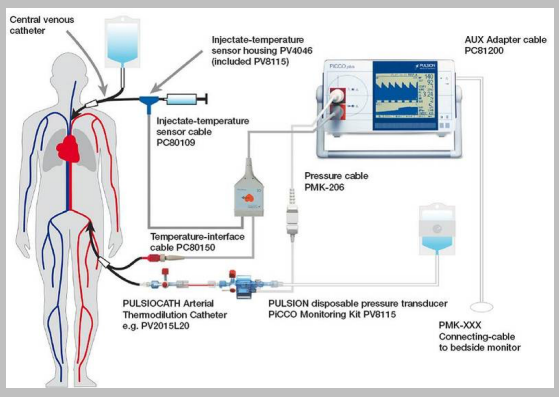
Guidelines for Advanced Haemodynamic Monitoring: PiCCO

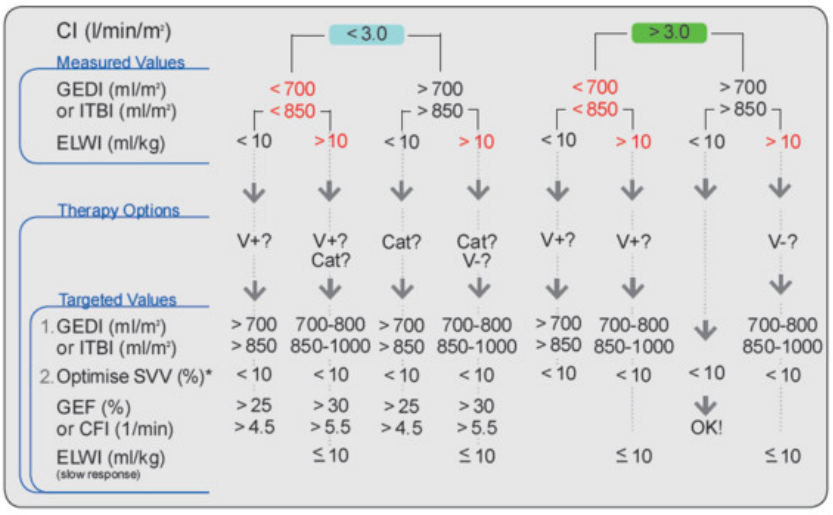
Insert PiCCO catheter



Connect lines and set up monitor

Perform thermodilution and discuss with medical team

This decision model is not obligatory. It cannot replace the individual therapeutic decisions of the treating physician.



V+ = volume loading V- = volume reduction Cat = catecholamine / cardiovascular agents
*SVV is only applicable in fully ventilated patients without cardiac arrhythmia

CONTENTS

1. INTRODUCTION

Background

The following devices are available for advanced haemodynamic monitoring on BSUH Critical Care units:

1. Oesophageal Doppler
2. PiCCO2 – Pulse Contour Cardiac Output Monitoring
3. Pulmonary Artery Catheterisation and Vigilance monitor

The following suggestions help clarify the use of the different devices within critical care:

- Oesophageal Doppler – device for simple intra-operative and early post operative fluid management.

- PiCCO2 – invasive monitoring for those patients who are acutely unwell and have more complex fluid management problems, and those patients requiring vasoactive drug doses > 0.2mcg/kg/min, or more than two vasoactive agents.

- PA Catheter – less commonly used, invasive monitoring indicated for patients requiring measurement of the cardiac output or pulmonary artery pressures, or those with a contraindication to other methods

Theory

PiCCO is a method used to monitor a patient's cardiac output. It uses a specialised arterial line and a central line. Pulse contour analysis assumes that the contour of the arterial waveform is proportional to the cardiac stroke volume. The device employs a cold thermodilution to calibrate the cardiac output, and from this, derives various indices of cardiac function and fluid status. It may give inaccurate readings in the following scenarios:

- intracardiac shunts
- aortic aneurysm
- aortic stenosis
- pneumonectomy
- pulmonary embolus
- in the presence of a balloon pump and in unstable arrhythmias

2. PROCESS

Catheter Insertion

Recommendation (Action)	Justification (Rationale)
The procedure for insertion requires full aseptic technique, as for central venous cannulation.	The technique for insertion uses the Seldinger technique, with the PiCCO cannula being inserted over a guide wire.
It is recommended for trainees that you have inserted at least one device supervised, before performing the technique without supervision.	The PiCCO arterial line can be difficult to insert,
It should be noted that the guide wires are quite fine, and can kink easily.	If this occurs, there are separately packaged guide wires which can be opened as the whole kit is expensive
The arterial catheter can be inserted into either the brachial or femoral artery	A 16cm catheter is used for the Brachial artery and a 20cm catheter for the Femoral. 22 cm catheters can be used in either.

