

$$\text{CPP} = \text{MAP} - \text{ICP}$$

Arterial transducer level –
A Variation in practice

Is There a Problem?

- ▶ In 2006 **M Ingram, R Lightfoot** and **A Eynon** from Southampton General Hospital, Southampton, UK conducted a multicentre survey
- ▶ 20 ICUs who cared for head injured patients placed the arterial transducer at heart level.
- ▶ 6 ICUs placed the transducer at head level

In 2008

- ▶ The practice at the Walton Centre for Neurology and Neurosurgery was to place the arterial transducer at head level
- ▶ This has been the case for over 12 years
- ▶ This was requested by neurosurgical teams

Head or Heart?

- ▶ In January 2007 I became Service Improvement Lead for ICU at the WCNN
- ▶ I work 7.5 hours a week for the Mersey and Cheshire Critical Care Network
- ▶ At last, there was time to sit down and examine our practices
- ▶ I was keen to start with the arterial transducer level when measuring CPP

A literature Search

- ▶ I found it nearly impossible to determine at which level researchers had placed transducers when conducting studies into CPP and outcome. Transducer level is never mentioned.
- ▶ There was little to describe CPP and transducer level specifically

The Facts

- ▶ It is recommended that CPP should be maintained at 60 – 70 mmhg
- ▶ If the arterial transducer is raised to head level, the forces exerted by hydrostatic pressure mean that the MAP will fall thus reducing the CPP reading
- ▶ The usual recommended head level is 30 degrees, but can be higher

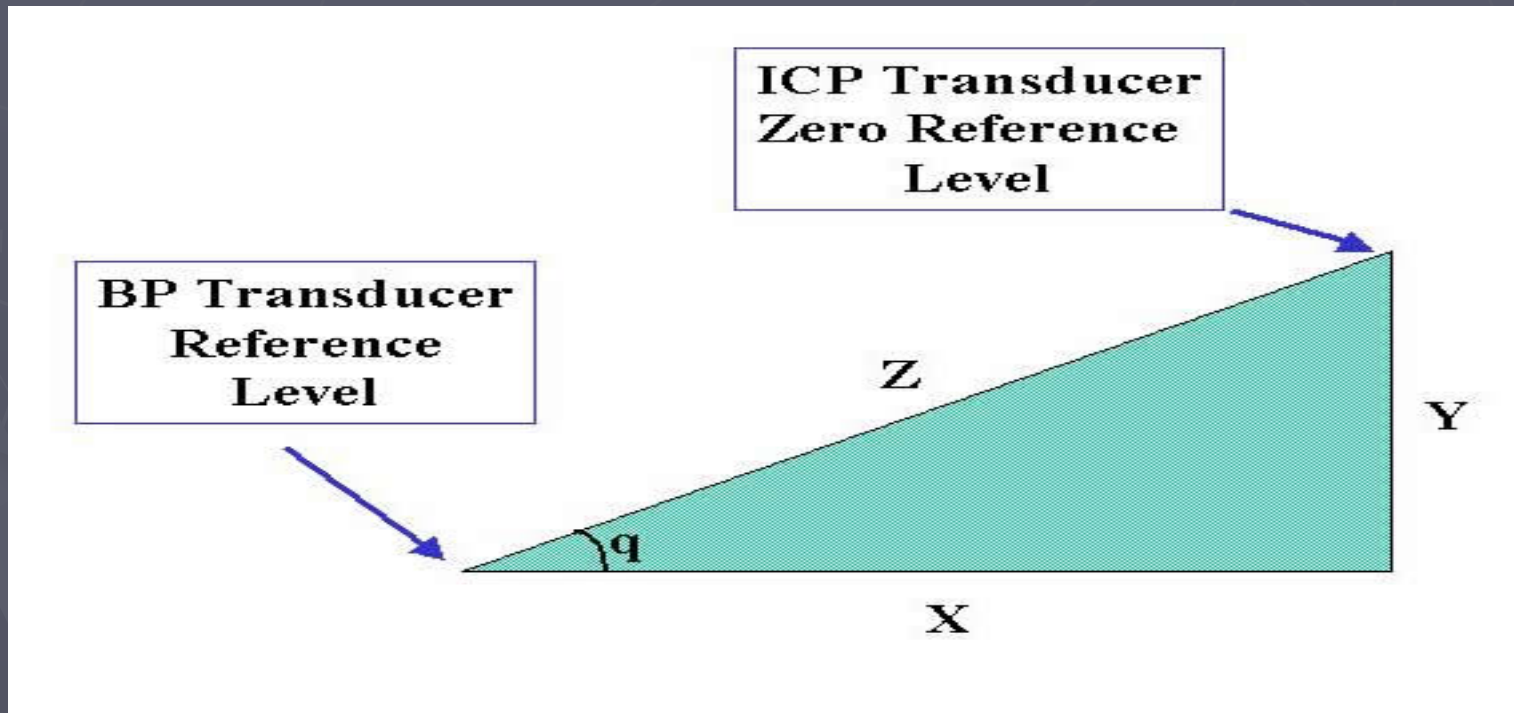
- ▶ In effect, this means that if there is a discrepancy between the BP and ICP zero reference level than this can cause the actual CPP to be under read by up to 15 mmHg.
- ▶ If centres are running trials and studies and using variable methods of measurement – how can the results be interpreted?

