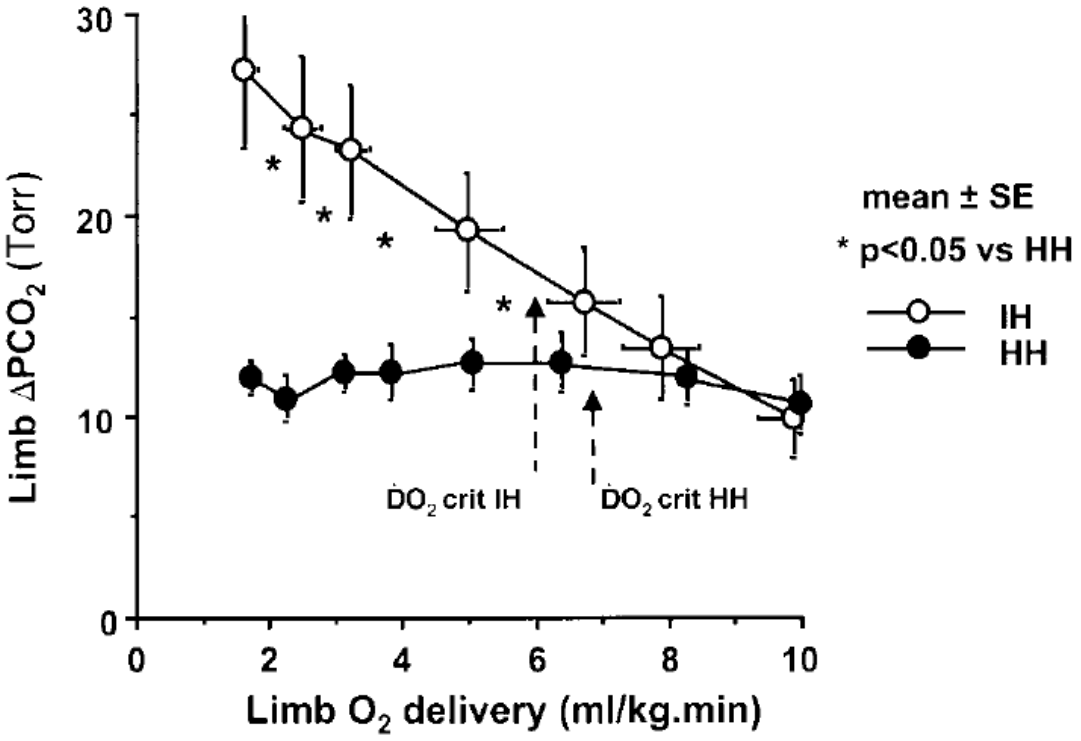