Set Up

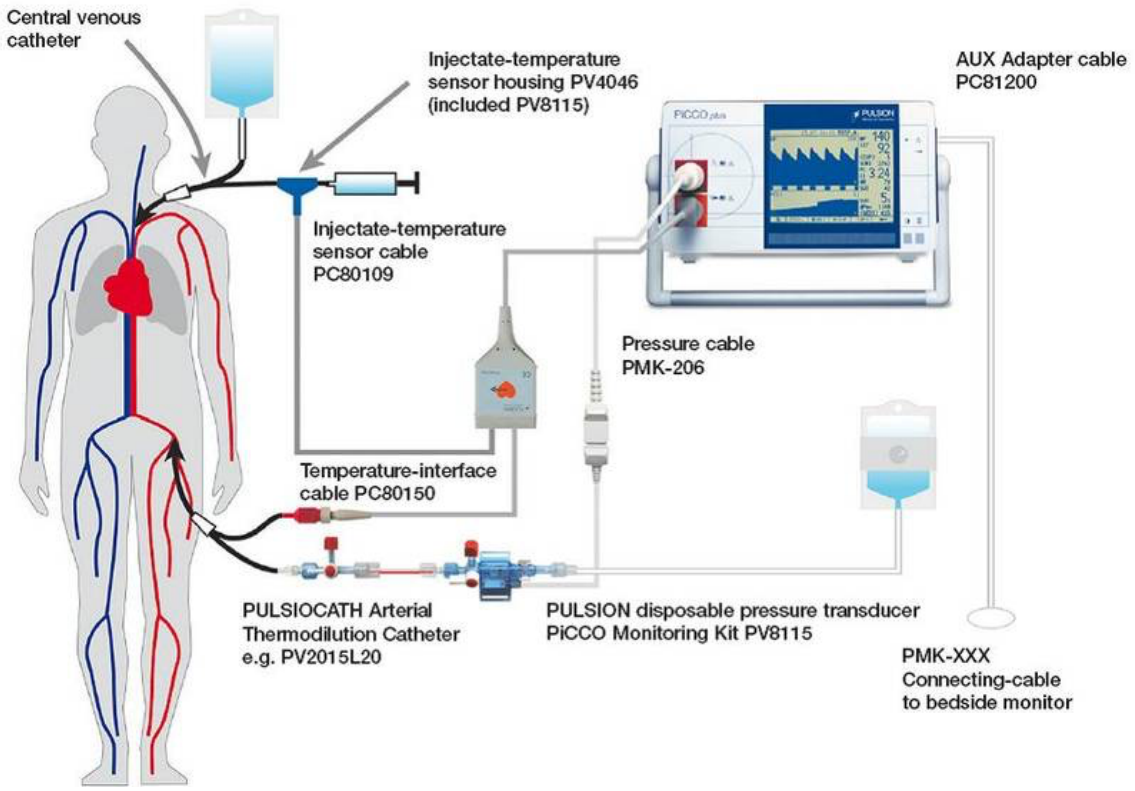
Equipment Required to Set up System

PiCCO2 monitor
Central venous catheter (CVC)
Arterial thermodilution catheter set
1 x 500ml 0.9% sodium chloride transducer bags for both PiCCO line and arterial line (ensure transducer zeroed before performing cardiac output studies).
Injectate temperature sensor (attached to CVC on distal lumen.)
Temperature interface cable (attached to arterial line probe) and Injectate temperature sensor cable (attached to injectate sensor on CVC).
Iced saline ready for injection (<11^{o}C)
3x 20ml syringes.
Sterile field
PDE cleaning cloth for devices.
Arterial line ‘splitter’ cable
Red 3 way tap