What difference does it make?

0.73 mm Hg change for each 1 cm H₂O in either direction.

- ▶ Clearly it is important to correct for this difference as two centres which purport to manage CPP at a level of 70 mmHg but who reference the BP transducer at different levels (mid ear vs mid chest) will in effect be comparing a CPP of 70 mmHg with that of 55 mmHg.

Example: For a typical head up tilt of 30 degrees from the horizontal and assuming a typical distance of 40 cm's for the distance "Z" (distance between heart and tip of intracranial ICP transducer). The calculated hydrostatic pressure column is $Z \sin 30 = 40 \times 0.500 = 20.0$ cm's long which, assuming $1.34 \text{ cm H}_2\text{O} = 1 \text{ mmHg}$, is equivalent to 14.9 mmHg.



The wrong treatment?

- ▶ If the CPP *was* being measured as 55 then treatment may be given –
- ▶ Inotropes
- ▶ Osmotic therapy
- ▶ Cooling
- ▶ Barbiturate
- ▶ Scan
- ▶ Surgery

Is it Just the UK?

- ▶ No!
- ▶ The USA has a problem with varying practices too
- ▶ A technology has been developed that directly measures the hydrostatic pressure gradient.

- ▶ The output of the device is used to automatically adjust the CPP value for the hydrostatic pressure gradient.
- ▶ Such a technology is currently being developed by the BrainIT group in the USA

Having read the Southampton study

- ▶ I conducted a postal survey of 15 centres
- ▶ 4/15 still used head level for the MAP reference point.
- ▶ Little had changed since 2006
- ▶ At the WCNN, we had to determine best practice

HOSPITAL	HEAD LEVEL	HEART LEVEL
wcnn	XXXXXXXXXXXX	
Manchester	XXXXXXXXXXXX	
Preston		XXXXXXXXXXXX
Newcastle		XXXXXXXXXXXX
Edinburgh		XXXXXXXXXXXX
Glasgow	XXXXXXXXXXXX	
Leeds		XXXXXXXXXXXX
Addenbrookes		XXXXXXXXXXXX
Queen's Sq		XXXXXXXXXXXX
Portsmouth	XXXXXXXXXXXX	
Southampton		XXXXXXXXXXXX
John Radcliffe		XXXXXXXXXXXX
Bristol		XXXXXXXXXXXX
Birmingham		XXXXXXXXXXXX
Belfast		XXXXXXXXXXXX

I e-mailed researchers

- ▶ Dear Helen
- ▶ In addition to the advice below from James, I have found a paper which has addressed this very question in detail. The results, albeit in an animal (porcine) model, support the view that the transducer should be placed at the level of the heart, irrespective of the patient's position and translates to the issues you raise in a critical care patient.

I e-mailed researchers

- ▶ In summary, standard practice is that invasive pressure measurement is done with the transducer at heart level. While there may still be minor variations due to actual location of the arterial cannula, these are usually not significant.
- ▶ Placing the transducer level at any other place will, strictly speaking, invalidate the readings because these transducers are calibrated by manometry or fixed pressure devices that are themselves calibrated by manometry

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Invasive Arterial BP Monitoring in Trauma and Critical Care* Effect of Variable Transducer Level, Catheter

Access, and Patient Position

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Schiller, MD; David E. Carney, MD;
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The important findings to be emphasized from this study are:

- (1) that valid arterial BP measurements are obtained only when the transducer is placed at the level of the aortic root, and
- (2) That direct arterial BP measurement is independent of catheter access site and patient position if the transducer is at the proper level. In other words, a patient may be in any position, with a catheter in any artery, and the clinician will be able to obtain a valid arterial BP as long as the transducer is level with the aortic root.

Inotropes

If the MAP falls and the CPP falls,
inotropes are used to raise the
MAP

Use of Inotropes

- ▶ Inotropes can cause ARDS, Organ failure (a study recently also linked noradrenaline with the development of micro-clots in the brain which cause ischaemia)
- ▶ Our patients with their transducers at head level were being given larger doses of noradrenaline

So what did the WCNN decide?

- ▶ A debate ensued involving the MDT teams
- ▶ We decided to lower the transducers to heart level

What Next?

- ▶ All research should state at which level the transducers are placed as this is a significant variable
- ▶ All Centres should follow the same practice
- ▶ Neuroscience benchmarking
- ▶ Development of a Neuro Critical Care Network (on going)

Standardisation of Practice

A Common Approach

All ICUs who care for head injured patients should be measuring values using the same methods

Any Questions?

Helen Jones

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