# Critical care: the eight vital signs of patient monitoring

Malcolm Elliott and Alysia Coventry


## Abstract

**Nurses have traditionally relied on five vital signs to assess their patients: temperature, pulse, blood pressure, respiratory rate and oxygen saturation. However, as patients hospitalised today are sicker than in the past, these vital signs may not be adequate to identify those who are clinically deteriorating. This paper describes clinical issues to consider when measuring vital signs as well as proposing additional assessments of pain, level of consciousness and urine output, as part of routine patient assessment.**


**Key words:** Vital signs ■ Patient monitoring ■ Assessment ■ Quality ■ Safety

One of the traditional roles of nurses involves surveillance. This might include watching patients for changes in their condition, recognising early clinical deterioration and protection from harm or errors (Rogers et al, 2008). For over 100 years, nurses have performed this surveillance using the same vital signs: temperature, pulse, blood pressure, respiratory rate and in recent years, oxygen saturation (Ahrens, 2008). Prompt detection and reporting of changes in these vital signs are essential as delays in initiating appropriate treatment can detrimentally affect the patient's outcome (Chalfin et al, 2007).

Patients admitted to acute hospitals today are sicker than in the past, as they have more complex health problems and are far more likely to become seriously ill during their admission (Ryan et al, 2004). In addition, patients who were once too sick to be operated on are now undergoing complex surgical procedures. This, coupled with the increasing demand for beds, means that ward nurses are often caring for patients who previously would have been cared for in a high-dependency or intensive care unit (Butler-Williams and Cantrill, 2005). Furthermore, system factors such as skill mix, nurse:patient ratios and bed shortages significantly impact on the quality of nursing care delivered in these environments.

This challenging situation is further complicated by increasing patient survival rates, which have resulted in an increasingly complex and older patient population (James et al, 2010). Patients aged 65 and older, for example, have twice the risk of younger adults of developing peri-operative complications. They are also more likely to be admitted as emergencies and undergo emergency surgery (Romano et al, 2003). Diminished reserves in cognitive, renal and hepatic function also contribute to older patients being a group at high risk of adverse events (Thornlow, 2009). As such, the five traditional vital signs may not be adequate to detect clinical changes in patients who have more complex care needs than nurses have encountered in the past.

Before an acute change in a patient's physiology can be recognised, the vital signs must be accurately assessed (Smith et al, 2006). The aim of this paper, therefore, is to provide an overview of the essential knowledge required to accurately assess these signs. This paper summarises the five traditional vital signs and recommends additional ones that should be part of an acute care nurses' repertoire of patient assessment. The signs are listed in *Table 1*.

## Temperature

The body's temperature represents the balance between heat produced and heat lost, otherwise known as thermoregulation. In the clinical environment, body temperature may be affected by factors such as underlying pathophysiology (e.g. sepsis), skin exposure (e.g. in the operating theatre) or age. Other factors may not affect the body's core temperature but can contribute to inaccurate measurements, such as the consumption of hot or cold fluids prior to oral temperature measurement.

Clinically, there are three types of body temperature: the patient's core body temperature; how the patient says they feel; and the surface body temperature or how the patient feels to touch. Importantly, these three are not always the same and may differ according to the underlying disease process. The nurse must be able to interpret conflicting assessment findings such as these in light of the patient's underlying pathophysiology.

When measuring body temperature, a number of factors must be considered. Not only must the measuring device be correctly calibrated, but the nurse must also be aware of the difference in the core temperature between anatomical sites. For example, a study found significant differences in the accuracy and consistency of several commonly used devices for measuring temperature – tympanic, oral disposable, oral electric and temporal artery (Frommelt et al, 2008). This highlights the importance of regular calibration, correct use, accurate documentation (site of measurement and temperature reading) and consistency (using the same site) as ways of accurately identifying trends in the patient's core temperature. No single thermometer or measurement site is recommended as best practice, but in order to ensure accuracy

