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Parameterization of clinical alarms of multiparameter monitors in a critical care unit

Parameterización de alarmas clínicas de monitores multiparámetros en una unidad de atención crítica

Parametrização de alarmes clínicos de monitores multiparâmetros em uma unidade de cuidados crítico

ABSTRACT

Objectives: To identify and classify the audible alarms of hemodynamic variables triggered by the multiparameter monitor, before and after the intervention of parameterization of the limit values of the alarms. Method: Quantitative approach, quasi-experimental design, evaluation study before and after, data collection technique, non-participant observation in an intensive care unit, for 60 h. The study participants were nursing professionals. Data production was divided into two moments: 1st moment of patient characterization and 2nd moment of alarm description (pre and post parameterization phase). Data analysis with calculation of the odds ratio (OR). Results: During the pre and post phases, 87 patients were counted and 42 (48%) had at least one alarm turned off. In the pre-phase, 513 alarms were registered, 428 (83.4%) were inconsistent, 497 (124 fatigued alarms and 373 missed) were not attended by the nursing staff. In the post phase, 438 alarms were recorded, 330 (75.3%) were inconsistent, 423 (90 fatigued alarms and 333 missed) were not answered. The OR for fatigued alarms and consistent alarms is 1.2 for the first event and 0.5 for the second. Conclusions: First step to map alarm fatigue, as well as equipment usability. Mapping that will subsidize the team's subsequent training, adoption of a protocol and routine regarding parameterization and usability, which will help in the correct clinical reasoning in the professionals' decision making, and will favor to the patient's surveillance and consequently their safety.
DESCRIPTORS: Clinical Alarms. Critical Care. Monitoring. Patient safety. Nursing.

RESUMEN

Objetivos: identificar y clasificar las alarmas audibles de las variables hemodinámicas activadas por el monitor multiparamétrico, antes y después de la intervención de parametrización de los valores límite de las alarmas. Método: enfoque cuantitativo, diseño cuasiexperimental, estudio de evaluación antes y después, técnica de recolección de datos, observación no participante en una unidad de cuidados intensivos, durante 60 h. Los participantes del estudio eran profesionales de enfermería. Producción de datos dividida en dos momentos: primer momento de caracterización del paciente y segundo momento de descripción de la alarma (fase de parametrización previa y posterior). Análisis de datos con cálculo de odds ratio (OR). Resultados: Durante las fases pre y post, se contaron 87 pacientes y 42 (48%) tuvieron al menos una alarma apagada. En la fase previa, se registraron 513 alarmas, 428 (83.4%) inconsistentes, 497 (124 alarmas fatigadas y 373 perdidas) no atendidas por el personal de enfermería. En la fase posterior, se registraron 438 alarmas, 330 (75.3%) fueron inconsistentes, 423 (90 alarmas fatigadas y 333 perdidas) no fueron respondidas. El OR para alarmas fatigadas y alarmas consistentes es 1.2 para el primer evento y 0.5 para el segundo. Conclusiones: primer paso para mapear la fatiga de la alarma, así como la usabilidad del equipo. Mapeo que subsidiará la capacitación posterior del equipo, la adopción de un protocolo y una rutina con respecto a la parametrización y la usabilidad, que ayudará en el razonamiento clínico correcto en la toma de decisiones de los profesionales, favoreciendo la vigilancia del paciente y, en consecuencia, su seguridad.
DESCRIPTORES: Alarmas Clínicas. Cuidado crítico. Monitoreo. Seguridad del paciente. Enfermería.

RESUMO

Objetivos: Identificar e classificar os alarmes sonoros de variáveis hemodinâmicas disparadas pelo monitor multiparâmetros, antes e após a intervenção de parametrização dos valores limítrofes dos alarmes. Método: Abordagem quantitativa, delineamento quase experimental, estudo de avaliação antes e depois, técnica de coleta de dados observação não participante em uma unidade de terapia intensiva, por 60 h. Os participantes do estudo foram os profissionais de enfermagem. Produção de dados dividida em dois momentos: 1° momento de caracterização dos pacientes e 2° momento de descrição dos alarmes (fase pré e pós parametrização). Análise dos dados com cálculo da razão de chance (OR). Resultados: Durante as fases pré e pós, 87 pacientes foram contabilizados e 42 (48%) encontravam-se com no mínimo um alarme desligado. Na fase pré, registraram-se 513 alarmes, 428 (83,4%) inconsistentes, 497 (124 alarmes fatigados e 373 perdidos) não atendidos pela equipe de enfermagem. Na fase pós, registraram-se 438 alarmes, 330 (75.3%) inconsistentes, 423 (90 alarmes fatigados e 333 perdidos) não atendidos. A OR para alarmes fatigados e alarmes consistentes é de 1.2 para o primeiro evento e 0.5 para o segundo. Conclusões: Primeiro passo ao mapeamento da fadiga

