

The response of theatre personnel to the pulse oximeter alarm

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Keywords: alarm, pulse oximeter, anaesthesia, anaesthesiologist, alertness

Abstract

Background: False alarms and sounds in the operating theatre (OT) that alert personnel to a crisis can be irritating. This can result in personnel ignoring genuine alarm warnings. This study was carried out to determine how alert OT personnel are in response to the pulse oximeter alarm.

Method: For the purposes of the study, 144 elective and 126 emergency cases, comprising 189 general anaesthesia and 81 regional anaesthesia cases, were included. After ensuring that the patients were physiologically stable, a false pulse oximeter alarm was activated. No other alarms were triggered. The first person to respond, time taken to respond, and the mode of action taken, were recorded. If no action resulted, the alarm was terminated a minute later.

Results: The anaesthesiologist was the most alert (p -value < 0.05), with a median time taken to respond of nine (4-14) seconds. The emergency OT personnel were significantly more alert than the elective OT personnel, with a p -value of < 0.001 . The level of readiness was similar in both general anaesthesia and regional anaesthesia cases [9.5 seconds (4.0-14.05) vs. 10 seconds (5-15)]. In 53% of cases, the first person to respond attended to the patients; in 30.7% of cases, they checked the monitor; and in 5.6% of cases, the pulse oximeter alarm was deactivated. The pulse oximeter alarm was ignored, and no action taken, in 10.7% of cases.

Conclusion: The anaesthesiologists were the most alert in responding to the pulse oximetry alarm, although, alarmingly, no action was taken in 10.7% of cases.

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South Afr J Anaesth Analg 2012;18(2):101-104

Introduction

The responsibility of the anaesthesiologist, surgeons, nurses and operation theatre (OT) assistants towards patients in the OT varies, according to their given tasks and duties. The main aim is to prevent morbidity and mortality, and to ensure patient safety. In 2010, the American Society of Anesthesiologists (ASA) recommended that the anaesthesiologist must be in the OT, regardless of whether the cases are being handled under general, or regional anaesthesia, and that standard monitoring, including an electrocardiogram (ECG), capnograph, pulse oximeter, and blood pressure, should be applied at all times, i.e. during elective, day, emergency, or monitored anaesthesia care.¹ The various physiological parameters should be monitored continuously, on a real-time basis, or intermittently, at specific time intervals.^{1,2} The ASA and the

American Association of Nurse Anaesthetists have adopted the Anaesthesia Patient Safety Foundation's alarm summit recommendations (2004), which state that the variable-pitch pulse oximeter tone and capnography auditory alarm should always be on, and audible.³

The ability of anaesthesiologists to appreciate changes in patients' physiological status may be limited, as it has been shown that the vigilance of anaesthesiologists and residents may be affected by fatigue associated with long working hours.⁴ Monitors help to provide prompt and reliable warnings of deranged physiological variables and deteriorating trends in a patient's condition, as well as equipment malfunction, thereby allowing corrective measures to be taken. Therefore, the auditory and visual alarms annexed to all equipment are very important.^{5,6} Anaesthesiologists are responsible for patients' physiological stability, and apart from using clinical

assessment, rely to a great extent on equipment monitoring of the patient.⁵

Auditory alarms are effective in seizing the anaesthesiologist's attention, and allow him or her to perform time-shared tasks more effectively.^{5,6} Morris and Montano suggested that it is safer to rely on auditory, rather than visual, alarms, where time-critical information, such as oxygenation, heart beat, and ventilation disconnection, is concerned.⁵ Loeb and Fitch found that anaesthesiologists spend less than one-third of their overall time looking at monitors, and that this may limit their ability to receive information from the visual display.⁶ However, they also found that, with a combination of auditory and visual alarms, events were identified faster.

Unnecessary alarms can be irritating,⁷ contribute to ambient noise,⁸ and may not be well tolerated by clinicians, co-workers and patients.⁹ Edworthy and Hellier suggest that alarm designs are less than ideal, that they are used too often, and that the rate of false alarms is often exceedingly high due to inappropriately set trigger points.¹⁰ The current study was carried out to determine how alert OT personnel are in response to the pulse oximeter alarm in the OT.

Method

This observational study was conducted from April 2009-July 2010, following the granting of approval by the dissertation committee of the Department of Anaesthesiology and Intensive Care, and the research and ethics committee, Universiti Kebangsaan Malaysia Medical Centre (UKMMC). All elective and emergency cases comprising ASA physical status I or II patients, between the ages of 12 -70 years, and performed under either general or regional anaesthesia were included.

