Case 2014-04: Alarm Fatigue

This discussion involves a series of related cases concerning the use and misuse of an essential anesthesia technology: audible and visual alarms.

The problem is significant – “Alarm Hazards” is first on the ECRI Institute’s top 10 list of technology hazards in healthcare. Following a series of sentinel event reports in which patient deaths were attributed to failure of alarm systems, the Joint Commission named alarm management as a 2014 National Patient Safety Goal. The core issue is alarm fatigue, the process in which providers, exposed to excessive or irrelevant alarms and alerts, modify their responsiveness to alarms – from ignoring alarms to silencing them altogether. While the focus of these initiatives is on alarms in the ICU and other acute care settings, these concerns are also important for the O.R.

Medical alarm systems can alert the provider to problems or potentially dangerous conditions related to the patient’s physiology (cardiopulmonary monitors), the environment (e.g., electrical isolation alarms, smoke detectors) or medical equipment (e.g., low oxygen pressure alarms). These alarms may be audible, display alerts (e.g., flashing icons or lights) or tactile (e.g., vibrating pager or novel tactile devices). Alarms are useful in non-O.R. environments, especially in situations in which one nurse may be caring for multiple patients or find it necessary to leave the bedside for necessary tasks.

In the O.R., while a provider generally has just a single patient and does not leave the patient unless relieved, alarms are still a necessity. Attention may be diverted while performing procedures: going “under the drapes” to check on lines or patient positioning, answering phone calls, teaching, washing hands, observing the surgical field, communicating with the surgeons, completing documentation, etc. Fatigue or cognitive errors may result in a lapse of attention or proper focus, which an appropriate alarm could mitigate. Recognizing the dire consequences of failure to identify hypoxia or inadequate ventilation, ASA recommends audible alarms for low \( \text{SpO}_2 \) and hypoventilation detection. In the case of other alarm conditions, the type of alarm and the thresholds are left to clinical judgment. Nevertheless, audible alarms are probably the safest option for any significant alarm condition, since visible alarms may be ignored if vigilance is low or if visual attention is directed elsewhere.

Case Report 1: The EHR was not receiving data and was warning “Device not connected.” Called IT, then Clinical Engineering, who said they don’t come in on weekends to deal with EHR issues. The patient was trying to die. This is quite a distraction.

This report illustrates one of the causes of alarm fatigue – annoyance out of proportion to the clinical risk. Although failure to receive automated data in the anesthesia electronic record is a problem, there are easy workarounds (e.g., manual entry or switching to a paper record). This is not a condition in which the patient’s well-being is in jeopardy. However, the reporter describes a crisis (“patient trying to die”), during which any unnecessary distraction could make a bad situation worse.

Case Report 2: \( \text{SpO}_2 \) monitor consistently alarming “low battery,” despite being plugged into wall outlet. [The device was functioning normally; however, the rechargeable battery required replacement.]

Although the imminent loss of oximetry does warrant a repetitious alarm, in this case the alarm is an artifact – the alarm algorithm and sensors have misinterpreted the situation.

Monitor alarm theory considers the standard threshold alarm to be akin to a diagnostic test. Like all tests, alarms have a sensitivity and specificity, and coupled with the prevalence of the condition to be diagnosed, a negative and positive predictive value can be measured (using the gold standard of physician review). Alarm systems may also be described by a signal-to-noise ratio, in which the signal must be distinguished from artifact such as electrical interference with ECG signals. The system is tasked with sounding the alarm only when it detects meaningful
signals — conditions that demand immediate action. When an alarm fires despite the measured parameter being within chosen acceptable limits, a false alarm is said to occur. When it fires in the absence of a clinically significant condition, this may be seen as noise or alarm pollution.

When exposed to alarms, workers in health care, aviation and other fields tend to match their reactions to their perception of the accuracy of the alarm. If the PPV is 90 percent, then they tend to respond around 90 percent of the time. If the alarm false-positive rate, instead, is 90 percent, the responder will tend to ignore alarms, respond slowly (~10 percent of the time) or simply turn them off. In addition to the toll on well-being and job satisfaction, a constant stream of unreliable alarms may degrade vigilance.

The problem of alarm fatigue results from clinical alarms systems functioning as screening rather than diagnostic studies, favoring sensitivity and negative predictive value over specificity and positive predictive value. The zeal to detect and alarm for every potentially dangerous situation has ironically decreased patient safety by creating an epidemic of false-positive alarms leading to alarm fatigue.4,5

Case Report 3: Transferred patient from O.R. (kidney/pancreas transplant) to the ICU ... Nurses were busy attaching ECG leads while I packed up portable monitor. \( \text{SpO}_2 \) is 88%, no alarms sounding. \( \text{O}_2 \) Sat number blinking red, but nobody is paying attention to it. Placed mask back on patient and encouraged him to breath. \( \text{SpO}_2 \) back to 100%.