de alarmes, assim como da usabilidade de equipamentos. Mapeamento que subsidiará posterior capacitação da equipe, adoção de protocolo e rotina referentes à parametrização e usabilidade, que irão concorrer no correto raciocínio clínico na tomada de decisão dos profissionais, favorecendo a vigilância do paciente e consequentemente sua segurança.
DESCRITORES: Alarmes Clínicos. Cuidados Críticos. Monitoramento. Segurança do Paciente. Enfermagem.

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INTRODUCTION

The Intensive Care Unit (ICU) is the specialized space in the care of patients with instability of one or more organ systems [1-2]. The critically ill patient, due to his organic vulnerability, is dependent on Medical Assistance Equipment (MAEs) for advanced life support, diagnosis, monitoring and treatment. However, these technologies can be harmful to patient safety, if the user is not familiar with their functionality [3].

The Emergency Care Research Institute (ECRI) annually releases a report on the dangers of health technologies ("Top 10 Health Technology Hazards"), quoting since 2007, equipment alarm systems as one of these hazards [4].

In this scenario, researchers have described alarm fatigue. This phenomenon refers to the large number of alarms that cover up clinically significant ones, allowing alarms of clinical relevance to be disabled, silenced or ignored by the team. The excessive number of alarms causes sensory overload and desensitization of the team, reducing confidence in the urgency of the alarms and leading to a lack of response to alarms. Alarms of clinical relevance, when underestimated, can result in serious consequences in the patient's clinical condition [5-7]. This desensitization of the health team in relation to alarms is due, among other factors, to the lack of parameterization (adjustment of values of maximum and minimum physiological parameters for alert) of these alarms, being still disabled, with low volume, predisposing to unwanted outcomes to patients, for unmarked situations. [7]

The Food and Drug Administration (FDA) and the Manufacturer and User Facility Device Experience (MAUDE) received 566 reports of patient deaths related to monitoring alarms in hospitals in the United States between 2005 and 2008, demonstrating that the misuse of alarm systems has a direct impact on patient safety. [7]

In a Korean study, it was found that nurses individualized alarms in only 9 (18.8%) of the 48 patients assisted in their unit, as they considered the correct configuration of the monitors difficult. [8]

In Brazil, a study carried out in a coronary care unit, identified 64% of alarms not attended by the day service team and 63% without response in the night service. The results demonstrate that the parameterization of the monitors' alarms in the research field was inadequate and that this fact is closely related to the alarm fatigue. [9]

Another Brazilian study carried out in a public hospital found that the multiparameter monitor was the device that most alarmed, totaling 68 times (66,09%), followed by the infusion pump 25 (24,27%) and the mechanical ventilator, with 8 (7,76%) alarms. [10]

If the individualization of alarms does not happen, frequent and unnecessary alarms will occur continuously for reasons that are not actionable, which will inevitably lead to noise, distraction and increased potential for alarm fatigue in that environment. [11]

Parameterization can be considered an excellent strategy to reduce the number of alarms within the ICUs and, thus, corroborate for better surveillance by professionals to critically ill patients in these environments and, consequently, guarantee their safety. [7] Therefore, the objectives of this study are to identify and classify the audible alarms of hemodynamic variables triggered by the multiparameter monitor, before and after the intervention of parameterization of the threshold values of the alarms.

In Brazil, a study carried out in a coronary care unit, identified 64% of alarms not attended by the day service team and 63% without response in the night service. The results demonstrate that the parameterization of the monitors' alarms in the research field was inadequate and that this fact is closely related to the alarm fatigue.