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**Table 1. Eight vital signs**

| Vital sign | Physiology | Influencing factors | Assessment issues |
|---|---|---|---|
| Temperature | Controlled by the hypothalamus | Age<br>Infection<br>Medications | Core temperature differs between anatomical sites |
| Pulse | Reflects circulating volume and strength of contractility | Intravascular volume<br>Contractility<br>Oxygen demand | Should be counted for at least 30 seconds. Regularity, strength and equality should also be assessed |
| Blood pressure | Regulated by vasomotor centre in the medulla | Intravascular volume<br>Vascular tone<br>Contractility | Automated monitors are less reliable than a sphygmomanometer |
| Respiratory rate | Controlled by the respiratory centres in the medulla and pons | Hypercapnia<br>Hypoxaemia<br>Acidosis | Indications for measuring: to establish a baseline; critical illness, a change in oxygenation, to evaluate response to treatment |
| SpO2 | Reflects the peripheral saturation of haemoglobin by O2 | Cardiac output<br>Hemoglobin level<br>Fraction of inspired O2 | Does not reflect respiratory function overall |
| Pain | Detected by peripheral nerve fibers; interpreted by thalamus and cerebral cortex | Patient's perception | Often under-assessed and treated in hospital |
| Level of consciousness | Controlled by reticular activating system in the brain stem | Cerebral perfusion | Influenced by intra-cranial and extra-cranial factors |
| Urine output | Produced by kidneys | Renal perfusion<br>Cardiac Output | Does not directly reflect renal function |

and safe practice, the nurse must be aware of these factors.

## Pulse

Pulse is defined as the palpable rhythmic expansion of an artery produced by the increased volume of blood pushed into the vessel by the contraction and relaxation of the heart (Piper, 2008). The pulse is affected by many factors including age, existing medical conditions (e.g. fever), medications (e.g. beta-blockers) and fluid status (e.g. hyper/hypovolaemia). Nurses should be aware that the pulse is not always a true reflection of cardiac contractility or output; in the case of aortic stenosis, for example, the pulse may be weak in spite of forceful cardiac contractions (Smith et al, 2008).

Pulse should also not be considered the same as heart rate, which is actually a measurable pulse characteristic. When the pulse is palpated, characteristics other than rate also need to be assessed. These include the strength or amplitude of the pulse, peripheral equality of pulses and the pulse's regularity. These provide the nurse with further insight into the patient's condition or response to clinical treatment.

There is debate in the literature about whether a pulse should be assessed for 15 seconds or longer. Counting the pulse for 30 seconds or less is potentially problematic as an irregular pulse may not be detected during this interval. Using a short time period, such as this, has also been shown to increase calculation errors four to six fold (Minor and Minor, 2006). A patient with atrial fibrillation, for example, may appear to have a regular pulse if it is assessed for 30 seconds or less. Assessing the pulse for a full 60 seconds may, therefore, highlight abnormalities not detected during a shorter assessment interval. However, the contradictory findings of studies reporting on the relationship between the length of pulse assessment and accuracy, suggest that the count period is only of limited significance (Joanna Briggs Institute, 1999).

Nurses should not rely on a pulse oximeter to determine a patient's pulse rate. Rather, they should use their knowledge and physical assessment skills to accurately assess the pulse. For example, if the pulse is irregular or the patient is cold or hypovolaemic, a pulse oximeter may provide an inaccurate reading. Reliance on technology for taking observations may be detrimental to patient care, as other obvious clues to the patient's condition can be easily missed (Wheatley, 2006). In addition, using a machine (e.g. pulse oximeter) to measure a physiologic parameter may limit the amount of time the nurse spends with the patient, both talking to them and touching them, missing the opportunity to identify further valuable clinical data.

## Blood pressure

Blood pressure (BP) refers to the pressure exerted by blood against the arterial wall. It is influenced by cardiac output, peripheral vascular resistance, blood volume and viscosity and vessel wall elasticity (Fetzer, 2006). BP is an important vital sign to measure as it provides a reflection of blood flow when the heart is contracting (systole) and relaxing (diastole). It is also one of many indicators of cellular oxygen delivery.

Changes or trends in BP may reflect underlying pathophysiology or the body's attempts to maintain homeostasis. A drop in BP, for example, has been found to be a common sign in patients prior to cardiac arrest (Rich, 1999). A change in BP alone, though, does not indicate that the patient will have a cardiac arrest, but should trigger the nurse to perform a more detailed assessment. The importance of measuring BP accurately cannot be over-emphasised; and yet, it is one of the most inaccurately measured vital signs (Pickering et al, 2005). If a BP reading consistently underestimates the diastolic pressure by 5 mm Hg, it could result in two thirds of hypertensive patients being denied preventative treatment (McAlister and Strauss, 2001).

