

Physiologic Alarm Management

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In response to an inquiry, analysts from the Pennsylvania Patient Safety Authority queried the Authority's reporting system database for event reports of patient deaths related to physiologic alarm monitoring from June 2004 through December 2010. Using the keywords *alarm*, *monitor*, *ECG* [electrocardiogram], *telemetry*, *pulse-ox*, and *defibrillator* in combination with *intensive care unit* or *telemetry unit*, where death was mentioned or harm score signified death (i.e., "I"), staff identified 187 reports. Thirty-five of the event reports indicated that patient death was related to some aspect of physiologic alarm management. The 35 event reports referenced the following types of monitoring equipment:

- Blood pressure machine (n = 1)
- Bilevel positive airway pressure machines (n = 2)
- Ventilators (n = 4)
- Telemetry monitors (n = 28)

The reports were categorized as either equipment (n = 4) or human (n = 31) failures (see Table 1).

HUMAN FAILURE

Equipment Not Connected

Forty-five percent (n = 14) of the human failures were related to disconnected monitoring equipment. Eight of the cases concerned patients found in rooms with disconnected equipment, including the following:

The nurse went in to check on the patient. [Patient was] put back on monitor, patient was in asystole. A code was called, [and staff were] unable to resuscitate patient . . .

[Elderly] female brought to emergency department [ED] . . . She was inadvertently off telemetry when she was found unresponsive and expired . . .

A patient was admitted through the ED . . . Admission orders include telemetry monitoring—nurse entered room and found patient unresponsive. A code was called and the patient was transferred to the intensive care unit. Later, [the patient] coded again and expired. . . . Discovered that telemetry monitoring was never initiated on admission to floor . . .

A nurse responded to the patient's IV [intravenous] pump alarm and found the patient unresponsive and pulseless. Cardiac leads were found to be disconnected from the monitor cable. The physician was immediately notified . . . the patient was pronounced dead.

Physiologic monitoring systems generate visual and audible alarm signals based on changes in patient physiologic conditions that exceed established alarm criteria for a specific patient or a particular patient population.¹ When monitoring equipment disconnects, or is left unconnected from the patient, important safety signals are not generated.

Monitoring Equipment during Diagnostic Testing

Six of the reports concerned patients who had been transported out of the unit for diagnostic tests, including the following:

The patient [required transfer to a higher level of] care. While preparing for transfer, the patient was discharged from the stationary telemetry, [so the patient could] be placed on a portable monitor. Prior to placement of the portable monitor [after approximately

Table 1. Patient Deaths Related to Physiologic Alarm Monitoring, Human versus Equipment Failures, Reported to the Authority, June 2004 through December 2010

FAILURE	NUMBER
STAFF	
Equipment not connected	14
Monitoring equipment during diagnostic testing	6
Inadequate response to alarms	6
Alarms silenced	4
Unknown	1
Total	31
EQUIPMENT	
Home equipment used in hospital without alarm capability	2
Manufacturer default setting caused battery to power down	1
Possible ventilator unit failure	1
Total	4

12 minutes], the patient was found unresponsive. . . . The patient was resuscitated and transferred and the patient expired . . .

The patient was received in CT [computed tomography] suite and placed on the scanner. No monitoring of vital signs was performed in radiology; the patient had been on a telemetry unit. When the patient was placed back in the radiology waiting area, the family alerted staff to the absence of respirations. Unsuccessful resuscitation efforts . . .

The patient was taken to radiology for an x-ray. Upon return to the ED, the patient was not placed [back on] the cardiac monitor. Approximately twenty minutes [later], the patient was found unresponsive and pulseless . . . the patient expired.

A telemetry patient was transported unaccompanied by nursing to CT [computed tomography], contrary to unit policy. After the CT [scan] was completed the patient was

awaiting transport and was discovered unresponsive . . .

A key function of monitoring systems is to alert appropriate staff to a change in patient condition so that staff can promptly intervene with the appropriate care.¹ When patients are transported without monitoring systems, or when they are left unmonitored before, during, or after diagnostic tests, staff is deprived of both audible and visual cues that would alert them to deterioration in patient status. While it is not possible to know with certainty that these patients would have survived if staff had received timely alarm cues, the event reports do illustrate the dangers of patient transport without necessary monitoring equipment.

Inadequate Response to Alarms

Six event reports concerned inadequate response to the physiologic alarm. In four events, the nurse assigned to the patient was busy caring for another patient and did not or could not respond to the alarm in a timely manner. In one case, a patient walked off the telemetry unit and entered

an unmonitored area of the facility. In another case, a team of healthcare providers was in the room when the ventilator alarm sounded and yet did not appear to respond quickly to the alarm, for reasons that were not clarified within the event report. However, the report did recommend training to avoid “desensitization to alarms.”