Recommendation (Action)	Justification (Rationale)
Turn on the PiCCO2 monitor	 The monitor performs a self test.
Confirm “new patient”	Enter patient specific data: *actual* patient body weight, the correct height (use a tape measure), gender and adult mode. Input the name and patient ID number.
Once the arterial catheter is inserted, connect to arterial line transducer.	Attach AP temperature interface cable, from side of monitor, to arterial line, an arterial waveform should appear on the PiCCO2 monitor. (See Figure 1 and Appx A)
Slave the PiCCO2 monitor to the bedside monitor via the IP2 port in the splitter cable.	You will get an extra pressure wave on the bedside monitor called either CVP or LA 3 or 4. Now change the name of the extra pressure waveform to Art line. It will then appear on the monitor as Art 3 or Art 4. For the time being keep both the PiCCO and original arterial traces on the monitor.
Connect the 3 way tap to the distal end of the CVC line	Do not put a needle free connector onto the brown port as this increases the pressures needed for thermodilution. Do not put needle free connectors onto any port of the 3 way tap. The CVP line should be connected to the 3 way tap. The injectate temperature sensor attaches to the 3rd port of the 3 way tap so that it sits at right angles the CVP line. Put a needle free connector on the end of this. Attach injectate temperature sensor cable (attached to blue injectate sensor) onto CVC.
Select Zero adjustment screen →0← .	Zero on the PiCCO first (after opening the transducer to air) and then zero the bedside monitor. Enter the CVP reading on this page from the monitor.
Press the TD button (bottom left) to go to the thermodilution screen.	Perform a minimum of 3 initial thermodilution measurements to calibrate the device and obtain the static parameters (see thermodilution technique below). Press exit once finished to go to the main monitoring screen.

Recommendation (Action)	Justification (Rationale)
You can remove the standard 'old' arterial line if the patient has one	When you are confident that the PiCCO arterial line values are accurate.

Figure 1.PiCCO set up



PiCCO Thermodilution

Recommendation (Action)	
Draw up 3x syringes with ice cold 0.9% sodium chloride separately before injecting	Use 0.9% sodium chloride from the fridge(needs to be 3-8°C) and rest it on an ice pack at the bedside to maintain the injectate temperature.
Flush the CVP line with 5mls cold saline before starting the thermodilution procedure to get rid of any warm fluid in the line.	Thermodilution works by measuring the temperature difference between the cold bolus into the CVC line and the thermistor tip on the end of the arterial line, so it relies on having minimal warm admix.
Press CO button on PiCCO block to initiate cardiac output studies.	

Recommendation (Action)	
Check reference numbers tally on the arterial probe sensor and the monitor.	
Insert patient's height and weight and state injection volume:	
Stop any fluids running through CVC and close 3-way port to the transducer (take note of CVP reading prior to closing).	This will interfere with the reading
Injection time should be <7secs.	
The ΔT (temperature difference between CVC and arterial sensor) should be >0.2.	If it is <0.2 you need colder solution to get accurate figures. You may need more than 3 readings to achieve this.
Ensure all readings within 20% each other	(if not reject and perform new reading)
Record results on Advanced CVS tab on CIS.	
Following initial calibration, a thermodilution should be performed to assess responsiveness to treatment	For example fluid challenges or alterations in inotropes / vasoactive drugs.
A thermodilution is recommended at least once every 8 hours	This calibrates the PiCCO
Ensure arterial/ CVC line not kinked/ blocked and zeroed	PiCCO readings rely on accurate arterial/ CVC waveforms/ readings.

Basic Troubleshooting

Information bar display		
Error Message	**Cause**	**Remedy**
Invalid / Faulty catheter - Change catheter	Faulty catheter, not compatible or not connected	Connect compatible catheter
Unknown catheter - Enter ACC	Unknown catheter type with unknown resistor	Enter ACC in corresponding field
Injection Error - Repeat injection, rapid and smooth	Injection not smooth	Repeat injection rapidly and smoothly
Injectate Temp. Sensor Error - Check sensor cable and sensor housing	Defective injectate temp. sensor or sensor cable	Check and replace if necessary
Injection Error - Inject faster than 10 s	Time of injection longer than 10 seconds	Repeat injection rapidly and smoothly
TD Curve Error - Stabilize patient temperature and repeat injection	Calculation error of MTt / DSt caused by temperature interferences	Eliminate interference and repeat injection
Baseline Error - Stabilize patient temperature and repeat injection	Large temperature variations detected	Eliminate temperature variations and repeat injection
Time Out - Repeat fast injection with cold injectate	Thermodilution curve not finished within 90 seconds, possibly very high EVLW with low CO	Repeat injection with cold and/or more injectate, if necessary stabilize patient
Error: Injectate too warm	Injectate temperature above blood temperature	Use colder injectate (< 24°C)
Warning: Injectate too warm	Tinj>26°C	Use colder injectate (< 24°C)
ΔT small - Use more and/or colder injectate	$\Delta T < 0.1$ °C	Use more and/or colder injectate
Invalid PCCO Calibration - Check AP signal and repeat injection	Implausible arterial pressure signal, signal interferences	Eliminate possible interferences and repeat injection

More information can be found in the this link to the PiCCO Operators Manual .

3. GLOSSARY

See Appendix B

4. REFERENCES AND ONLINE RESOURCES

Maquet website

PiCCO learning package

King D and Price A. Measuring cardiac output using the PiCCO system. British Journal of Cardiac Nursing. Nov 2008;3:11. 2.

