Respiratory rate: the neglected vital sign

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ABSTRACT

- The level of documentation of vital signs in many hospitals is extremely poor, and respiratory rate, in particular, is often not recorded.
- There is substantial evidence that an abnormal respiratory rate is a predictor of potentially serious clinical events.
- Nurses and doctors need to be more aware of the importance of an abnormal respiratory rate as a marker of serious illness.
- Hospital systems that encourage appropriate responses to an elevated respiratory rate and other abnormal vital signs can be rapidly implemented. Such systems help to raise and sustain awareness of the importance of vital signs.

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Recording a full set of vital signs (pulse rate, blood pressure, respiratory rate and temperature) at least daily is considered standard for monitoring patients on acute hospital wards. However, two recent multicentre studies found that the level of documentation of vital signs in many hospitals is poor.[1,2] Of the four vital signs, respiratory rate, in particular, is often not recorded, even when the patient's primary problem is a respiratory condition.[2-6] This is in spite of the fact that an abnormal respiratory rate has been shown to be an important predictor of serious events such as cardiac arrest and admission to an intensive care unit (ICU).[3,7-10]

Respiratory rate as an indicator of serious illness

In 1993, Fieselmann and colleagues reported that a respiratory rate higher than 27 breaths/minute was the most important predictor of cardiac arrest in hospital wards.[7] Subbe and colleagues found that, in unstable patients, relative changes in respiratory rate were much greater than changes in heart rate or systolic blood pressure, and thus that the respiratory rate was likely to be a better means of discriminating between stable patients and patients at risk.[9] Goldhill and colleagues reported that 21% of ward patients with a respiratory rate of 25–29 breaths/minute assessed by a critical care outreach service died in hospital.[8] Those with a higher respiratory rate had an even higher mortality rate.[8] In another study, just over half of all patients suffering a serious adverse event on the general wards (such as a cardiac arrest or ICU admission) had a respiratory rate greater than 24 breaths/minute. These patients could have been identified as high risk up to 24 hours before the event with a specificity of over 95%.[10]

What respiratory rate threshold value merits action?

Among the systems used to activate medical emergency response teams, such as outreach and medical emergency teams, the definition of an "abnormal" respiratory rate for adults varies from over 14 to over 36 breaths/minute.[1,9] Some investigators have relied on an "abnormal breathing indicator" or dyspnoea as a surrogate for tachypnoea when the respiratory rate was not recorded.[3,11] Recent evidence suggests that an adult with a respiratory rate of over 20 breaths/minute is probably unwell, and an adult with a respiratory rate of over 24 breaths/minute is likely to be critically ill.[3,7-10,12,13]

Why is respiratory rate so important?

Alveolar ventilation (a product of respiratory rate and tidal volume) is normally carefully controlled by the actions of central and peripheral chemoreceptors and lung receptors.[14] Ventilation is driven by both the arterial partial pressure of oxygen (PaO_2) and the arterial partial pressure of carbon dioxide ($PaCO_2$), with $PaCO_2$ being the most important driver.[14] The body attempts to correct hypoxaemia and hypercarbia by increasing both tidal volume and respiratory rate. Thus these conditions can be detected by measuring the respiratory rate.

Importantly, any condition that causes metabolic acidosis, such as abdominal pathology or sepsis, will also precipitate an increase in tidal volume and respiratory rate through an increased concentration of hydrogen ions, which leads to increased CO_2 production.[14] In addition, any other condition that causes hypercarbia or hypoxia will also increase alveolar ventilation.[14] In effect, the respiratory rate is an important indicator of a severe derangement in many body systems, not just the respiratory system, and is therefore a key predictor of adverse events.

It is important to note that not all causes of hypoxia and hypercarbia result in an increase in tidal volume and respiratory rate. Medications such as opiates, which are commonly used in hospitals, depress the respiratory drive and the respiratory response to hypoxia and hypercarbia. In these circumstances the respiratory rate can still be a useful tool to monitor for an adverse event, as the respiratory rate may be lowered, often in association with a reduced level of consciousness.