Heavy clinical workloads or nurse:patient ratios may result in nurses using automated BP monitors to save time. Inadequate psychomotor skills, lack of confidence or local culture may also contribute to their use. However, using automated BP monitors significantly increases the risk for measurement error. In a study of 95 patients comparing digital and aneroid monitors with a sphygmomanometer, only 34% of systolic blood pressures measured with a digital device were within 5 mm Hg of the sphygmomanometer (Johnson et al, 1999).

Automated BP monitors should also not be used as 'random number generators'. If one of these machines records a BP

measurement that is outside normal range, it is easy for the nurse to perform another reading using the machine and keep doing so, until a value within normal range is obtained. This has been described as observer bias or prejudice, where the nurse simply 'adjusts' the BP recording to what he or she thinks it should be or wants it to be (Beevers et al, 2001).

This practice indicates a lack of critical thinking and may also be defined as professional misconduct. Vital signs recorded by a nurse must be a true reflection of the patient's condition. In the situation where an automated monitor gives varying BP readings, the BP should be assessed using a sphygmomanometer. In a systematic review, the use of auscultation to ensure accurate BP measurement is recommended (Lockwood et al, 2004).

## Respiratory rate

Respiratory rate is an important baseline observation and its accurate measurement is a fundamental part of patient assessment (Jevon, 2010). Respiratory rate measurement serves a number of purposes, such as being an early marker of acidosis (Cooper et al, 2006). It is also one of the most sensitive indicators of critical illness (Smith et al, 2008). An increase from the patient's normal rate of even three to five breaths per minute is an early and important sign of respiratory distress and potential hypoxaemia (Field, 2006).

Despite this, research has found that the respiratory rate is often not recorded in clinical settings or is simply guessed (Van Leuvan and Mitchell, 2008). This is disturbing given that an abnormal respiratory rate is the best predictor of an impending adverse event such as cardiac arrest (Cretikos et al, 2007). The reason for this haphazard assessment is unclear. Perhaps it is because nurses assume that oxygen saturation provides a greater reflection of the patient's respiratory function or because there is no automated machine for measuring respiratory rate (Hogan, 2006).

In the acutely ill patient, respiratory rate should be counted for a full minute, rather than 30 seconds and then doubled (Morton and Rempher, 2009). In measuring the respiratory rate, the pattern should also be assessed and classified as eupnoea, tachypnoea, bradypnoea or hypopnoea (Moore, 2004). Labeling it as such encourages the nurse to do more than simply count a number, and to consider why the respiratory rate may be fast or slow. Nurses should also assess respiratory effort (depth of inspiration and use of accessory muscles) and equality of thoracic expansion.

## Oxygen saturation (SpO2)

A pulse oximeter is an extremely valuable clinical tool and easy to use. Research suggests that pulse oximetry is useful for detecting a change in condition that may otherwise have been missed, resulting in changed patient management and a reduction in the number of investigations undertaken (Lockwood et al, 2004). To avoid error with its use, the nurse must understand the factors that affect its accuracy, but studies have shown this knowledge is often lacking (Giuliano and Liu, 2006). Specifically, the nurse must understand respiratory physiology, how to assess peripheral circulation and the oxyhaemoglobin dissociation curve.

To work effectively, a pulse oximeter requires an adequate peripheral blood flow. This flow may be impaired by factors such as patient movement (e.g. tremor, shivering), hypovolaemia, hypothermia, arrhythmias, vasoconstriction or heart failure. The SpO2 reading may also be misleading if the patient is anaemic, because an oximeter does not measure the patient's haemoglobin level, and an anaemic patient may have a normal SpO2 despite having a lowered potential to carry oxygen (Tollefson, 2010). For this reason, nurses should not rely on SpO2 as the sole indicator of the patient's tissue oxygenation. Other assessments, such as respiratory rate and BP measurements, should also be performed.