Alarms Silenced

Alarms were silenced in four events reported to the Authority. Three events involved telemetry alarms. In one event, a telemetry technician silenced the alarm of a patient with metastatic disease. In the second event, the floor nurse had silenced the telemetry alarm in the room and was relying solely on the telemetry technician (who was performing additional duties while watching the monitors) to relay alarm information. The third event involved a patient in the critical care unit, whose nurse silenced the telemetry alarms. A resident found the patient unresponsive approximately 40 minutes after the nurse documented her assessment. Finally, a noninvasive blood pressure monitoring system had been silenced and the patient was found hypotensive and hypothermic; resuscitation efforts were unsuccessful.

EQUIPMENT FAILURES

Four of the events reported to the Authority were related to equipment failures. In two of the cases, patients came to the hospital with bilevel positive airway pressure machines that did not have alarm capabilities. Both patients’ equipment failed and both were found after telemetry technicians alerted staff to abnormal heart rates. In the third case, a default setting by the telemetry manufacturer to conserve battery power caused telemetry units to automatically power down after ten minutes of nonusable waveform. In this instance, the battery needed to be manually removed and replaced to restart accurate telemetry monitoring. The

fourth case concerned a possible ventilator unit failure.

FACILITY SPECIFIED CONTRIBUTING FACTOR DATA

The Pennsylvania facilities reported 102 potential contributing factors associated with the 35 events (see Table 2). The categories with the highest number of factors were communication problems between providers ($n = 14$; 13.7%), workplace distraction and interruptions ($n = 14$; 13.7%), procedures not followed ($n = 12$; 11.8%), and training issues ($n = 8$; 7.8%).

The Authority previously published information on physiologic alarm management. Several risk mitigation strategies were included in the publication, all of which remain important in light of these recent findings:¹

- Placing slave displays and alarm enunciators in strategic locations throughout a telemetry care area
- Developing a protocol for setting the volume level of an alarm to higher than the minimum audible level that can be heard in a typical environmental noise level for given care area (the volume level setting will be specific to the noise level for each healthcare facility's care area environment)
- Developing standardized practices for periodic ECG-electrode and lead-set inspection and replacement and proper electrode-site skin preparation
- Developing a protocol that requires prompt response for all alarm conditions (low-, medium-, high-priority alarms)
- Developing a protocol that establishes alarm limit default settings based on a particular patient population in a given care area
- Developing protocols that establish criteria for when and how to adjust alarm default limits per patient condition

Table 2: Potential Contributing Factors to Patient Deaths Related to Physiologic Alarm Monitoring Reported to the Authority, June 2004 through December 2010

POTENTIAL CONTRIBUTING FACTOR	NUMBER
Team	
Communication problems between providers	14
Shift change	4
Cross-coverage situation	2
Unplanned workload increase	2
Total	22
Work Environment	
Distractions/interruptions	14
Limited access to patient information	3
High noise level	2
Equipment availability	2
Total	21
Task	
Training issues	8
Cardiac/respiratory arrest situation	7
Emergency situation	2
Inexperienced staff	1
Order-entry system problem	1
Total	19
Staff	
Inadequate system for covering patient care	3
Issues related to proficiency	3
Use of float staff	2
Insufficient staffing	2
Total	10
Patient Characteristics	
Patient compliance	7
Patient understanding	2
Total	9
Organizational/Management	
Procedures not followed	12
Unclear policies and procedures	5
Inadequate bed availability	2
Lack of policies and procedures	1
Presence of boarding patients	1
Total	21

- Developing protocols to delineate responsibility for primary alarm response and to establish tiers of backup alarm coverage

Alarm management is a critical issue for all Pennsylvania facilities. The 35 patient deaths and 102 associated potential contributing factors that were reported

to the Authority illustrate a wide variety of reasons for alarm management failure and suggest focus areas for improved alarm management strategies. Basic staff interventions (i.e., education regarding physiologic alarms, clear lines of responsibility for responding to alarms, discouraging silenced alarms) can be

paired with equipment management interventions (i.e., scheduled equipment testing, replacement, and battery change; alarm audibility testing; policies for alarm default limits) for maximum impact. Facilities can also monitor for alarm desensitization in both primary care staff and remote monitoring technicians.

NOTE

1. Alarm interventions during medical telemetry monitoring: a failure mode and effects analysis [online]. Pa Patient Saf Advis 2008 Mar [cited 2011 Aug 3]. Available from Internet: [http://patientsafetyauthority.org/ADVISORIES/AdvisoryLibrary/2008/mar5\(suppl_rev\)/Pages/mar5\(supplrev\).aspx](http://patientsafetyauthority.org/ADVISORIES/AdvisoryLibrary/2008/mar5(suppl_rev)/Pages/mar5(supplrev).aspx).

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