Alarm Safety in 2017: Moving Beyond ECG Monitors

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Clinical Professor, UCSF; San Francisco, CA
• Discuss a comprehensive approach to alarm management that reduces non-actionable alarms while optimizing clinical responses for a broad array of clinical alarm systems.
A stroke patient on a tele unit was taken to x-ray. Upon return, the transporter put him in his room, but failed to notify the nurse; ECG monitoring was not resumed. An hour later, a nurse discovered the patient slumped over in a chair; attempts to resuscitate him were unsuccessful.
The Problem With Alarms

We count on alarms for notification of important physiologic changes.

Alarms occur with great frequency, and most do not require intervention.

100% response impossible → overload/fatigue → slowed/absent response.
How Do Alarms Work?

- Current designs = Frequent alarms
  - Highly sensitive – even minute changes detected
  - Not specific – does not distinguish if real or important

- Threshold technology
  - Alarm sounds when a specified threshold is breached (e.g., low HR at 50 bpm)
  - Thresholds are not integrated (e.g., asystole alarm with normal arterial BP). Smart Alarms are coming . . .
Question #1
Evidence based approaches to reduce alarm fatigue include:

a) Turning down the alarm volume
b) Reducing the time delay on physiologic alarms
c) Increasing the time delay on physiologic alarms
d) Defaulting alarms to ‘off’ when staff are with the patient
Evidence based approaches to reduce alarm fatigue include:

a) Turning down the alarm volume
b) Reducing the time delay on physiologic alarms
c) Increasing the time delay on physiologic alarms
d) Defaulting alarms to ‘off’ when staff are with the patient
How to Reduce Alarms

- Disable the parameter.
- Change the threshold.
- Increase the delay to allow “self correction”.

ON

OFF

MIN

MAX
Question #2
What percentage of alarms are non-actionable?

a) 40-50%
b) 50-60%
c) 60-75%
d) 74-99%
Question #2
What percentage of alarms are non-actionable?

a) 40-50%
b) 50-60%
c) 60-75%
d) 74-99%
32 papers met criteria, including 8 interventional studies.

Q: What proportion of alarms are actionable in adult (n=15) and pediatric patients (n=9)?

<table>
<thead>
<tr>
<th>Location</th>
<th>Adult</th>
<th>Pediatric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensive Care</td>
<td>&lt;1 – 26%</td>
<td>3-13%</td>
</tr>
<tr>
<td>Telemetry Ward</td>
<td>20-36%</td>
<td>1%</td>
</tr>
<tr>
<td>PACU</td>
<td>Combined Adult/Pedi = 17%</td>
<td></td>
</tr>
</tbody>
</table>

Q: What is the relationship between alarm frequency and response time?

Two studies evaluated alarm burden vs response

Response time 12.2 seconds slower in quartile of pts with highest frequency of alarms (57.6 sec) vs lowest (45.4 sec; p=0.046)*

Response time increased incrementally in pedi pts with frequent non-actionable alarms in prior 2 hrs (ICU p<0.001; ward p=.009)†

Q: What interventions are effective in reducing alarm frequency?

Eight studies, most with bundled interventions

- Widen default settings
- Increase alarm delays
- Reconfigure alarm acuity settings
- Disposable leads and/or daily electrode changes

Q: Are the proposed interventions safe for our patients?

Three studies specifically evaluated patient safety

- Rescue events and transfers to ICU decreased
- No acute decompensation events post intervention
- More true hypoxic events detected

Our Alarm “Make Over”

• Multidisciplinary team reviewed baseline data and formulated plan; committee approvals required

• Phase 1 – change default parameters to “actionable” settings

• Phase 2 – education regarding clinical policy/best practices from unit-based ‘alarm champion’ RNs
  o Focus on lead placement and electrode skin prep w/ daily change
  o Policy: RN to change Afib alarm ‘off’ for non-acute AF; change pacer alarm to ‘on’ when pacing may occur; no MD order needed
Monitoring Strategy

Predicted 65% reduction by eliminating: PVC pairs and runs, Multiform PVCs, Bi- and Tri-geminy, and redundancies.

