Measuring central venous pressure

Cole E (2007) Measuring central venous pressure. *Nursing Standard*. 22, 7, 40-42.
Date of acceptance: April 4 2007.

Summary

Central venous pressure measurement is often associated with intensive and critical care settings. However, with increasing numbers of critically ill patients being cared for on medical and surgical wards, it is essential that nursing staff are able to record central venous pressure measurement accurately and recognise normal and abnormal parameters as highlighted in this article.

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Keywords

Central venous pressure; Manometer system; Transducer system

These keywords are based on the subject headings from the British Nursing Index. This article has been subject to double-blind review. For author and research article guidelines visit the *Nursing Standard* home page at **www.nursing-standard.co.uk**. For related articles visit our online archive and search using the keywords.

BLOOD FROM systemic veins flows into the right atrium via the inferior and superior vena cava. The pressure in the right atrium is known as central venous pressure (CVP). The benefits of measuring CVP include the ability to:

- Monitor central intravascular blood volume and assess whether the patient is dehydrated, overhydrated or hypovolaemic.
- Measure the effectiveness of intravenous (IV) fluid therapy.
- Assess right-sided heart failure.

Many patients with such problems are nursed in general wards; it is essential therefore that CVP is measured and interpreted accurately. The condition of the patient and the treatment being administered determine how often CVP measurement should take place, for example, critically ill unstable patients may need hourly measurements.

Central venous pressure measurement

CVP is measured using an indwelling central venous catheter (CVC) and a pressure manometer or transducer (Figures 1 and 2). Available resources will dictate which method is used, for example, accident and emergency departments, high dependency units and intensive therapy units have transducers, whereas wards generally use manometers. Both methods are reliable when used correctly.

Nursing staff must be familiar with the equipment being used to ensure accurate readings and provide patients with appropriate care. There are a variety of sites where a CVC may be inserted, depending on the patient's condition, the procedure or treatment and the experience of the medical staff inserting the device. Ultrasound may be used to guide CVC insertion (National Institute for Clinical Excellence 2002, Wiklund *et al* 2005). Insertion sites include:

- Internal jugular veins – this site is chosen frequently as there is a high rate of successful insertion and a low incidence of complications such as pneumothorax (Woodrow 2002). Internal jugular veins are short, straight and relatively large allowing easy access, however, catheter occlusion may occur as a result of head movement and may cause irritation in conscious patients.
- Subclavian veins – this site is often chosen as there are more recognisable anatomical landmarks, making insertion of the device easier (Jevon and Ewens 2007). Because this site is positioned beneath the clavicle there is a risk of pneumothorax. A subclavian CVC is generally recommended as it is more comfortable for the patient (Woodrow 2002).
- Femoral veins – this site provides rapid central access during an emergency such as a cardiac arrest. As the CVC is placed in a vein near the groin there is an increased risk of associated infection. In addition, femoral CVCs are reported to be uncomfortable and may discourage the conscious patient from moving (Woodrow 2002).

CVP is usually recorded at the mid-axillary line where the manometer arm or transducer is level with the phlebostatic axis (Woodrow 2002). This is where the fourth intercostal space and mid-axillary line cross each other allowing the measurement to be as close to the right atrium as possible (Figure 3).

Using a manometer Many general wards and units use a manometer to measure CVP. This system is easy to use once staff have been trained appropriately and it allows intermittent, hourly measurements to be recorded (Figure 1) (Jevon and Ewens 2007):

1. Explain the procedure to the patient to gain informed consent.

2. If IV fluid is not running, ensure that the CVC is patent by flushing the catheter.

3. Place the patient flat in a supine position if possible. Alternatively, measurements can be taken with the patient in an upright or semi-upright position. The position should remain the same for each measurement taken to ensure an accurate comparable result.

4. Line up the manometer arm with the phlebostatic axis ensuring that the bubble is between the two lines of the spirit level.

5. Move the manometer scale up and down to allow the bubble to be aligned with zero on the scale. This is referred to as 'zeroing the manometer'.

6. Turn the three-way tap off to the patient and open to the manometer. Open the IV catheter from the fluid bag and slowly fill the manometer to a level higher than the expected CVP.

7. Turn off the flow from the fluid bag and open the three-way tap from the manometer to the patient (Figure 1).

8. The fluid level inside the manometer should fall until gravity equals the pressure in the central veins.

9. When the fluid stops falling the CVP measurement can be read. If the fluid moves with the patient's breathing, read the measurement from the lower number.

10. Turn the tap off to the manometer, document the measurement and report any changes or abnormalities.

Using a transducer Critical care areas often measure CVP using a transducer. The transducer will be available as part of the unit monitoring equipment, to which the patient will be attached. The benefit of using a transducer system is that continuous readings are displayed on the monitor. Staff must receive education and training in use of monitoring equipment (Figure 2) (Jevon and Ewens 2007):

1-3. As per procedure for manometer.

4. Find the three-way tap that leads from the fluid bag to the CVC. Catheters differ between manufacturers, however, the white or proximal lumen is suitable for measuring CVP.

5. Turn the tap off to the patient and open to the air by removing the cap from the three-way port opening the system to the atmosphere.