## Pain

Although it may be expected that patients in acute hospitals will have pain (such as post-operatively), it is not acceptable that they suffer from it. Patients should be assessed frequently for the presence of pain and it should be treated promptly and effectively. For some time, pain has been described as the sixth vital sign and this reflects its importance in nursing assessment and patient care (Cordell, 1996).

Pain is also a nurse-sensitive patient outcome, meaning that its successful management is directly related to the quality of nursing care provided (Given and Sherwood, 2005). Nurses must, therefore, make pain assessment a routine part of their care, rather than waiting for patients to express their pain. Research has also found that appropriate pain management results in decreased lengths of hospital stay and improved functional outcomes (Klassen et al, 2009).

Research, however, suggests that patients experience pain too frequently in hospital and this could be because nurses do not assess or manage it as well as they should (Manias et al, 2002). This is partly explained by the frequent interruptions which occur during nursing care, causing delays between pain assessment and analgesic administration (Manias et al, 2002). These interruptions may occur owing to system factors beyond the control of the nurse such as clinical workloads or nurse:patient ratios, though knowledge gaps may also contribute.

Assessment of pain is vital, as it provides the only way to ensure that management methods are appropriate and effective (Mac Lellan, 2006). Assessment is also important in establishing the cause of the pain and evaluating the effectiveness of analgesics (Australian and New Zealand College of Anaesthetists, 2005). However, just because a nurse does not work in an acute surgical ward, he or she is not excused from having sound pain assessment skills. Numerous mnemonics (e.g. PQRST (Position, Quality, Region, Symptoms/Severity, Triggers/Treatment); Castledine and Close, 2009) are available to help nurses remember how to assess pain. Importantly, the patient's self-reported pain should be considered the most reliable indicator. Furthermore, as with any assessment, it is important that the findings are documented, even if the patient is pain free.

## Level of consciousness

As many factors can alter a patient's level of consciousness, nurses should assess it routinely along with other vital signs (Palmer and Knight, 2006). Cognitive deficits are often subtle in their presentation and can easily be overlooked by nurses who are focused on more obvious physical problems, such as

severe pain (Aird and McIntosh, 2004). Unfortunately, many nurses do not have a good understanding of the underlying mechanisms that produce altered levels of consciousness (Waterhouse, 2005). For example, subtle changes in a patient's personality such as a patient who is uncharacteristically abrupt or aggressive could suggest alcohol withdrawal, hypoxia, hypercapnia, hypoglycaemia, hypotension or a medication side effect (e.g. benzodiazepines, anxiolytics, opioids (McLeod, 2004)).

Nurses do not need to perform a full neurological assessment as part of their vital sign measurement, however, level of consciousness should be part of routine patient assessment. Nurses should not assume that just because a patient does not have a primary neurological condition, his or her central nervous system will not be compromised by their disease process. Nurses should always be alert for subtle neurological changes in their patients, which warrant further investigation. The Glasgow Coma Scale is the most common tool for assessing level of consciousness. An even simpler tool is the AVPU mnemonic – Alert, responds to Voice, responds to Pain, Unresponsive (Albarran and Tagney, 2007).

## Urine output

Urine output is an indirect reflection of renal function and fluid status and, therefore, should be monitored closely in acutely ill patients. Urine output is not an absolute indicator of renal failure as such; but rather, may be the first clinical indicator of a fluid and electrolyte imbalance, which if left untreated may lead to renal failure. In a study of over 2000 consecutive hospital admissions, 5% of patients developed acute renal failure, with the main causes being hypoperfusion (e.g. hypotension, cardiac dysfunction) and major surgery (Liano and Pascual, 1996). In hospital-acquired acute renal failure, hypoperfusion is the most common cause (Cooper et al, 2006). The patients most likely to develop acute renal failure are those with poor renal perfusion, pre-existing renal dysfunction, diabetes mellitus, sepsis, vascular disease and liver disease (Galley, 2000).

For an adult the normal urine output is at least 0.5 ml/kg/hour (Jones, 2008). In patients who are catheterised, an output of less than 0.5 ml/kg/hour for 2 consecutive hours is a marker of renal hypoperfusion and should trigger assessment and further action (Cooper et al, 2006). It is also worth noting, however, that acute renal failure may be present despite normal volumes of urine being produced (Woodrow, 2006).

