

Which patients should be monitored, how should they be monitored, and why should they be monitored?

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Intensively monitoring severely ill patients is like placing a smoke alarm in a burning building; it makes no sense. Smoke alarms only makes sense if they are placed in buildings before a fire starts, or after a fire has been extinguished in order to make sure it does not start again. Therefore, logic suggests that it is more important to monitor sick patients with normal vital signs in order to detect any deterioration as early as possible, or AFTER a severe illness in order to ensure they do not relapse, and it is safe for them to be discharged from hospital and return home.

Paradoxically, it may be a lot more difficult to determine from vital sign changes if a patient is getting better than if he or she is getting worse. Consider an unfortunate victim hurled into the Colosseum in Rome to be chased by a lion for the amusement of the crowd. On the first lap around the arena the victim's vital signs are likely to be at their maximum derangement. However, no one in the arena will imagine that the slowing of his heart and respiratory rate on the second and subsequent laps signifies an improvement in his situation, unless the lion is removed. How long after the danger from lion has gone will it take for the victim's vital signs to return to normal? This will depend on several things, such as the victim's prior level of health and fitness, other ill-understood emotional and physiological factors, and on if another lion enters the arena.

In this edition of *Acute Medicine*, Subbe et al¹ report a system that identifies patients fit for hospital discharge by analyzing trends in vital sign recordings made every four hours.

A machine learning algorithm was able to identify clinical stability within just 12 hours of observation (i.e. 3 sets of vital signs), three times faster than a traditional manual system. Before these impressive results are accepted at face value two important caveats that must be considered: firstly the definition of clinical stability was arbitrary, and secondly the acceptable failure rate of the system was determined by present day readmission rates for medical emergency admissions of 12-13%,² which some might consider a very low bar. Nevertheless, further development of this technology, especially if applied to continuous measurement of vital signs by wearable devices, is likely to allow earlier detection and discharge of stable patients, thus reducing the

pressure on overworked emergency departments and acute medical units.

A more pressing question than identifying patients fit for discharge is the assessment and monitoring of sick patients who present with normal or near normal vital signs. These patients account for 60-70% of patients admitted to hospital.³ Although many will develop vital sign changes during their admission, only a small minority of these patients will die in hospital, and many of them will die with minimal vital sign derangement or even normal vital signs.⁴ Yet, it is these infrequent deaths that cause the most concern and angst. They nearly always result in an inquest or inquiry, which start with de facto assumption that all those involved with the patient's care were in some way to blame. Most medical illness starts with the patient having nonspecific feelings of being unwell. The interval between these subjective nonspecific symptoms and the development of specific symptoms and objective signs may be seconds in acute cardiac disease, minutes in meningococcal sepsis, and hours or even days in other conditions. It should not be surprising that the deterioration of such patients is often missed, especially if it is gradual. If these patients are only monitored intermittently it is highly likely that important blips in their vital signs will be missed, along with the opportunity to save them. For example, vital signs recorded every 4 hours would not detect the rapid deterioration of conditions such as meningococcal septicaemia. On the other hand, the overwhelming majority who do not die will also develop unimportant vital sign abnormalities, which will require no intervention and should be ignored.

It may seem that the obvious solution to this conundrum is the continuous monitored of these patients by machine-learning computer algorithms. However, maybe this technology does not need to be applied to all of them. It may be possible to identify at initial assessment patients who are clinically stable and, therefore, extremely unlikely to die. In addition to vital signs,⁵ impaired mobility has been shown to be a predictor of mortality, and normal mobility a powerful predictor of survival.⁶ Biomarkers,⁷ ECG changes⁸ and most importantly, the patient's subjective feelings and symptoms⁹ may also help identify clinically stable patients who are highly unlikely to

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deteriorate. It may also be that clinical stability could be determined by continuously monitoring patients for a short time using machine-learning algorithms.¹⁰ These are all interesting and exciting possibilities,

just waiting for to be tried and tested. Artificial intelligence and computer technology have much to offer acute medicine, but maybe there is still a role for touching, feeling, observing and talking to patients.

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