Standardize HR defaults to 135, 50 and SpO2 88%.

Eliminate redundant alarms.

A Fib Alarm
Results: Yellow Alarms/Patient Day - Reductions By Unit

Overall Reduction 77%
From 9515 alarms/146 pts to 1901 alarms/130 pts

# alarms/pt/day

57% 59% 60% 77% 80% 82% 85% 85% 86% 88% 89%

Before
After
Reaudit 1 year later: Yellow Alarms/Patient Day By Unit
### Johns Hopkins Hospital – CVSICU Parameter Changes

**Table 1. Phase I Monitor Alarm Parameter Changes**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Manufacturer Alarm Settings (Adult ICU)</th>
<th>CVSICU Baseline Alarm Settings</th>
<th>CVSICU Alarm Settings Phase Ia</th>
<th>CVSICU Alarm Settings Phase Ib</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asystole</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
</tr>
<tr>
<td>Ventricular Tachycardia/Fibrillation</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
</tr>
<tr>
<td>Ventricular Tachycardia</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
</tr>
<tr>
<td>Ventricular Tachycardia &gt; 2</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Advisory*</td>
<td>Advisory</td>
</tr>
<tr>
<td>Ventricular Bradycardia</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
<td>Crisis</td>
</tr>
<tr>
<td>Accelerated Idioventricular Rhythm</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Pause</td>
<td>Message</td>
<td>Advisory</td>
<td>Advisory</td>
<td>Advisory</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>R Wave on T Wave</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Couplet</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Bigeminy</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Trigeminy</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Premature Ventricular Contraction</td>
<td>Advisory</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Irregular</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
<td>Message</td>
</tr>
<tr>
<td>Pulse Oximetry Probe Off</td>
<td>System Warning</td>
<td>System Warning</td>
<td>System Advisory*</td>
<td>System Advisory</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>50/150 Warning</td>
<td>50/120 Warning</td>
<td>50/120 Warning</td>
<td>50/130 Warning</td>
</tr>
<tr>
<td>Oxygen Saturation (%)</td>
<td>90</td>
<td>89</td>
<td>88*</td>
<td>88</td>
</tr>
<tr>
<td>Oxygen Saturation Alarm Delay (seconds)</td>
<td>5 seconds</td>
<td>5 seconds</td>
<td>15 seconds*</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Systolic BP High (mmHg)</td>
<td>200</td>
<td>150</td>
<td>150</td>
<td>170*</td>
</tr>
<tr>
<td>Systolic BP Low (mmHg)</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Diastolic BP High (mmHg)</td>
<td>120</td>
<td>110</td>
<td>110</td>
<td>130*</td>
</tr>
<tr>
<td>Diastolic BP Low (mmHg)</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>30*</td>
</tr>
</tbody>
</table>

* Phase Ia changes.
1 Phase Ib changes.

CVSICU, Cardiovascular Surgical ICU; BP, blood pressure.
Figure 3: As shown by quarterly reported event data, the numbers of CVSICU cardiac arrest or acute respiratory compromise events trended downward after initiation of the bundled set of physiologic monitor alarm interventions.

Telemetry Criteria

Gone Amuck

Question

A hospital establishes a complicated set of criteria for nurses to use in discontinuing telemetry, calling it a "standing order." Is this legal?

Response from Carolyn Buppert, MSN, JD Healthcare attorney

Is This Standing Order to Discontinue Telemetry Legal?