It may be difficult to monitor urine output closely if a patient does not have an indwelling urinary catheter. Patients at high risk of acute renal failure should, therefore, have a urinary catheter inserted, particularly as a sudden and precipitous drop in urine output is rarely a sign of simple dehydration that will be corrected with fluids (Marino, 2007). If the patient cannot be catheterised, then a fluid balance chart must be maintained, which obviously requires the patient's cooperation. Nurses should also be observant of other urine characteristics such as colour, sediment, odour and specific gravity.

## Summary

Historically, acute care hospitals have relied on a dedicated and highly skilled professional workforce to compensate for any system failures that might occur during patient care (Tucker and Edmondson, 2003). Despite this, a landmark study found the expertise, skills and experience required to care for patients when they become acutely unwell is not always possessed by staff in general ward environments (McQuillan et al, 1998). This suggests that even in the absence of system failures, patients still may not receive the care they require because staff do not possess the prerequisite knowledge or skills.

A study of the prevalence of recording abnormal vital signs recommended the implementation of clinical training programmes for ward staff in the recognition and management of early and late signs of critical illness (Harrison et al, 2005). One of the main findings of this study was that more than half of the 3160 admissions to five acute hospitals had at least one recording of an early sign of critical illness (e.g. SpO2 < 95%). Given the importance of recognising and acting upon these signs, it can be argued that the knowledge required to identify these signs is mandatory for all nurses in acute settings.

The measurement of vital signs, however, may be perceived by senior ward nurses as being a basic or skill-based task rather than a knowledge-based one (Boulanger and Toghill, 2009). Vital signs measurement may, therefore, be delegated to less qualified or inexperienced nursing staff (Hogan, 2006). But knowledge, skills and the ability to think critically are required not only to measure vital signs accurately but also to interpret them in the context of the patient's illness and medical treatment.

Registered nurses should remember that if they delegate the measurement of vital signs to another member of staff (e.g. a nurse assistant or student), they are still ultimately responsible for patient care and so, accountable for analysing and interpreting the vital signs and planning patient care (Wotton, 2009). Regardless of who measures vital signs, a recent review recommended that every patient have a documented plan for vital sign monitoring that includes which physiological parameters to assess and how often (Canadian Agency for Drugs and Technologies in Health, 2011).

Clinical tools for identifying and monitoring acutely ill patients are being used more frequently in clinical practice. These tools are based on the premise that critically ill patients frequently demonstrate signs of deterioration and that early intervention improves outcomes. A common example is the Early Warning Score, which can be calculated from the common physiological parameters described in this paper. Derangement in any of the parameters is assigned a number and the sum of these is used to calculate an overall early warning score (Garcea et al, 2010).

Research has found an association between easily recordable physiological derangements and mortality, establishing the clinical usefulness of Early Warning Scores (Goldhill and McNarry, 2004). These Scores, though, have some limitations. For example, increased scores from a single parameter do not always translate into an increased overall risk of clinical deterioration (Naeem and Montenegro, 2005). Regardless, these Scores are one resource to help clinicians recognise acutely ill patients and provide prompt intervention to improve patient outcomes.

## Conclusion

The interpretation of data from assessments is vital in determining the level of care a patient requires, providing treatment and preventing a patient deteriorating from an otherwise preventable cause (Wheatley, 2006). As patients in hospital today are sicker than in the past, nurses can no longer rely on the traditional five vital signs to identify clinical changes in their patients. Nurses must not only know how to measure these vital signs accurately, they must also know how to interpret and act on them. In addition, they must incorporate additional vital signs when performing assessments of their patients. BJN

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### KEY POINTS

- Five vital signs are traditionally used to assess patients at the bedside: temperature, pulse, blood pressure, respiratory rate and oxygen saturation
- Owing to increasing patient acuity and illness complexity, these vital signs may not be sufficient to detect patient deterioration
- Given the importance of recognising and acting upon clinical deterioration, the knowledge and skills to recognise deterioration is mandatory for all nurses in acute settings
- Nurses should consider incorporating other assessment parameters into their routine care: pain, level of consciousness and urine output