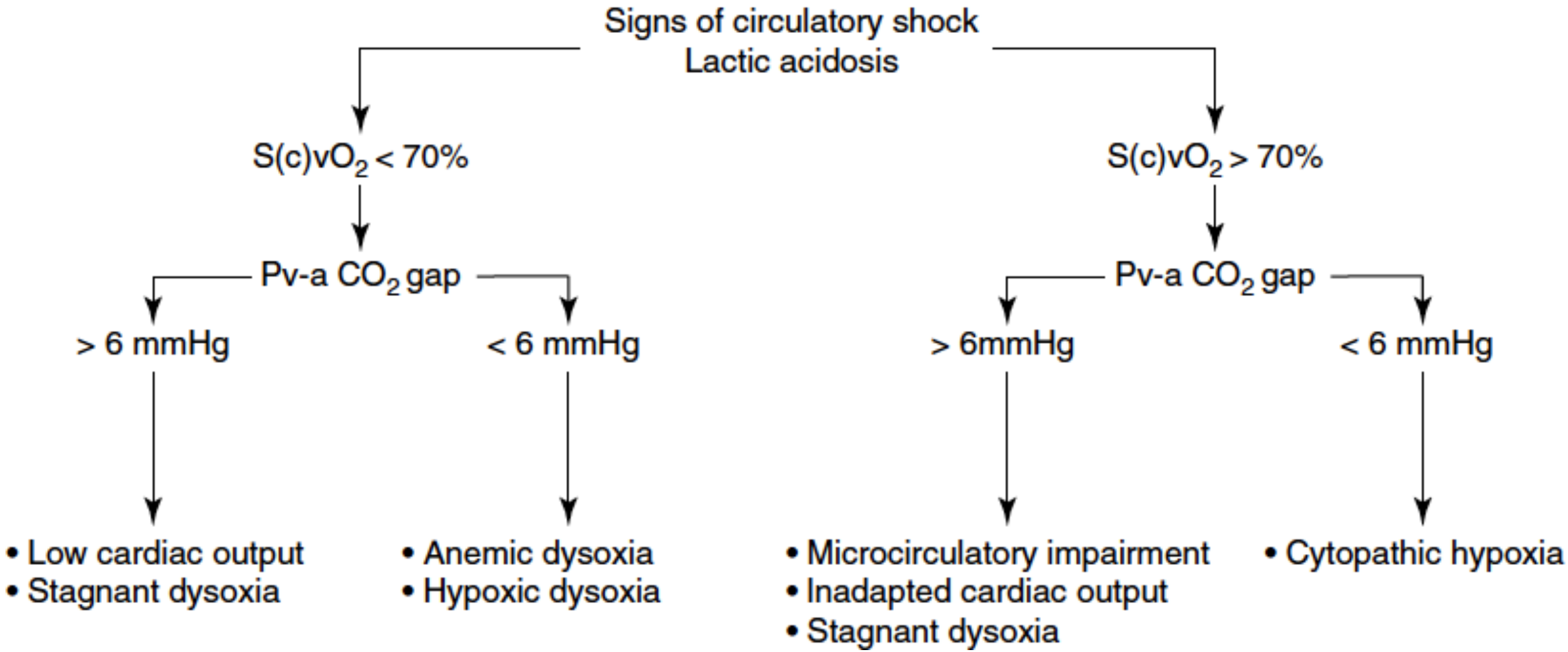


