Patient Safety Tip of the Week

August 16, 2016

How Is Your Alarm Management Initiative Going?

By now your organization should be well on its way in implementation of an alarm management initiative to meet The Joint Commission's NPSG on Alarm Management (see our August 2013 What's New in the Patient Safety World column "Joint Commission Formalizes 2014 NPSG on Alarm Management"). As of January 1, 2016 in phase 2 of that NPSG The Joint Commission expects hospitals will have established and implemented policies and procedures for managing clinical alarms and have done appropriate staff education.

Our July 2, 2013 Patient Safety Tip of the Week "Issues in Alarm Management" discussed in detail the issue of alarm fatigue and provided recommendations on how you should put together an alarm management program with attention to several very relevant issues. But now we also have the benefit of many valuable lessons learned as organizations have grappled with implementation of alarm management programs.

One issue that many hospitals have struggled with in phase 1 of the NPSG on Alarm Management was inventorying and data collection about alarms. While hospitals with the most up-to-date technology systems and large IT departments have used IT analysts to look at virtually all alarms over a period of time, smaller hospitals and those with fewer resources may have chosen to use a sampling strategy rather total strategy. But one problem frequently noted is that **often one or two patients have accounted for a disproportionate number of alarms**. So in cases where sampling is used you may need to include a way of dealing with such outliers in both your baseline data and your ongoing data collection. For example, you might consider dropping from your statistics those patients with alarm frequencies greater than 2 standard deviations beyond the mean. We're sure there will be some statistician out there who will rail at this but let's be practical – we're not publishing the data in a peer reviewed journal! We're using it as the key measure in our performance improvement activities. That doesn't mean you ignore the outliers (because their alarms are still requiring your staff to respond) but the outliers may require different approaches, such as **customizing alarm settings** for individual patients.

Many hospitals were surprised during their alarm inventory to find they had more than one alarm doing basically the same thing! For example, such **duplicate alarms** may have included separate alarms for bradycardia and low heart rate or tachycardia and high heart

rate (Sendelbach 2015). And the built-in default values for those alarms may have actually been different!

After you did an inventory of you alarms you **categorized and prioritized** them. Some categorized alarms as clinical vs. technical. But all should have identified which alarms pointed to **actionable** conditions and then determined how and how urgently those alarms needed to be attended to. Most have identified **low priority alarms** but many found they had alarms which triggered for conditions for which they never took action. The best examples are alarms for PVC couplets or bigeminy. Since almost no one takes an action when **couplets or bigeminy** occur, there is little reason to keep such alarms active in your systems.

An outstanding example of doing an alarm inventory with categorization and prioritization comes from researchers at UCSF (Drew 2014). Over a 31-day study period in 5 adult intensive care units with 461 patients they found an **audible alarm burden of 187/bed/day**. 88.8% of the 12,671 annotated arrhythmia alarms were false positives. Conditions causing excessive alarms included inappropriate alarm settings, persistent atrial fibrillation, and non-actionable events such as PVC's and brief spikes in ST segments. Low amplitude QRS complexes in some but not all available ECG leads caused undercounting heart rate and false arrhythmia alarms. Wide QRS complexes due to bundle branch block or ventricular pacemaker rhythm caused false alarms. 93% of the 168 true ventricular tachycardia alarms were not sustained long enough to warrant treatment.

Alarms for PVC's were the most frequent nonactionable type of alarm. Even though guidelines do not recommend intervention for isolated PVC's, clinicians were apparently concerned about the potential for torsade de pointes in patients with prolonged QTc intervals so PVC alarms were not disabled (see our prior columns on torsade de pointes listed at the end of today's column for potential solutions to that issue). Atrial fibrillation alarms would repeat in patients with persistent atrial fibrillation. And in one patient with atrial fibrillation and a ventricular response rate of 130-135 per minute the high heart rate alarm would fire because the hospital default threshold was 130 per minute (resulting in an average of 211 alarms per hour!). They also noted that accelerated ventricular rhythms and non-sustained ventricular tachycardia (lasting less than 30 seconds) were not considered "actionable". True positive ventricular tachycardia alarms (where intervention was required) were relatively infrequent. Sometimes an artifact mimicking a ventricular arrhythmia might appear in one lead and trigger an alarm even though other leads showed a different rhythm (other leads may not have been visible on monitors). Notably, 91% of asystole or pause false alarms had visible QRS complexes in other leads that could have been detected had multiple leads been used. Apnea or respiratory rate alarms occurred, on average, 79 alarms/bed/day. Many of these were false alarms where the waveform looked flat in patients who were known to be breathing adequately.