A reader says: "Our hospital in California has begun to roll out standing orders for registered nurses to discontinue telemetry monitoring on patients who have been on telemetry for 24 hours. The protocol says to discontinue telemetry when the following criteria are met:

- No episodes of heart rate <40 beats/min in the past 24 hours;
- No episodes of heart rate >120 beats/min in the past 24 hours;
- No troponin >0.04 ng/mL in the past 24 hours;
- Serum potassium >3.0 mEq/L and <5.7 mEq/L;
- No significant arrhythmias (no episodes of >4 consecutive premature ventricular contractions or pauses >3 seconds) in the past 24 hours;
- No evidence of chest pain, ST elevation myocardial infarction (STEMI), non-STEMI, or syncope;
- No coronary revascularization during this admission (percutaneous coronary intervention or coronary artery bypass graft);
- Not on telemetry for overdose or toxicology; and
- Not on intravenous (IV) haloperidol, IV amiodarone, IV beta-blockers, or IV calcium channel blockers.

We feel that this is outside of our scope of practice. What do you think?"

A Bad Idea
Question #3
In 2016, National Patient Safety Goal 06.01.01 requires all of the following EXCEPT:

a) Identify important alarms to address by facility.
b) Develop policies and procedures to address alarm safety.
c) Educate staff and physicians regarding alarm safety.
d) Establish a Biomedical Safety Committee to approve all alarm related policies.
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**NPG.06.01.01**

**Improve the safety of clinical alarm systems**

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### TJC Elements of Performance

<table>
<thead>
<tr>
<th>Nbr</th>
<th>Elements of Performance (EPs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leaders establish alarm system safety as a hospital priority.</td>
</tr>
<tr>
<td></td>
<td>- Identify the most important alarm signals to manage.</td>
</tr>
<tr>
<td></td>
<td>- Input from the medical staff and clinical departments.</td>
</tr>
<tr>
<td></td>
<td>- Risk to patients if the alarm signal is not attended to or if it malfunctions.</td>
</tr>
<tr>
<td></td>
<td>- Whether specific alarm signals are needed or unnecessarily contribute to alarm noise and alarm fatigue.</td>
</tr>
<tr>
<td></td>
<td>- Potential for patient harm based on incident history.</td>
</tr>
<tr>
<td></td>
<td>- Published best practices and guidelines.</td>
</tr>
<tr>
<td></td>
<td>(For more information on managing medical equipment risks, refer to Standard EC.02.04.01.)</td>
</tr>
</tbody>
</table>

| 2   | Identify the most important alarm signals to manage. |
|     | - Establish policies and procedures for managing the alarms identified in EP 2 above that, at a minimum, address the following: |
|     |   - Clinically appropriate settings for alarm signals. |
|     |   - When alarm signals can be disabled. |
|     |   - When alarm parameters can be changed. |
|     |   - Who in the organization has the authority to set alarm parameters. |
|     |   - Who in the organization has the authority to change alarm parameters. |
|     |   - Who in the organization has the authority to set alarm parameters to "off". |
|     |   - Monitoring and responding to alarm signals. |
|     |   - Checking individual alarm signals for accurate settings, proper operation, and detectability. |
|     | (For more information, refer to Standard EC.02.04.03.) |

| 3   | Educate staff and licensed independent practitioners about the purpose and proper operation of alarm systems for which they are responsible. |
What Are Your Alarm Priorities?!?

- Warming Devices
- Infusion Pumps
- Foot Pumps
- Bed Alarms
- SpO2 Monitors
- Ventilators/CPAP
- Hemodynamics
Infusion Pump Alarms

- Reports/observations of frequent alarms
- Interdisciplinary task force formed
- Gathered data: nursing survey to explore issues

### Alaris Infusion Pump Alarm Questionnaire for Nursing Staff at CPMC

#### Alaris Pump Alarm Questionnaire

1. How important are infusion pump alarms to patient safety?

<table>
<thead>
<tr>
<th>Not Very Important</th>
<th>Somewhat Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. How likely are you to respond to an infusion pump alarm within 2-5 minutes?

