



Interpretation of Alarm in the ICU

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Introduction

The hallmark of an intensive care unit (ICU) is intense continuous monitoring that allows for acute identification and management of physiologic derangements. Nobody could disagree with the idea that patients would benefit from clinicians being alerted to sudden changes in their physiology that may be detrimental. An alarm is an automatic warning that results from a measurement, or any other acquisition of descriptors of a state, and indicates a relevant deviation from a normal state⁽¹⁾.

all available monitoring systems mainly work with the principle of threshold alarms. Users can specify upper and lower alarm limits, and alarms are generated as soon as the measured values surpass or fall below the thresholds. This technique can be useful in determining physiologic limits of variation of parameters⁽²⁾. The high number of false positive alarms has long been known to be a serious problem in critical care medicine – yet it remains unresolved. This “false alarm fatigue” causes workers’ response times to slow, and leads to detrimental decreases in the quality of patient care⁽³⁾.

At the same time, threats to patient safety due to missing or suppressed alarms are being reported.

Alarm Design

Alarms are typically displayed in two ways or as a combination of both:

1. Acoustic

The alarm is given as a warning sound. Alarms directly mentioning organ systems, device hardware, or parts of it (e. g., ventilation or circulation) or alarms with direct labeling of the physiological problem ('blood pressure' or 'oxygen') have also not been introduced into practice⁽⁴⁾.

2. Visual

Visual alarms involve mostly flashing or coloring of the related parameter in an eye-catching manner.

Alarms in the Hospital

In general, there are three types of clinical alarms in the hospital

1. Arrhythmia alarms: detect a change in cardiac rhythm
2. Parameter violation alarms(threshold alarms): detect when a vital sign (e.g., heart rate, blood pressure, etc.) exceeds the alarm limit settings

3. Technical alarms: indicate poor signal quality (e.g., low battery in a telemetry device)

‘Alarms on acute care units are generated from any number of devices – infusion pumps, respiratory monitoring equipment, feeding pumps, sequential compression devices, cardiac monitors, ventilators, and patient call systems’.

Goals of Clinical Alarms

‘An ideal alarm should only detect immediate or threatening danger that requires prompt attention’.

Device alarms may have levels (or categories) of alarms which

may or may not follow a hierarchical order⁽⁵⁾

An example of this hierarchical order can be seen in a physiologic monitor:

5 D’s

- Detection of life-threatening situations (crisis alarm),
- Detection of life-threatening device malfunction (system failure)
- Detection of imminent danger (warning alarm),
- Detection of potential device malfunction (system warning),
- Detection of unsafe situation (advisory alarm). The severity of the alarm can be determined by the type of sound emitted.

Goals of alarm

‘These systems are intended to alert the clinician regarding a deviation from a predetermined normal status and are considered to be a key tool to improving the safety of patients by communicating information that requires a response or awareness by the operator’⁽⁶⁾

The needle in the haystack

(what alarms are looking for)

- Physiological events
- Gradual and continuous over time
- multiple physiological parameters

Variable

- ◆ In a single patient
- ◆ Between patients

In relation to time

Alarm systems that are used today..

Follow a single parameter (e.g. heart rate)

- Are boundary based
- Have fixed, audiovisual output
- Are discrete
- Are unaware of interventions

Alarm Sensitivity

- 86% are false readings
- 6% are true but clinically insignificant
- 8% are significant*
- For some devices - only 2% are significant⁽⁷⁾

Alarm-Related Problems

Alarms help to prevent patient harm by providing rapid recognition of and reaction to critical situations, but only if they are not 'false alarms'.

Medical

Progress leads to an increasing number of 'monitorable' parameters and thus an increasing number of possible alarms.

False alarms

Studies done in the 1990’s showed that the rate of false alarms is high^(8,9). 'better-safe-than-sorry'-logic’ A large number of false alarms are accepted rather than risking missing one valid alarm⁽¹⁰⁾.

Artifacts: a common source of false alarm

Most of these artifacts directly influence the measured signals⁽¹¹⁾, leading to incorrect measurements and this, in turn, triggers the alarm. Most common artifacts in day to day practice is shown in table-1.

Table-1

Signal	Artifact source	Parameter
Ventilatory alarms		
Pulse Oxymetry	Movement Interpretation of blood flow by NIBP Measurement Ambient light	Oxygen saturation Pulse frequency
Capnography	Occlusion of CO2-line Ventilator circuit leakage Atmospheric pressure variation Suctioning Dead Space measuring circuit	End tidal CO2 Inspired CO2 Respiratory rate
Hemodynamic Alarms		
ECG	Electro surgical infrerence Power point interference Movement Electrode instability Incorrect lead contact Pacing	HR ST-values Arrhythmia detection
Signal	Artifact Source	Parameter
NIBP	Movement Inadequate Size of cuff Cuff compression Kinked cuff tubing and leaking cuff bladder	Systolic/Diastolic Bp. Mean arterial Pressure
Other Alarms		
Temperature	Dislocated sensor	Temperature

Consequence of false alarm:

“Crying wolf phenomena: for the desensitization caused by high false alarm rates, with the possible consequence of ignoring relevant alarms⁽¹²⁾.

‘The high incidence of false alarms in Anaesthesiology & CCM is not only a disturbance but risk factors when relevant alarm in critical situations are ignored’.

Alarm fatigue

‘It is ironic that the very alarms that are meant to protect patients have instead led to increased unit noise, alarm fatigue and a false sense of security’.

Effective Clinical Alarm Management

Key sources for alarm overload are false-positive alarms, technical alarms, inappropriate protocols for alarm inactivation, inappropriate alarm limits and settings, overutilization of patient monitoring in some instances, and under-utilization of alarms in other settings.

Trends for the Future

The perfect alarm system should signal clinically relevant data exclusively and contribute to clinical decision-making⁽¹³⁾. In order to accomplish this, several features must be present. First, the alarm should signal only when the event is real, a feature of instrument sensitivity. Secondly, the alarm should not be activated in the absence of the event, which represents specificity of the instrument. Thirdly, the alarm signal should offer positive/negative predictive value, which reflects accuracy of the instrument.

Conclusion

Medical progress has led to obvious improvements in ICU and perioperative monitoring over recent decades. With the increase in 'monitored' parameters, rates of alarms have also increased. But technical progress has rarely affected the rates of false alarms. In addition to noise-related increase in burn-out rates, false alarms lead to desensitization of medical staff to alarms with the risk of critical situations potentially being ignored despite correct alarming. Patients are also directly affected by alarm-related sleep disorders with subsequent development of delirium and increased sympathetic nervous system activity and catecholamine secretion. Alarms should never be completely silenced; clinical staff should instead problem solve why an alarm condition is occurring and work to

resolve it .Cardiac monitor devices have a high sensitivity for detecting arrhythmias and vital sign changes but a low specificity ,Therefore, they generate many false positive alarms. Clinicians should learn to tailor alarm thresholds to individual patients to avoid excessive alarms and alarm fatigue

Alarm safety is a National Patient Safety Goal, highlighting the importance of developing institutional policies and standards to reduce the burden on clinicians, while ensuring patient safety

In recent years, many promising approaches using statistical methods and artificial intelligence have been developed for the reduction of false alarms without obvious changes in false alarm rates in our clinical reality.

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