METHODS

The research had a quantitative approach and a quasi-experimental design, characterizing an evaluation study before and after. The data collection technique was non-participant observation (except in cases where there was a risk for the patient). The production of data was divided into two moments: 1st moment of patient characterization and 2nd moment of alarm description (pre and post parameterization phase). The physiological variables monitored by the multiparameter monitors for the purpose of observing the alarms triggered in the unit were: heart rate (HR), respiratory rate (RR), non-invasive blood pressure (NIBP) and invasive blood pressure (IBP), considering their systolic, diastolic measurements and average.

The study scenario consisted of 6 beds that allowed full patient visibility and audible alarms in an adult ICU, a private hospital, located in the city of Rio de Janeiro. The period was 60 hours of observation, with each phase lasting 30 hours. The collection took place in 15 non-consecutive days, between Monday and Friday, with an average of 4 hours of daily observation in the afternoon shift. The research was approved by the Research Ethics Committee with CAAE: 59557316.9.0000.5285.

The study participants were nursing professionals (nurses and nursing technicians), who were observed regarding the attendance to alarms triggered by multiparameter monitors.

The study participants were nursing professionals (nurses and nursing technicians), who were observed regarding the attendance to alarms triggered by multiparameter monitors. [9] The number of alarms that sounded in the observation period was carefully counted manually through a stopwatch by the researcher in a specific instrument. For an alarm to be considered attended, the professional should have gone to the bedside, even if he did not take any action required by the audible alarm.

The maximum timed waiting time for

the professional to respond to the audible alarm was up to 04 minutes. Audible alarms triggered that did not respond in that time interval were classified as fatigued alarms (no response). Audible alarms that were automatically silenced without any response, also within this time interval, were classified as lost alarms. The delimitation of this time was based on how long the electrical phase of the heart lasts, according to the phase-dependent concept in cardiopulmonary arrest (CPA), where it is possible to identify 03 different phases in a CPA: the electrical phase, which extends from the minute zero to the fourth minute after CPA; the circulatory, which goes from approximately the fourth minute to approximately the tenth minute after the CPA, and the metabolic phase, which sets in after the tenth minute post-CPA [12].

In the pre-parameterization phase, the researcher activated alarms that were off without individualizing their borderline values according to the clinical condition of the patients, that is, leaving the borderline values of the equipment's factory.

The parameterization of the audible alarms of the physiological variables monitored by the listed bed monitors was according to the clinical condition of each patient, assessed by the researcher by recording the last 24 hours of the patients' evolution. Individualization was necessary because, although patients were separated into clinical categories, there were individuals within the same category, with differentiated organic responses and the same therapeutic proposal.

An increase of 10% in the tolerance margin to the minimum and maximum values defined for the intervention was established, considering the vital signs of the last 24 hours of hospitalization registered in the water balance, even if the patient was in support, aiming at reaching the therapeutic target, as recommended by the Summit Clinical Alarms. [13] For the quantitative analysis of the data, the resources and functions of the Excel® program were used. Statistics were used to describe and analyze the variables of interest to the study, namely: the number of alarms triggered by the multiparameter monitor and the consistency of the alarms triggered. The OR ("oddsratio" or Possibility Ratio) was calculated for the occurrence of a fatigue alarm before and after parameterization and for having a consistent alarm before and after parameterization.

RESULTS

At first, were recorded information through a diary on the characterization of patients admitted to the ICU and the Nursing Activities Score (NAS), and the record of situations that could be relevant and complementary to the study.

Regarding the NAS, an instrument to measure the nursing workload, the average was 78 points. Each point in the NAS corresponds to 14.4 minutes, so the average is equivalent to 18.72 hours of nursing care per patient in a 24-hour shift.

In table 1, image 1 and chart 1, the following data from the two moments of the methodology and the comparison between them are exposed.

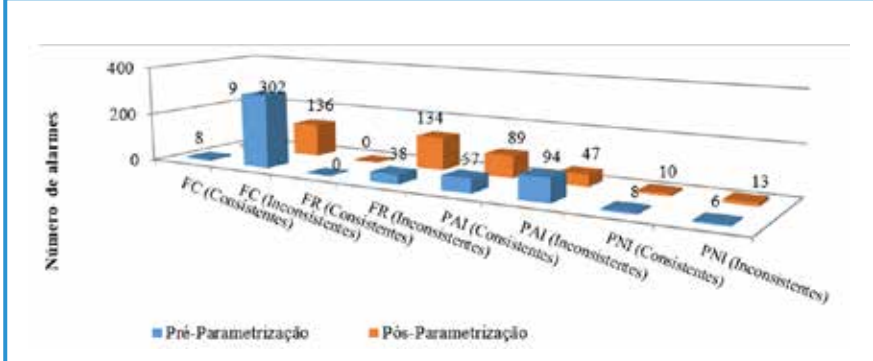
Chart 1: Data referring to the first and second moment of data collection - Intensive Care Unit (ICU) - Rio de Janeiro, 2017.