- ○ Ischaemic (stagnant) hypoxy
  - → high pCO2 gap
- ● Hypoxic hypoxy
  - → normal pCO2 gap

… pCO_2 gap = $PcvCO_2 – PaCO_2$
Is a marker of tissue blood flow, but not tissue hypoxy!



Ltaief *et al. Crit Care* (2021) 25:318

The Case

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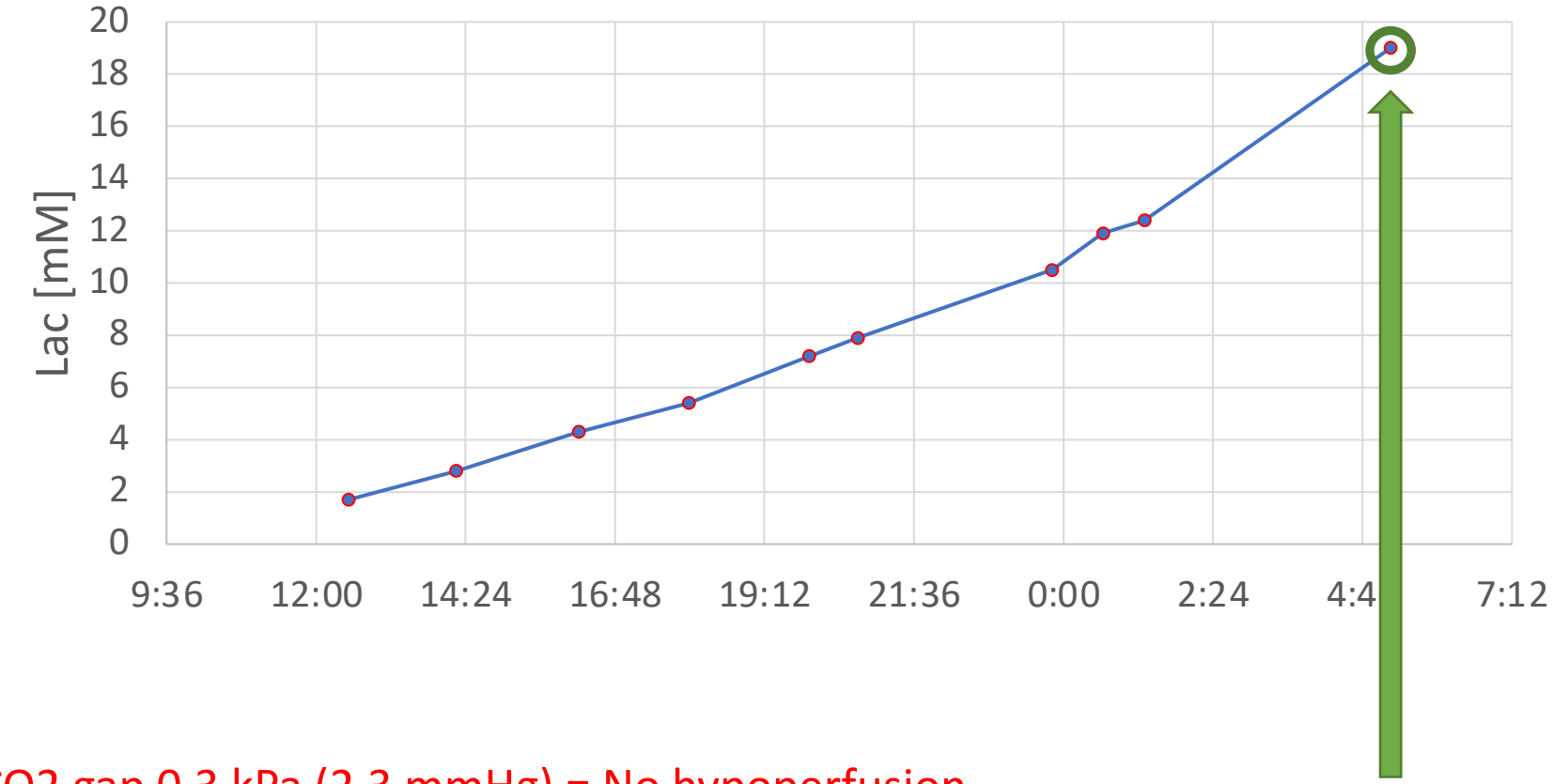
- CRT normal, ScvO2 71.3%, Hb 121 g/L
- pCO2 gap 0.3 kPa (2.3 mmHg) = no signs of tissue hypo

	OR		ICU							
Time	12:31	14:15	16:13	17:59	19:55	20:42	23:49	0:38	1:18	5:15
Laktát	1.7	2.8	4.3	5.4	7.2	7.9	10.5	11.9	12.4	19