The Drew article ends with some good recommendations for hospitals (especially regarding the need for customizing alarms and avoiding nonactionable alarms) and for

vendors/manufacturers (eg. integrating multiple ECG leads into monitors, messaging when alarms continue when atrial fibrillation is persistent) and others.

The other area in which much success has been achieved is reducing the amount of **unnecessary telemetry**. In our July 2, 2013 Patient Safety Tip of the Week "Issues in Alarm Management" we noted that telemetry is one technology we often see overutilized in many hospitals, which may contribute to alarm fatigue. When we discuss alarm management strategies with hospitals one of the first areas of focus we recommend is telemetry, particularly that occurring outside ICU's. The American Heart Association and American College of Cardiology (AHA/ACC) have published guidelines on telemetry monitoring and suggested criteria. Yet many hospitals have never developed local guidelines to help identify which patients should be monitored (and which should not). Moreover, criteria for continued monitoring are extremely important because all too often a physician orders telemetry and it gets continued indefinitely. Getting your physician staff involved early in developing your telemetry criteria is the key.

In our October 2014 What's New in the Patient Safety World column "Alarm Fatigue: Reducing Unnecessary Telemetry Monitoring" we cited a study at Christiana Care Health System that successfully implemented a system that significantly reduced unnecessary non-ICU telemetry and achieved substantial financial savings while not adversely impacting patient safety (Dressler 2014). A multidisciplinary team designed the program and ensured appropriate training of impacted departments. The key component was **hardwiring the AHA guidelines into their electronic ordering system**. Providers were now required to choose an indication from a list, each of which included a duration based upon the AHA guidelines. In addition, they removed telemetry orders from order sets for conditions where monitoring was not supported by the AHA guidelines. Also, guidelines were established for automatic discontinuation of telemetry monitoring.

After implementation there was a 70% reduction in the mean daily number of patients being monitored by telemetry. The mean weekly number of telemetry orders dropped 43% and the mean duration of telemetry dropped by 47%. They assessed for potential impact on patient safety and found no worsening of mortality, code blues, or rapid response team activations. Their mean daily cost for non-ICU telemetry decreased from $18,971 to $5,772, with a projected annual savings of $4.8 million. Undoubtedly, this also had a beneficial effect on the phenomenon of alarm fatigue, though they had no specific measure of the latter. This excellent work by Christiana Care Health System demonstrates that such a focus on unnecessary telemetry monitoring can lead to significant financial savings without sacrificing patient safety and likely reducing alarm fatigue.

Do you implement an entire "bundle" of interventions in one fell swoop or do you add interventions sequentially? One hospital system took the latter approach and piloted interventions before taking them system-wide and, by sequencing the interventions, was able to determine the relative impact attributable to each intervention (Turmell 2016). Their program **reduced alarms up to 30%** and they estimated it had the potential to save $136,500 and 841 hours of registered nurses' time per year. No patient harm occurred

during the 2-year project and, though it could not be directly measured, there was a perception of reduced alarm fatigue. There were 5 individual components to their program. **Daily electrode changes** reduced alarms 33% and reduced "artifact" alarms 26%. **Eliminating nonactionable and duplicate alarms** and **adjustment of thresholds** reduced alarms 36-84% (the unit with the lesser reduction having one patient accounting for the majority of alarms). As we'd expect, appropriate use of telemetry (using the AHA/ACC guidelines) identified an average of 15 patients per day who could potentially have telemetry monitoring removed (with actual removal occurring in an average of 6 patients per day). Interestingly, they found their initiative on **customization of alarms** actually increased alarms! So they did not roll that intervention out to the rest of the system. But that customization relied heavily on technology so even though they "turned off" that setting, they still proceeded with education of nursing staff about customization of alarms. Turmell and colleagues emphasize that this is not a "one and done" type of project but rather that there is a need for continued evaluation, particularly for adjusting default alarm settings.