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Chew MS, Aneman A. Haemodynamic monitoring using arterial waveform analysis. Current Opinion in Critical Care. June 2013;19:234-41

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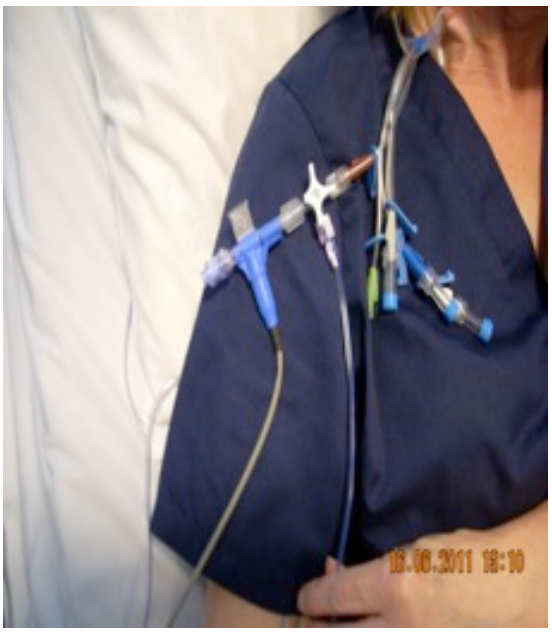
APPENDIX A

How to connect to a CVC

A

B



How to connect to an arterial line

Arterial and CVC Attachment

Cardiac Output Lead Attachment

APPENDIX B

Flow:

- CO (Cardiac Output) - Volume of blood pumped by heart in 1x minute.
- CI (Cardiac Index) - Cardiac Output indexed to body surface area.
- SV (Stroke Volume) - Volume pumped by the heart in one heart beat.
- SVI (Stroke Volume Index) - Stroke volume indexed to body surface area.
- **Normal range**: CI: 3.0- 5.0 l/min/m^2
  SVI: 40-60 ml/m^2

Preload:

- Volume of blood in the heart (or amount of stretch of cardiac muscle fibre) at the end of diastole.
- GEDV (Global End-Diastolic Volume) - Filling volume of all four-heart chambers.
- GEDI (Global End-Diastolic Volume Index) - GEDV indexed to predicted body surface area.
- ITBV (Intra Thoracic Blood Volume) - Filling volume of all four heart chambers and pulmonary blood volume.
- ITBI (Intra Thoracic Blood Volume Index) - ITBV indexed to predicted body surface area.
- **Normal Range**: GEDI: 680-800 ml/m^2
  ITBI: 850-1000 ml/m^2

Volume Responsiveness:

- SVV (Stroke Volume Variation) - Changes in stroke volume over the respiratory cycle.
- **Normal range**: SVV: <10%

Afterload:

- Resistance the heart has to overcome to eject blood.
- SVR (Systemic Vascular Resistance) - Resistance to flow to be overcome to push blood through the circulatory system.
- SVRI (Systemic Vascular Resistance Indexed) - SVR indexed to body surface area.
- **Normal Range**: SVRI : 1700-2400 dyn/sec/cm^{-5}/m^2

Contractility:

- Performance of the heart muscle.
- dPmx (Parameter of the left heart contractility)- Maximum pressure increase in the aorta (P_{max}/t).
- GEF (Global Ejection Fraction)- Global cardiac contractility parameter.
  - Global stroke volume divided by global end-diastolic volume (GEF = 4x SV/ GEDV)
- CFI (Cardiac Function Index)- Parameter of the global cardiac contractility
  - Fraction of the preload volume pumped in one minute.
  - Cardiac output divided by global end-diastolic volume (CFI = CO/GEDV)
- **Normal range**: GEF: 25-35%
  CFI: 4.5-6.5 1/min

Lung Function:

- EVLW (Extravascular Lung Water) - Direct and easy quantification and monitoring of lung oedema. Includes intra-cellular, interstitial and intra-alveolar water (not pleural effusion).
- ELWI (Extravascular Lung Water Index) - EVLW indexed to predicted body surface area.
- PVPI (Pulmonary Vascular Permeability Index)- Differentiation of the origin of pulmonary oedema (permeability or cardiogenic)
    - Relation between extra- and intra-vascular fluid (PVPI = EVLW/PBV (Pulmonary blood volume.
- **Normal range**: ELWI: 3.0-7.0 ml/kg
  PVPI: 1.0-3.0 (hydrostatic lung oedema)
  PVPI: >3.0 (Permeability lung oedema)