General surgical, orthopaedic, obstetric, gynaecological, urological, maxillofacial, ophthalmic, neurosurgery, and otorhinolaryngology surgical cases were selected using simple randomisation. Systems to monitor the anaesthesia included Datex Ohmeda®, Datex Engstrom® and Siemens SC6002XL®. All the pulse oximeter monitors used in this study feature both visual and auditory alarms. The pitch and tone of the alarms are not standardised, and the setting of these is left to OT personnel. The false pulse oximeter alarm was triggered by the investigator, after ensuring that the patient's parameters were stable. These stable parameters included SpO₂ > 98%, systolic blood pressure (BP) 100-150 mmHg, diastolic BP 60-90 mmHg, heart rate 50-100 beats per minute with sinus rhythm, and EtCO₂ levels at 30-45 mmHg. The investigator identified and recorded the first person to respond to the alarm, the time taken to do so, and the mode of action taken. If no action resulted after one minute, the false alarm was terminated and the study terminated.

The responders were categorised into anaesthesiologists (including consultants, specialists and registrars), surgeons (including consultants, specialists and registrars) and nurses. The time taken from the moment that the alarm was triggered, to enactment of the first response, was considered to be the response time. The mode of action was classified as "action taken", or "no action taken". Alertness was defined as the time taken, in seconds, to respond to the triggered false pulse oximeter alarm.

Statistical analysis

The study was designed to achieve a prevalence of 20%, with five per cent precision. The calculated sample size was 270, which included a 10% dropout rate. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS version 19.0, Chicago, IL) software. All categorical variables were expressed as frequency. Non-normally distributed data were expressed as median and interquartile range (IQR), and analysed using bivariate analysis, using either the Mann-Whitney (MW) or Kruskal-Wallis (KW) method. A p-value of less than 0.05 was considered to be statistically significant.

Results

Two-hundred and seventy cases, from eight different surgical disciplines, were included in this observational study. There were no dropouts. The majority of cases dealt with comprised those undergoing general surgery, and orthopaedic cases (Table I).

Table I: Distribution of cases from various disciplines

Surgical disciplines	Number of cases (%)
General surgery	71 (26.3%)
Orthopaedic	69 (25.6%)
Obstetrics and gynaecology	39 (14.4%)
Urology	32 (11.9%)
Maxillofacial	24 (8.9%)
Ophthalmology	16 (5.9%)
Neurosurgery	11 (4.1%)
Otorhinolaryngology	8 (3.0%)
Total	270

This study shows that anaesthesiologists were the majority of first responders to the triggered false pulse oximeter alarm, and took a median time of nine seconds (IQR 4-14). The overall median time taken by those who were first to respond was 10 seconds (IQR 5-15). There was no significant difference in the degree of alertness when there was one, or more, anaesthesiologists in the OT. The study also showed that OT emergency personnel were significantly more alert to the triggered false pulse oximetry alarm, than those in

the elective OT. The degree of alertness was similar in both general and regional anaesthetic cases (Table II).

Table II: Comparison of degree of alertness of operating theatre personnel in terms of type of case, mode of anaesthesia and personnel who noticed the alarm

	Total	Median in seconds (IQR ^a)	p-value
Operating theatre			
Elective	144	10.0 (5-15)	< 0.001
Emergency	126	9.5 (4.5-14.5)	
Mode of anaesthesia			
General	189	10.0 (5-15)	0.18
Regional	81	9.0 (4-14)	
Person who noticed the alarm			
Anaesthesiologists	180	9.0 (4-14)	< 0.001
Surgeons	14	10.0 (5-15)	
Nurses	59	10.0 (5-15)	

a = interquartile range

In 89.3% of cases, action was taken in response to the triggered false pulse oximeter alarm. However, in 10.7% of cases, there was no response from the OT personnel to the false pulse oximetry alarm within the one-minute study duration (Table III).