pCO2 gap 0.3 kPa (2.3 mmHg) = No hypoperfusion

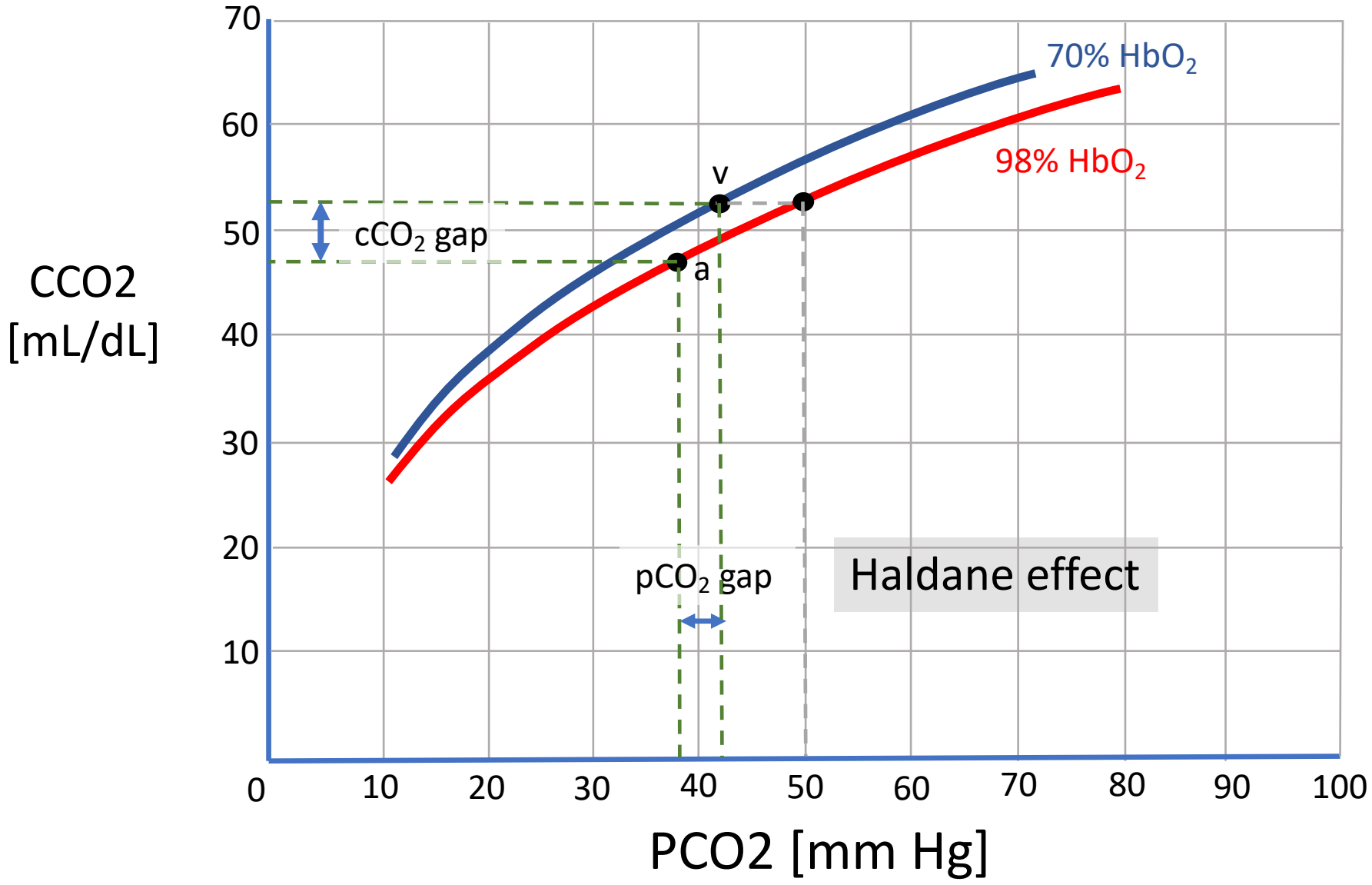
Cause was fulminant liver failure with reduced lactate clearance

What pCO_2 gap adds to $ScvO_2$ measurement?

- Helps to detect patients who might benefit from increasing cardiac output despite having ScvO2 > 70% (eg. microcirculatory shunts)
- Help to diagnose ”nonstagnant hyperlactatemia” and avoid futile fluid boluses