<table>
<thead>
<tr>
<th>Not Very Likely</th>
<th>Somewhat Likely</th>
<th>Very Likely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. The following pump alarms occur most often. Please rate your knowledge of how to *prevent* these pump alarms from occurring.

   | Patient Side Occlusion Alarm (Flow has occluded at patient & infusion is stopped) |
   |---------------------------------|-------------------------------|-------------------------------|-------------------------------|
   | Limited                         | Adequate                      | Excellent                     |                               |
   |                                  |                               |                               |                               |
RN responses: how to reduce infusion pump alarms (n=253)

- Careful priming of the line will help prevent a lot of air bubbles.
- Pausing the infusion only gives a minute, not long enough for a patient to go to the bathroom.
- Stocking IV pumps. They need to be plugged into an outlet. All the IV pumps have dead batteries in supply room.
- Get the prior nurse to set up the pump correctly.
- Educate patient about avoiding occlusion on patient side.
Question #4
Effective strategies to reduce infusion pump alarms include:

a) Defaulting most alarm parameters to “off”
b) Optimizing delays for self-correction of alarms
c) Educating ancillary staff to silence alarms more quickly
d) Programming alarms to alert pharmacy of medication errors
Effective strategies to reduce infusion pump alarms include:

a) Defaulting most alarm parameters to “off”
b) **Optimizing delays for self correction of alarms**
c) Educating ancillary staff to silence alarms more quickly
d) Programming alarms to alert pharmacy of medication errors
Baseline Alarm Frequencies

Infusion Pump Alarms (Top 5) 3Q 2015

- Patient Side Occlusion Alarm: 120,000
- Bolus Air In Line Alarm: 80,000
- Door Closed Alarm: 60,000
- Free Flow Alarm: 40,000
- Door Opened Alarm: 20,000

215,000 Alarms per Qtr
2,237 Alarms per day

- California
- St. Luke's
- Davies
- Pacific
Nurse to administer Vedolizumab, starts infusion at 9:19

First alarm at 9:30

Nurse spends 22 minutes trying to correct alarm

Infusion pump sounds 26 times!
There go our HCAPS!

SO, YOU JUST GOT YOUR PATIENT TO SLEEP?

LET ME PLAY YOU THE SONG OF MY PEOPLE!
Opportunity: Auto-Restart Alarm

- >50% of pump alarms were due to patient side occlusion
- Re-configuration of ‘Auto-Restart’ recommended
  - Feature gives patient 15 seconds to straighten their arm, allowing infusion to continue automatically if self corrected
  - Learned all pumps had this defaulted “off” (0 attempts to correct)

- Change implemented: Auto-Restart attempts added
  - 4 attempts to correct - critical care, NICU/PICU, peds
  - 8 attempts to correct - telemetry, med-surg, OB
Results: Auto-Restart Change Implemented

Change in Alarms After 30 Days

- Pac: -3.4%
- Cal: -8.1%
- Dav: -17.7%
- STL: -19.2%

Pt Side Occlusion Alarms/Patient Day
Total Number of Alarms/Patient Day
Over **350 hours** of nursing time spent on Air-In-Line alarm each month *alone*
Air-In-Line: Alarm Frequency

<table>
<thead>
<tr>
<th>Alarm Type</th>
<th>Care Area Profile</th>
<th>July 2016 Alarms</th>
<th>% AIL Alarms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolus Air In Line Alarm</td>
<td>Critical Care</td>
<td>4,001</td>
<td>39%</td>
</tr>
<tr>
<td>Bolus Air In Line Alarm</td>
<td>Floor</td>
<td>3,100</td>
<td>30%</td>
</tr>
<tr>
<td>Bolus Air In Line Alarm</td>
<td>Oncology</td>
<td>1,794</td>
<td>17%</td>
</tr>
<tr>
<td>Bolus Air In Line Alarm</td>
<td>Telemetry</td>
<td>1,087</td>
<td>11%</td>
</tr>
<tr>
<td>Bolus Air In Line Alarm</td>
<td>Step Down</td>
<td>325</td>
<td>3%</td>
</tr>
</tbody>
</table>
Air-In-Line: Nursing Audit

- Estimating volume when programming?
  - 53% underestimate

- Adding volume when Infusion Complete?
  - 52% are adding volume

- How far above pump is primary bag?
  - 19% hanging >20 inches above pump

- Where was pump in relation to patient?
  - 24% at level of patient’s heart
Alarm Intervention: Education