PRIMEIRO MOMENTO				
	PRÉ-PARAMETRIZAÇÃO		PÓS-PARAMETRIZAÇÃO	
Número absoluto de pacientes	47		40	
Média de idade dos pacientes (anos)	78 anos			
Média de tempo de internação(dias)	19 dias			
Taxa de Mortalidade (%)	23,75%			
Pacientes com ao menos um alarme sonoro desligado (%)	48%			
Pacientes com aminas vasoativas com ao menos uma variável PAI/PNI com alarme sonoro desligado (%)	44%			
Pacientes classificados na categoria clínica de sepse (100%)	68%		62,50%	
Distribuição das variáveis fisiológicas monitoradas que estavam com alarmes desligados (100%)	FR	PAI/PNI	FR e PAI	FR e PNI
	23,8%	57,2%	4,8%	14,2%
SEGUNDO MOMENTO				
FASE PRÉ-PARAMETRIZAÇÃO				
Alarmes Disparados (100%) (513)	Atendidos		Não Atendidos	
	3,1% (16)		96,9% (497)	
	Consistentes		Inconsistentes	
	16,6% (85)		83,4% (428)	

Alarmes Disparados Não Atendidos (100%) (497)	Alarmes Fatigados	Alarmes Perdidos
	25% (124)	75% (373)
	Consistentes	Inconsistentes
	15,9% (79)	84,1% (418)
FASE PÓS-PARAMETRIZAÇÃO		
Alarmes Disparados (100%) (438)	Atendidos	Não Atendidos
	3,4% (15)	96,6% (423)
	Consistentes	Inconsistentes
	24,7% (108)	75,3% (330)
Alarmes Disparados Não Atendidos (100%) (423)	Alarmes Fatigados	Alarmes Perdidos
	21% (90)	79% (333)
	Consistentes	Inconsistentes
	23,4% (99)	76,6% (324)

Caption: Respiratory Rate (RR), Invasive Blood Pressure (IBP) and Non-Invasive Blood Pressure (NIBP).

Image 1: Distribution of audible alarms triggered by a monitored physiological variable according to their consistency (pre- and post-parameterization phases).



Caption: Heart Rate (HR), Respiratory Rate (RR), Invasive Blood Pressure (IBP) and Non-Invasive Blood Pressure (NIBP).

Table 1: Comparison of the number of audible alarms triggered by the physiological variables observed in the pre and post-intervention phases - Intensive Care Unit (ICU) - Rio de Janeiro, 2017.

Variável Fisiológica	Número de alarmes (pré-parametrização)		Número de alarmes (pós-parametrização)		Relação de acréscimo/ decréscimo dos valores	
	Quantidade	%	Quantidade	%	Quantidade	%
FC	310	60,4%	145	33,1%	Decréscimo	53,2%
FR	38	7,4%	134	30,6%	Acréscimo	252,6%
PAI	151	29,4%	136	31,1%	Decréscimo	9,9%
PNI	14	2,7%	23	5,3%	Decréscimo	64,3%
TOTAL	513	100%	438	100%	Decréscimo	14,62%

Caption: HR (heart rate); RR (respiratory rate); IBP invasive blood pressure); NIBP (non- invasive blood pressure).

Once the OR was calculated for the occurrence of fatigued alarms and consistent alarms, a value of 1.2 was obtained for the first event and 0.5 for the second.

DISCUSSION

Safe parameterization must consider the profile of the patients and their clinical conditions, in order to correctly define the alarm limits and thus, not contribute to the existence of alarm fatigue in the location. [11]

Careful observation of blood pressure values, aiming at titration of vasoactive amines is an imperative point for reaching the therapeutic target in this type of patient. Therefore, it is extremely worrying to find these physiological variables with their audible alarms off or outside the safety parameters.