Respiratory rate and pulse oximetry

While the introduction of pulse oximetry was a major advance in bedside monitoring, it still suffers from a number of practical drawbacks. These include poor understanding of the purpose and correct use of pulse oximetry among nurses and junior doctors.[15-17] Recent surveys have found that only 56% of nurses understood that pulse oximetry is not an indicator of adequate ventilation, and only 14% of doctors and nurses acknowledged that an arterial blood gas measurement is needed to identify hypercarbia.[15,16] Pulse oximetry may be inaccurate for a number of reasons, including reduced perfusion at the site of measurement, as in hypothermia or shock.[18]

Pulse oximetry measurement has not been demonstrated to be a specific indicator of serious illness, and there is evidence that it lacks specificity.[3,12] Reduced arterial haemoglobin saturation is common in hospitalised adults, with saturations of between 90% and 95% occurring in up to 37% of patients and saturations of less than 90% occurring in about 11% of patients.[13]

Measuring arterial haemoglobin saturation through pulse oximetry alone does not constitute adequate monitoring of ventila-

Respiratory rate: summary of evidence and recommendations

- Respiratory rate is the vital sign least often recorded and most frequently completely omitted from hospital documentation.
- A raised respiratory rate is a strong and specific predictor of serious adverse events such as cardiac arrest and unplanned intensive care unit admission.
- Pulse oximetry measurement is not a replacement for respiratory rate measurement.
- All staff should be educated to measure the respiratory rate as an easy and specific assessment for critical illness, and should be given guidance on appropriate action to be taken when abnormally high respiratory rates are recorded.
- Hospital systems that encourage appropriate responses to a raised respiratory rate and other abnormal vital signs can be readily and rapidly implemented. Such systems help to raise and sustain awareness of the importance of vital signs. ◆

tion. As discussed above, measurement of the respiratory rate provides information that pulse oximetry cannot provide. The two measurements are complementary and should not be substituted for one another.

Education

The lack of understanding of the purpose of pulse oximetry may be indicative of a broader lack of understanding of acute medicine by both nurses and junior medical staff.[17] The importance of education and re-education of hospital staff cannot be overstated.

Basic educational resources such as medical textbooks may contribute to under-appreciation of the importance of the respiratory rate. Despite the fact that a raised respiratory rate is associated with life-threatening conditions such as shock and cardiac failure, a recent study found that only four out of 30 medical textbooks examined emphasised the importance of the respiratory rate as a vital sign in adults.[19] One text even stated that "counting the respiratory rate is a traditional nursing observation, yet the precise rate is rarely of practical importance".[19]

Solutions and recommendations

It is possible for hospitals to systematically improve the frequency of recording of respiratory rates. One study found that, before the introduction of an early warning scoring system and new charts for vital signs, only 30% of ward patients had their respiratory rate recorded at least once a day. At follow-up one year later, this had improved to 90%.[4] Another study that introduced a similar system reported improvements in documentation of vital signs, along with improved confidence of nurses in assessing and prioritising patients.[5] These systems have also recently been recommended by the National Institute for Health and Clinical Excellence in the United Kingdom.[20] Attention to other organisational factors may also be important in optimising recording of respiratory rates.[6]

Measurement of the respiratory rate does not require complex technology. In view of the strong evidence that it is an under-recognised and under-recorded but specific and useful marker for patients at risk of serious adverse events (Box), we suggest that:

- nurses and doctors, both before and after graduation, should be educated to appreciate that the respiratory rate is an easily obtained, useful marker for risk of serious adverse events;
- all hospital staff should be advised that measuring pulse oximetry is not a replacement for measuring respiratory rate;
- the respiratory rate should be measured and documented accurately in all hospital patients at least once a day, and should always be documented when other vital signs are measured;
- hospitals should consider implementing systems for monitoring and responding to patients' vital signs in order to improve compliance with recommendations for respiratory rate documentation;
- respiratory rate and other vital signs should be measured more frequently in patients who are unstable, or in adult patients whose respiratory rate is greater than 20 breaths/minute;
- adult general ward patients with a respiratory rate greater than 24 breaths/minute should be monitored closely and reviewed regularly, even if the other vital signs are normal;
- a patient with a respiratory rate greater than 27 breaths/minute should receive immediate medical review; and
- patients with a respiratory rate greater than 24 breaths/minute, in combination with other evidence of physiological instability (eg, hypotension or a reduced level of consciousness), should also receive immediate medical review.

The importance of an abnormal respiratory rate as a marker of serious illness must be emphasised when educating both nurses and doctors. The level of documentation of the respiratory rate is currently poor, but can be markedly improved through the use of education, "track and trigger" systems (such as the early warning scoring system), and improved vital signs charts. Regular monitoring and documentation of the respiratory rate, along with education on appropriate action when the respiratory rate is abnormal, may help to identify and manage patients at risk and thereby reduce the incidence of serious adverse events.

Competing interests

None identified.

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