- Consultant available 5-days all campuses/units
- Topics included:
  - Proper set-up, including priming
  - Air-in-line mitigation techniques
  - Quick start/Restore
  - Tamper resistant feature
  - Use of guardrails
- Feedback from nurses overwhelmingly positive
  - Requested additional in-services
  - Piggyback (secondary) alarms identified as knowledge deficit
Tools for Ongoing Education

- Tip Sheets
- Video Training
- Newsletter Quick Tips
- Hang Tag for Pumps
- Additional Classes

Alaris Infusion Pump

Overview

The Alaris Infusion pump software utilizes a drug library designed to facilitate programming. The software uses upper and lower dosing limits called Upl and lown limits to prevent programming errors.

The Guardrails® drug and IV fluid list and limits were developed by a functional team from this facility. There may be some entries that are not needed for your clinical use. If you would like to see change drug or IV fluid list or limits, please contact a pharmacy supervisor with that information:

- contact information
- campus and profile area
- what is to be changed and why

Alaris Training Videos: Click on the link below and enter code "8" for instruct for Guardrail programming, Pump Module set-up, PCA Module set-up.


Alaris Documents

- Alaris Infusion Pump Manual
- Alaris Infusion Pump Usage Guide
- PCA Module Pocket Guide
- PCA Module Tip Sheet
- Tip Sheet - Air-in-Line Reduction
- Tip Sheet - Secondary Infusion Setup
- Tip Sheet - Set Loading and Unloading Guide
- Tip Sheet - Set Loading Guide (Improper Setup)
Sustaining Change: System-Wide Alarm Policy

POLICY AND PURPOSE

Alarm management is a Joint Commission National Patient Safety Goal (NPSG.06.01.01) that this organization has identified as a priority. Clinical alarm systems are intended to alert caregivers to an important change in the patient's physiologic condition or a medical device equipment issue and, if not managed properly, can compromise patient safety.
# Alarm Priority Levels Established

Modified from policy provided by Johns Hopkins Medical Center

<table>
<thead>
<tr>
<th>Priority</th>
<th>Criteria</th>
<th>Response Time</th>
<th>Level of Oversight</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>• Potentially life-threatening, loud audible alarm</td>
<td>Immediate</td>
<td>Need for close observation of patient and device all or most of time*</td>
</tr>
<tr>
<td></td>
<td>• Inattention could result in permanent harm or death</td>
<td>Goal &lt;2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>minutes</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>• Not life-threatening, medium priority, audible warning</td>
<td>Rapid</td>
<td>Need for close observation of patient and device many times throughout shift</td>
</tr>
<tr>
<td></td>
<td>• Non-emergent; requires attention as quickly as possible</td>
<td>Goal 2-5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>minutes</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>• No harm to patient if evaluated within short time period</td>
<td>As soon as</td>
<td>No need for intervention throughout shift anticipated or patient harm if unattended</td>
</tr>
<tr>
<td></td>
<td>• Audible advisory signal indicates need for reassessment</td>
<td>possible</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goal 5-7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>minutes</td>
<td></td>
</tr>
</tbody>
</table>
Alarm Safety for EVERY Employee and Physician

- Ensure that alarms are activated with adequate volume to be heard
- Ensure that critical alarms (e.g., a life-threatening condition) are not turned off under any circumstance
  - OK to pause/silence briefly when appropriate staff are at bedside
- Provide a timely response:
  - Any employee who hears an alarm should investigate; if response is out of their scope, notify appropriate staff immediately
  - Trouble shoot alarm conditions and provide appropriate actions
  - Remain with patient until help arrives
- Report any device malfunction and remove defective equipment from patient care areas
Summary

- The Joint Commission NPSG requires us to address alarm safety for ALL alarms.
- Performance improvement strategies can result in dramatic results.
- There are still some relatively easy “wins” to be had.
- Bedside staff are critical participants in all aspects of alarm safety.