Table III: Reaction of the OT personnel to the false alarm

Mode of action	Total, n (%)
Action taken	
Attended to the patient	143 (53.0%)
Checked the pulse oximeter	83 (30.7%)
Alarm was silenced	15 (5.6%)
No action taken	
Noticed, but no action taken	12 (4.4%)
Sound of false alarm went unnoticed	17 (6.3%)

Discussion

This study used a combination of auditory and visual alarms. We found that anaesthesiologists were the most alert OT personnel to the sound of the pulse oximeter alarm, and their median of responsiveness was 9 seconds (4-14). An earlier study by McIntyre found that anaesthesiologists reacted more quickly to critical events highlighted by an auditory alarm, or a combination of auditory and visual alarms, than a visual alarm alone.⁴ Morris and Montano found that the responsiveness of anaesthesiologists to auditory alarms was only one second, but it took them six seconds to respond to visual alarms.⁵ Loeb and Fitch found that anaesthesiologists responded to critical events more rapidly on the basis of combined auditory and visual alarms

(10.4 seconds), than on the basis of the visual alarm (12.8 seconds), or auditory alarm (13 seconds) alone.⁶

This study also found that personnel in the emergency OT were significantly more alert to the pulse oximeter alarm, than those in the elective OT. A multicentred study comparing hospital performance in emergency vs. elective general surgery, showed that patients undergoing emergency surgical procedures were at substantially greater risk of morbidity and mortality than those who had opted for elective surgical procedures.¹¹ This awareness among OT personnel could explain why staff in the emergency OT were more vigilant when monitoring emergency cases.

A review by Breen and Park showed that there was some evidence to support that regional anaesthesia cases are associated with less morbidity and mortality than general anaesthesia cases.¹² Even so, the ASA recommends that qualified anaesthesia personnel should be present in the theatre throughout all general and regional monitored anaesthesia care, during which the patient's oxygenation, ventilation, circulation and temperature, should be evaluated continually.¹ In this study, it was found that there was no significant difference in the alertness of OT personnel between general and regional anaesthesia cases.

In the OT, the responsibility of monitoring patients lies mainly with the anaesthesiologists. This is reflected in the current study as the high percentage of first responders were anaesthesiologists (71.1%), followed by the nurses (23.3%) and, lastly, the surgeons (5.6%). This finding is not really surprising, as anaesthesiologists are trained to monitor patients while surgeons operate. However, anaesthesiologists, surgeons, and assistants, work as a team in a theatre. Therefore, attending to any alarm in the OT should not be the sole responsibility of specific personnel.

In this study, the pulse oximeter alarms were ignored, and no action was taken in 10.7% of cases. Studies have shown that alarms can be irritating, upsetting, and may cause anaesthesiologists to feel uneasy. This could be due to a high rate of false alarms and equipment malfunction.^{4,7,13} False alarms are a threat to patient care.⁴ It has been found that most people can remember approximately five alarm sounds consistently. However, in the OT, besides the alarms, there were many other alerting signals, e.g. signals from communication devices, electrical isolation monitors, and electrocautery machines.¹⁴ Many manufactured devices, that once were "silent", such as blood warmers, patient beds, and various surgical instruments, are now equipped with their own alarms.⁷ The perceived urgency of an alarm signal can be influenced by various acoustic variables. Finley and Cohen suggested that a higher pitch, change in pitch, and increased complexity of the harmonic

series, increases the perceived urgency of an alarm signal.¹⁴ The use of surgical diathermy and patients' poor peripheral perfusion and shivering, may also prevent reliable pulse oximeter monitoring.¹⁵ All of these factors may lead to a situation in which alarms are deactivated or simply ignored.

Over the years, there have been many studies and research on improving alarm systems, for example, the use of sonification in the pulse oximeter alarm. At present, the pitch of the heartbeat sound is linked to oxygen saturation.⁷ It has been suggested that monitors that are equipped with alarms should be designed to assist clinicians to avoid undesirable incidents, rather than merely detect them.⁹

Three different types of anaesthesia monitoring systems were used in this study, namely Datex Ohmeda®, Datex Engstrom®, and Siemens SC6002XL®. All of the alarms had a different tone, pitch, quality, and lag time. This could have caused confusion among OT personnel about what, or which, alarm, was being triggered. It is quite common for more than one type of monitoring device to be used in one institution. Therefore, as suggested by Edworthy and Hellier, the warning sounds should be standardised, and when trigger points are appropriately set, the urgency of the alarm sounds should match their criticality.¹⁰

This study concludes that anaesthesiologists were the most alert OT personnel in responding to pulse oximetry alarms, and in general, were the first to respond. However, it is a cause for alarm, that in 10.7% of cases, alarms were left unnoticed, or ignored, and no action was taken within the one-minute study duration.

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