On the other hand, Sendelbach and colleagues took a "bundled" approach to alarm management in a medical coronary care unit (Sendelbach 2015). They prioritized their alarms as "**life-threatening**", "**serious**", or "**advisory**" based upon what was likely to happen to the patient if the alarm were not immediately attended to. Note that, in attempt to reduce the noise created by alarms, some of the alarms in the "advisory" category now are sent via their mobile communication device system rather than continuing as audible alarms for everyone to hear. Individual program components were similar to those in the Turmell study and included: elimination of duplicate alarms, adjusting default alarm settings, customization of alarms based on individual needs, daily changes of ECG electrodes, standardized skin preparation, and use of disposable ECG leads. Overall, this "bundled" approach led to an **80-90% reduction in alarms** in their CCU (from a mean of 28.5 alarms per patient per day down to 3.29 alarms per patient per day)! This basically preserved all the alarms for life-threatening events and eliminated most of the alarms that were of lower priority. Moreover, their improvement was sustained over time. As in the Turmell study, ongoing evaluation is important. They found that the use of disposable ECG leads did not reduce alarms so that component was dropped.

One intervention they found to be ineffective was decreasing the alarm threshold on pulse oximetry from 90% to 88% (an intervention found to be successful and safe in the literature). So it is important to remember that what works one place or setting may not work at another.

The above studies and, in fact, the bulk of studies on alarm management have focused on intensive care settings. On the other hand, a significant quality improvement project aimed at reducing alarms on **general med/surg units** actually preceded announcement of The Joint Commission's NPSG on Alarm Management. Whalen and colleagues at Boston Medical Center began their performance improvement project in 2008 and expanded upon it in 2011 (Whalen 2014). They did the usual data mining of alarms but one crucial thing they did was direct observation of nurses' responses to various alarms. That observation not only determined how nurses responded to the alarms but also

demonstrated that those responses affected the staff's ability to respond to other important alarms.

The focus was on self-resetting alarms (audible alarms capable of self-resetting once alarm conditions are no longer met) that contribute significantly to excess audible alarms and the phenomena of clinical alarm fatigue. For the QI project they set default heart rate limits to a lower limit of 45 and upper limit of 130 per minute. They also added an audible alert for atrial fibrillation (raising its status from a message alarm to a patient status arrhythmia advisory alarm). They did this to help better identify paroxysmal episodes of AF. However, nurses had the ability to reassign it to the nonaudible message alarm for patients with chronic AF. For the study, if a crisis alarm sounded nurses would respond immediately to the patient but they also had the opportunity to reset the default settings to better reflect the patients' baseline heart rate and rhythm. A few other interventions occurred during the study (order sets were redesigned, short runs of V tach were moved from audible status to message status, and daily ECG lead changes were begun).

Following implementation there was an overall 89% reduction in total mean weekly audible alarms was achieved on the pilot unit, without requirement for additional resources or technology. The largest contribution to the reduction in alarm frequency was a 93% reduction in bradycardia, tachycardia, and heart rate parameter limit alarms. There were no adverse events related to missed cardiac monitoring events, and the incidence of code blues decreased by 50%. The maximum decibel level of noise on the pilot unit improved and both staff and patient satisfaction improved. The authors speculated that the improved patient satisfaction reflected not only the reduction in noise level but also that the nursing staff now had more time to spend with patients.

Moving lower priority alarms from audible status to messaging status can go a long way to reduce alarm fatigue and excessive noise in a variety of settings. Just keep in mind that things can still go wrong. See our February 9, 2016 Patient Safety Tip of the Week "It was just a matter of time…" for such an example.