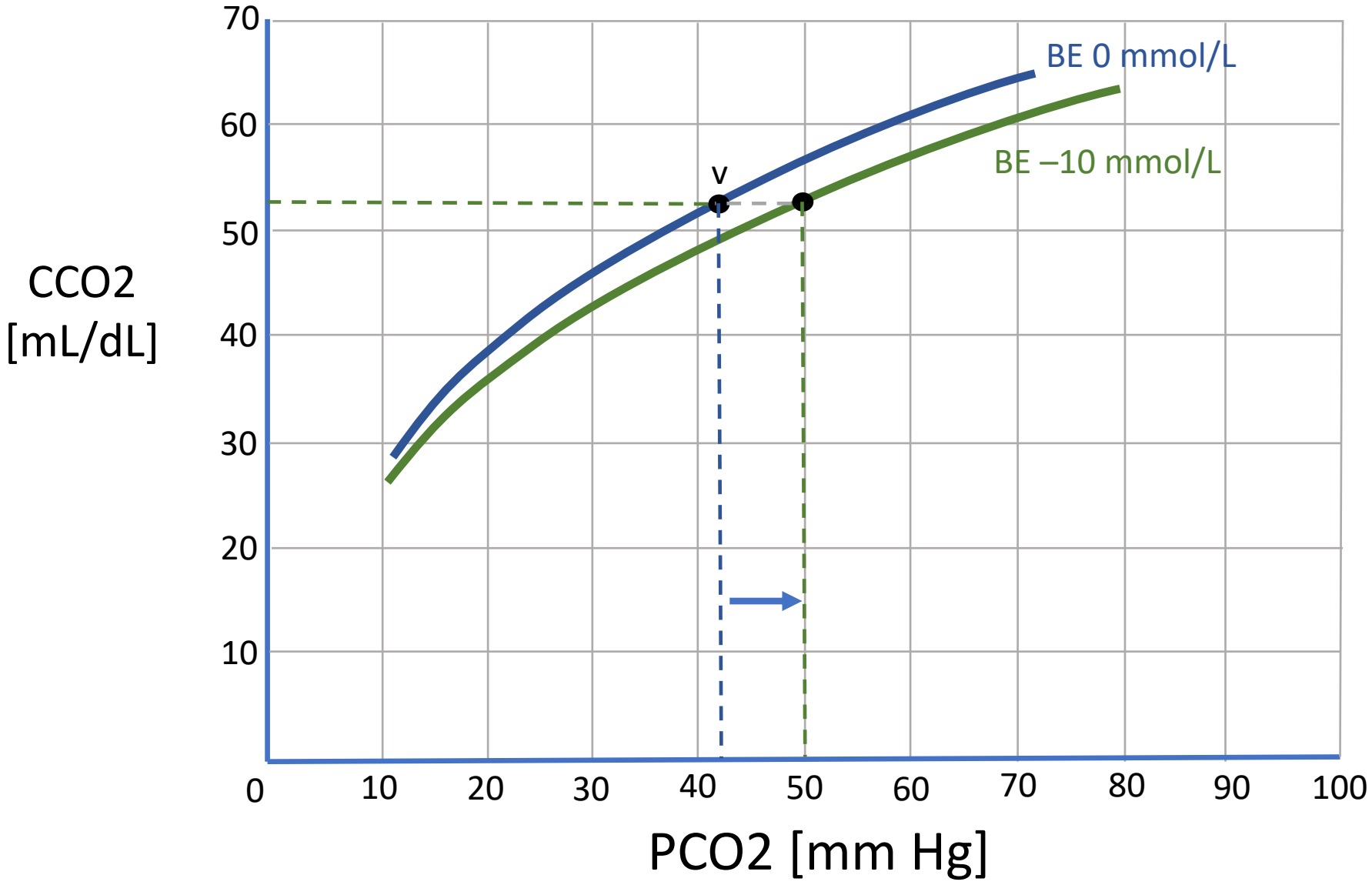
Pitfalls of pCO_2 use

Haldane effect: oxygenation of Hb enhances CO2 release



Coca-cola efect

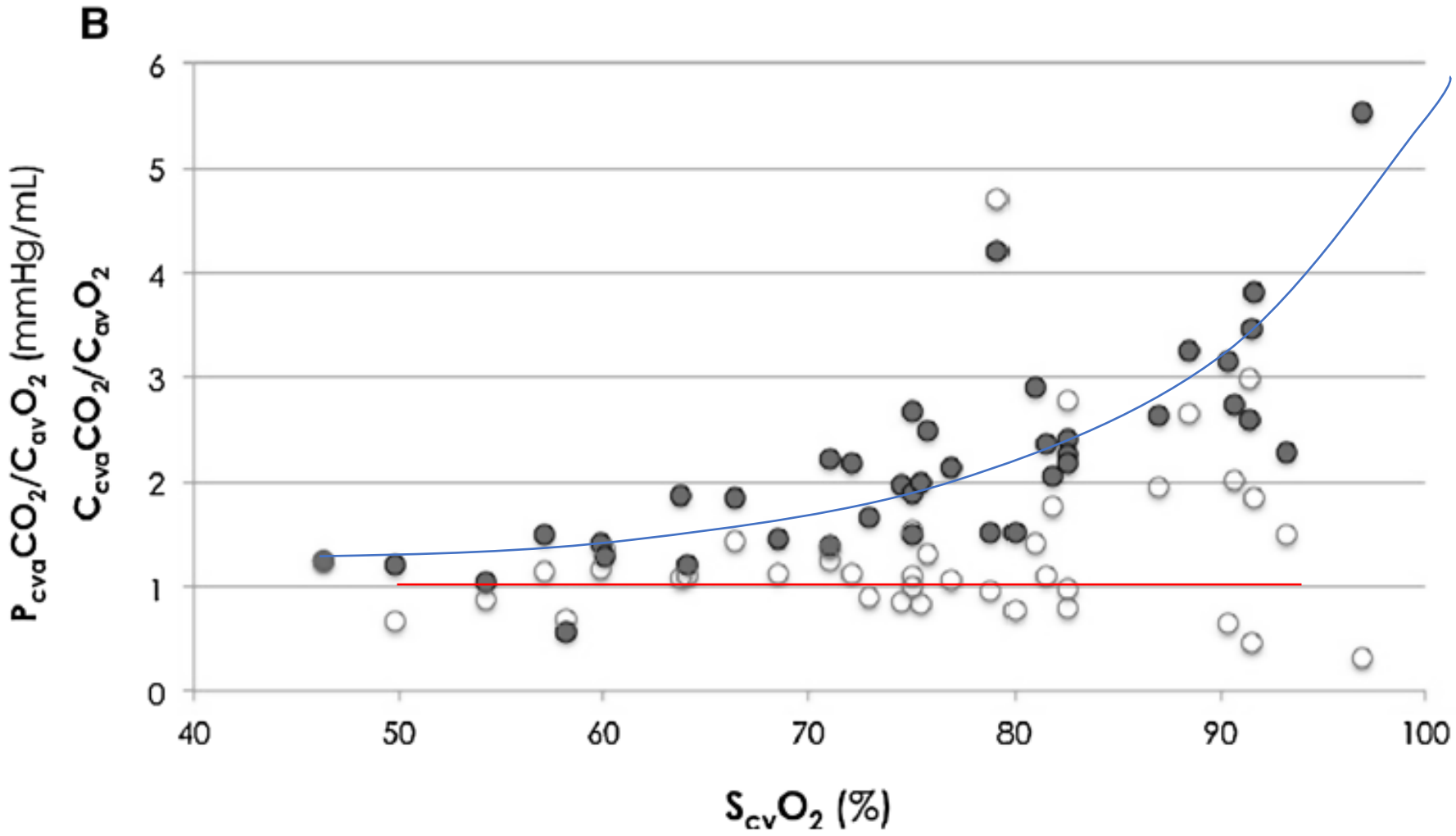
Tissue acidosis enhances CO_2 release



Pitfalls

- pCO2 gap is a surrogate for CCO2 gap and relation of pCO2 and CCO2 is not strictly linear
- Normally deoxygenation and mild acidification of the blood in tissues cancel out each other and pCO_2 vs. CCO_2 relation remains linear, but hyproxemia (e.g. FiO2) or respiratory alkalosis might cause false pCO_2 elevation

For constant flow, central venous hyperoxemia increases CO_2 gap



(Saludes et al. 2016)

Conclusions

- pCO_2 gap can help in the differential diagnosis of shock and/or hyperlactatemia
- Mind the gap before giving fluid for elevated lactate
  - pCO_2 gap >6 mmHg (0.8 kPa) seems to be a good marker of tissue hypoperfusion (fluids may help)
  - pCO_2 gap remains normal in aneamic, hypoxic and cytopatic hypoxia (fluids will not help)
- Interpretation should be cautious in hyperoxemia or respiratory alkalosis, which widen pCO2 gap artificially
- Now we need clinical trials and look at patient-centred outcomes

Thank you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