The percentage of audible alarms triggered by the monitors considered inconsistent in this research (83%) is similar to that found in an Australian study that found 99% of inconsistent alarms and in another one that occurred in a Brazilian orthopedics hospital whose result was 91.1% alarms inconsistent. [14-15] In a Korean study, team members were repeatedly exposed to an average of 771 alarms / patients / day and after the experience they reported decreased concentration, feeling distracted, predisposing them to errors. [8]

The high percentage of inconsistent alarms in the studied ICU is linked to the phenomenon of alarm fatigue, since the number of alarms considered fa-

tigued was 25% of the total triggered. Professionals who work in environments with exposure to high levels of noise, including those from equipment, may develop disorders in their physical, mental and psychological state, and, for consequent changes in communication, poor performance, fatigue, stress, illness and even accidents working. [16]

In the post-intervention phase, the number of audible alarms triggered by the researcher decreased in relation to the first phase (before parameterization) in a proportion of 14.6%. It is noted that there was a reduction of almost 10% in the percentage of inconsistent alarms between the two observation phases; in the first phase of the total number of alarms registered by the researcher (428) 83% were inconsistent and in the second phase (330) 75,3%.

This result is similar, keeping the due proportions, with 2 surveys that individualized the alarms, limiting them according to the criticality of the patients, and obtained, respectively, a reduction of 43% and 44% of the total alarms, mainly the false ones alarms, minimizing the phenomenon of alarm fatigue. [5,17]

We can infer that the increase in the number of sound signals of consistent alarms triggered in the post-parameterization phase, was strongly influenced by the appropriate adjustment of the variable alarms in situations where the parameterization was with values incompatible with life, without considering the clinical conditions. patients to trigger alarms and alert the team. To motivate the increase in the attendance of consistent alarms, multidimensional interventions in the institutions and the appropriate training to improve the usability and security of these alarm systems are suggested as a strategy. [18]

Regarding the number of audible alarms attended, we observed an insignificant drop in the total value between the pre and post-parameterization phases, where in the pre-phase were 16 and in the post-15 phase, however, after parameterization, the highest percentage of audible alarms attended was that of alarms consistent (60%), that is, the alarms attended really indicated the need for intervention.

We can infer that the increase in the number of sound signals of consistent alarms triggered in the post-parameterization phase, was strongly influenced by the appropriate adjustment of the variable alarms in situations where the parameterization was with values incompatible with life, without considering the clinical conditions. patients to trigger alarms and alert the team.

After the step of the alarm adjustment intervention, there was a drop in the values of fatigued alarms in the sector, from 124 (25%) to 90 (21%), bringing more suggestive evidence, that parameterization can influence in minimizing fatigue alarms.

All variables, with the exception of RR, showed a decrease in their rates after parameterization, however, this action depends on the knowledge acquired by the professional who handles MAE according to the needs and particularities of each patient, preventing injuries resulting from its inappropriate use. [19]

In the search for satisfactory results in the parameterization, the nursing team needs to evaluate the current conditions of the patients and define the alarm intervals individually. To this end, the training of professionals and their adherence to good monitoring practices are essential. [11] It is important to emphasize that to improve the usability of MAEs, there must be interaction between the healthcare team and manufacturers, representatives and, mainly, the clinical engineering of hospitals. (16). The author also emphasizes that knowledge of the changes determined by alarms is essential for directing nursing actions and care safely and efficiently.

From the values obtained by calculating the OR, it is possible to infer that the fatigued alarm event is unfavorable in the post-parameterization phase, since the chance of finding a fatigued alarm in the pre-parameterization phase is 1,2 times greater than in the post-parameter phase. Regarding the consistent alarm event, it is considered favorable in that the chance of having a consistent alarm in the pre-intervention phase is 0,5 times less than after the intervention.

CONCLUSIONS

The parameterization of the limits of the audible alarms of the physiological variables of the patients hospitalized in the scenario in question contributed to a

decrease of alarms triggered, especially of the inconsistent ones, and, consequently, of the alarm fatigue.

This type of study becomes essential as a first step in mapping the unit, regarding the phenomenon of alarm fatigue, as well as the usability of equipment by the team. This mapping, which will subsidize the team's subsequent training, adoption of a protocol and routine regarding parameterization and usability, which will compete in the correct clinical reasoning in the professionals' decision making, favoring the patient's surveillance and consequently their safety. ■

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