One interesting approach on setting alarm thresholds was recently taken by a children's hospital. Most thresholds are set via very arbitrary methods. But researchers at Stanford (Goel 2016) analyzed the heart and respiratory rate data from 16 months of Packard Children's records and calculated the 5th and 95th percentiles for the measures, cutoffs chosen as reasonable thresholds for abnormally low or high values. They broke the data down by age range and, to avoid having the results skewed by critically ill children, excluded data from patients who spent time in the intensive care units. There were 55.6% fewer out-of-range measurements using data-driven vital sign limits. Safety evaluation of data-driven limits suggests they are as safe as those currently used. The authors suggest that implementation of these parameters in physiologic monitors may mitigate alarm fatigue. It will be most interesting to see if these findings can be replicated in adult and other settings. It would add a degree of rationality to setting alarm thresholds.

Not mentioned in any of the above studies and resources is the need to **ensure you have chosen the correct monitoring parameter**. We've done numerous columns about the limitations of pulse oximetry in patients on opioids and the need to use capnography to identify respiratory depression early. We've even noted how in patients with obstructive sleep apnea (OSA) you may hear audible pulse oximetry alarms when the patient's oxygenation desaturates. By the time a nurse or respiratory therapist responds, the patient may have awakened and now is breathing normally and has a normal oxygen saturation. Often the alarm is written off as a false alarm. Such contributes to both excessive noise and alarm fatigue yet allows the patient to be in a very vulnerable status.

We refer you back to our July 2, 2013 Patient Safety Tip of the Week "Issues in Alarm Management" for suggestions on how to approach your alarm management and links to some useful resources. Another great resource is Clinical Alarm Management Compendium from the AAMI Foundation (AAMI 2015). Many of you may have participated in the series of webinars on alarm management put on by AAMI in 2015. And, of course, ECRI Institute's Alarm Safety Resources is another valuable resource. And, by the way, Joint Commission Resources does make available a complimentary self-assessment process can help you maintain alarm safety in your organization. This is worth your while to help you prepare for your next Joint Commission survey.

Prior Patient Safety Tips of the Week pertaining to alarm-related issues:

- March 5, 2007 "Disabled Alarms"
- March 26, 2007 "Alarms Should Point to the Problem"
- April 2, 2007 "More Alarm Issues"
- June 19, 2007 "Unintended Consequences of Technological Solutons"
- April 1, 2008 "Pennsylvania PSA's FMEA on Telemetry Alarm Interventions"
- February 23, 2010 "Alarm Issues in the News Again"
- March 2, 2010 "Alarm Sensitivity: Early Detection vs. Alarm Fatigue"
- March 16, 2010 "A Patient Safety Scavenger Hunt"
- November 2010 "Alarms in the Operating Room"
- February 22, 2011 "Rethinking Alarms"
- February 2013 "Joint Commission Proposes New 2014 National Patient Safety Goal"
- May 2013 "Joint Commission Sentinel Event Alert: Alarm Safety"
- July 2, 2013 "Issues in Alarm Management"
- August 2013 "Joint Commission Formalizes 2014 NPSG on Alarm Management"
- February 4, 2014 "But What If the Battery Runs Low?"
- October 2014 "Alarm Fatigue: Reducing Unnecessary Telemetry Monitoring"
- December 15, 2015 "Vital Sign Monitoring at Night"
- February 9, 2016 "It was just a matter of time…"

Some of our prior columns on QT interval prolongation and Torsade de Pointes:

June 29, 2010 "Torsade de Pointes: Are Your Patients At Risk?"
February 5, 2013 "Antidepressants and QT Interval Prolongation"
April 9, 2013 "Mayo Clinic System Alerts for QT Interval Prolongation"
June 10, 2014 "Another Clinical Decision Support Tool to Avoid Torsade de Pointes"
April 2015 "Anesthesia and QTc Prolongation"

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ECRI Institute. Alarm Safety Resources.
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