6. Press the zero button on the monitor and wait while calibration occurs. When 'zeroed' is displayed on the monitor, replace the cap on the three-way tap and turn the tap on to the patient.

7. Observe the CVP trace on the monitor. The waveform undulates as the right atrium contracts and relaxes, emptying and filling with blood.

8. Document the measurement and report any changes or abnormalities.

Interpreting measurements

The normal range for CVP is 5-10cm H_2O (2-6mmHg) when taken from the mid-axillary line

FIGURE 1

Manometer system

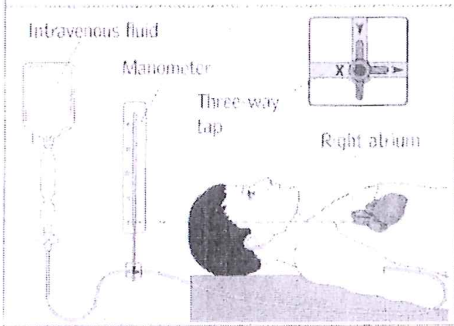


FIGURE 2

Transducer system

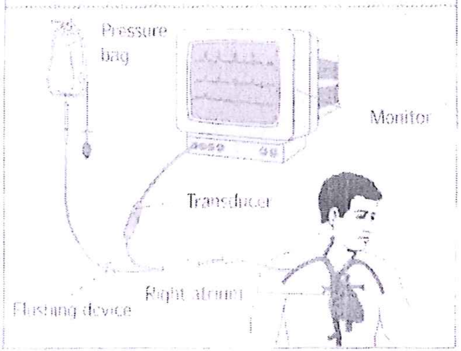
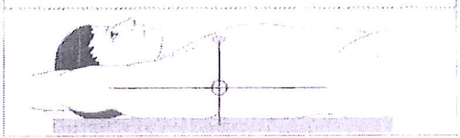


FIGURE 3

Phlebostatic axis



at the fourth intercostal space (Woodrow 2002, Gabriel *et al* 2005). However, many factors can affect CVP, including vessel tone, medications, heart disease and medical treatments (Box 1). Therefore, an isolated CVP measurement can be misleading and it is preferable to monitor trends over a period of time (Gabriel *et al* 2005, Jevon and Ewens 2007), in conjunction with other observations such as pulse, blood pressure and respiratory rate.

Potential complications As well as ongoing monitoring of the patient, it is essential that CVCs and associated equipment are checked carefully. Patients with a CVC *in situ* are exposed to a variety of potential complications (Hamilton 2006a). If any of the following are suspected urgent senior nursing or medical help should be sought:

- Local or systemic infection is one of the most serious complications associated with CVCs and preventive measures should include good handwashing and aseptic techniques (Hamilton 2006a). If a CVC site looks infected a swab should be taken for microscopy, culture and sensitivity (Woodrow 2002).
- The most common cause of CVC occlusion is a blood clot (Woodrow 2002). Other causes include kinking of the catheter and precipitate formation from medications (Hamilton 2006b). Pulling and pushing on the CVC with a syringe by an inexperienced operator is not recommended as it may liberate a clot in the patient's circulation. The inability to infuse or flush a CVC, indicating a potential occlusion, should be reported to an experienced practitioner.
- Catheter displacement into atria or ventricles may cause mechanical irritation in the myocardium or sinoatrial node. Sudden development of cardiac arrhythmias may indicate dislodgement and should be reported (Woodrow 2002).
- Extravasation from the site can occur as with peripheral cannulae, although rare. Redness, pain, swelling or difficulty infusing drugs or fluids should be reported (Hamilton 2006b).
- If the infusion giving set or manometer becomes disconnected and air enters the venous system, there is risk of a life-threatening air embolus (Morton *et al* 2005, Hamilton 2006a). All connections and taps should be checked at the start of each shift to avoid this risk, starting from the CVC in the patient working back up to the fluid bag. A clear occlusive dressing should cover the CVC so that the site is exposed to observe for disconnection.

Conclusion

Recording CVP is important to evaluate blood pressure within the right atrium and vena cava, and assists with fluid balance measurement. This article focused on methods of measurement, accuracy and interpretation of results, whether using a manometer or a transducer. Potential causes of an abnormal CVP measurement and potential complications associated with a CVC have been outlined **NS**

BOX 1

Common causes of raised and lowered central venous pressure (CVP) measurements

Raised CVP:

- Occluded central venous catheter, either as a result of a clot or a kink in the catheter.
- Heart failure.
- Pulmonary embolism.
- Fluid overload.
- Vasoconstriction resulting from medication use or arteriosclerosis causing narrowing of the vessel walls.
- Increased intra-thoracic pressure, for example, in the patient receiving continuous positive airway pressure (CPAP) ventilation.
- User error, for example, when the air filter in the manometer becomes wet, the fluid level does not fall easily (Woodrow 2002).

Lowered CVP:

- Fluid loss as a result of haemorrhage, vomiting, burns or ketoacidosis.
- Excessive use of diuretics.
- Vasodilation resulting from medication use, sepsis or neurogenic shock.

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