Case Report 4: Default alarm volumes on multiple anesthesia machines are found to have been set to the lowest (inaudible volume) value.

Case Report 5: Attending is insisting that all alarms be disabled prior to giving an anesthetic on all cardiac patients. Anesthesia technicians have been instructed to accomplish this. I don’t feel this is safe.

In cases three and four, useful alarms were turned off or muted, presumably in response to the distraction or annoyance of false alarms. In case five, it is taken to the highest level: “just turn it off!” Unfortunately, this strategy throws the baby out with the bath water: although false positives are eliminated, the sensitivity of the alarm is now zero.

Techniques to Fight Alarm Fatigue

The best way to combat alarm fatigue is to build better alarm systems, in which both sensitivity and specificity are improved. A close second would be to support the providers in setting the alarms rationally for each patient. There have been many proposals for improvements to alarm system quality, from integrated systems that compare one signal to another (e.g., ignore the artifact-laden ECG that looks like v-fib when the arterial line and \( \text{SpO}_2 \) signals are regular and pulsatile) to systems with “knowledge” of human physiology or surgical case progression. The hazard in Case 2 could have been fixed immediately had the oximeter included an override to silence the alarm indefinitely in case of device failure. In the meantime, there are concrete steps that anesthesia providers can take to reduce the likelihood of alarm fatigue:

Implement an Alarm Management Policy (AMP): Intervention number one is to establish oversight of the alarm policy in the O.R. The AMP should include specification of various alarm default settings and mandate participation in training and familiarization sessions with the alarm systems for all anesthesia professionals. An appropriate AMP would prevent the situation described in Case 3 by establishing an appropriate default anesthesia alarm volume. Training should include anesthesia technicians and others who could turn off phantom alarms during case turnover to reduce alarm desensitization.

Customize Alarm: The second intervention is the “ounce of prevention” step — set specific alarm settings appropriate for the individual patient and case (and perhaps for the mental state of the provider?) prior to induction of anesthesia. Setting appropriate limits has been shown to substantially reduce the frequency of false alarms in nursing settings and can be facilitated through the use of default alarm setting profiles, as permitted
by a variety of medical devices, such as infant, child, child-cardiac, adult and adult-cranotomy. Selection and customization of the appropriate profile could become a part of the preoperative readiness checklist.

Do Not Disable: This might have prevented the potentially dangerous situations of Cases 4 and 5. However, it may be easiest to convince providers to forgo disabling of alarms once the other interventions have been successfully implemented. As Raymer and colleagues put it in their review of anesthesia monitor alarm theory: “So the question becomes not ‘How can we design alarms that anesthesiologists cannot disable?’ but rather, ‘How can we design alarms that anesthesiologists will not want to disable?’”

Choose Process over Technology: The utility of each alarm must be assessed with the overall goals of patient safety and a reasonable work environment. Although the alarm in Case 1 was not audible, the persistent visual alarm likely had similar alarm fatigue effects on the reporter. It would be reasonable for the alarm policy to include guidelines for alarms arising from related systems, such as the electronic medical record.

Improve Acoustics and Alternative Notification Modalities: Interventions five and six are two more strategies to improve the quality of alarms. Quieter places with better acoustics may make alarm tones easier to detect without worsening the problem of workplace noise with louder alarms. Use of visual alerts and the development of tactile alarms may also reduce the noise of the O.R.8

Optimize Alarm Limits and Delays: Increasing alarm delay (the time period the threshold has been crossed before the alarm fires) has been found in nursing practice to substantially decrease the number of false-positive alarms and may be especially useful for alarm settings for physiologic variables that are subject to brief but frequent artifact. In the O.R., the ECG signal may be temporarily degraded during electro-cautery or patient movement.9 The pulse oximeter or arterial line will be degraded during noninvasive blood pressure measurement when it is necessary to have both these monitors on the same extremity. Oscillometric noninvasive blood pressure determination can be degraded during lumbar spine surgery involving stabilization due to motor artifact of somatosensory-evoked potentials. Setting a delay for these or other appropriate signals may greatly reduce false alarms. An anesthesiologist-triggered “manual delay” may also be an appropriate response to the high frequency of certain alarms at induction and emergence, but for the appropriate parameters. For instance, it is expected that the capnograph waveform will be interrupted during direct laryngoscopy. Pausing this alarm for a minute during intubation seems a reasonable application of this intervention.10

In summary, alarm fatigue is a serious safety issue to which anesthesia providers in the O.R. are not immune. By taking control of alarms before they control us, we can improve the safety and well-being of both patients and the health care team.

References:
1. A Siren Call to Action: Priority Issues From the Medical Device Alarms Summit. Arlington, VA: Association for the Advancement of Medical Instrumentation; 2011.