Occupational Exposure to Noise Pollution in Anesthesiology

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Summary: Oliveira CRD, Arenas GWN – Occupational Exposure to Noise Pollution in Anesthesiology.

Background and objectives: The harmful effects of workplace noise pollution are well known and described in the literature. The effects of prolonged exposure to noise in areas demanding high level of concentration, such as operating rooms, depend on the variability of individual responses and intensity of different generation sources. The aim of this paper is to present a review of occupational exposure to noise in anesthesiology.

Content: The results of the main articles in literature on the subject are discussed, concerning the sources of noise pollution and its effects on workers, particularly the anesthesiologist. Emphasis is given to legislation and recommendations to minimize the effects caused by noise.

Keywords: Anesthesia Department, Hospital; Occupational Exposure, Noise, Occupational.

INTRODUCTION

The concern with environmental sounds and their effects on individuals have been around since ancient Rome, when animal-drawn carts traveled down the first paved roads and disturbed people inside their houses during informal conversations and sleep. The first reports on deafness are from residents living near the Nile River waterfalls, establishing a causal relationship between noises and hearing loss.

A Brazilian decree of May 6, 1824 forbade noise pollution in the city, setting fines of 8,000 *réis* and penalties of 10 days imprisonment or 50 lashes when the offender was a slave.

Noise pollution is the emission of harmful noise in a continuous manner and in disregard to legal levels, which during a certain period of time threaten human health and welfare of the community.

The logarithmic unit of sound intensity is called Bel (B). Bel is the logarithm of a ratio of 10, which is divided into 10 parts called decibels (dB). The Bel unit was named after Alexander Graham Bell (1847-1922), Scottish physicist and inventor of the telephone. It was used in the United States for measuring losses in telephone lines to quantify the reduction of noise level on a one mile long standard telephone cable.

In order to record more accurately the ear sensitivity to sound intensity within the frequency range of hearing, researchers developed a balanced unit of sound intensity, known as A-weighted sound level (dBA). At this scale, an increase of 10 dBA results in a sound twice as loud.

Noise has been increasing over the years, particularly in large metropolitan areas. This increase can also be observed inside hospitals. The first studies about noise pollution in operating rooms were conducted in the 70s [1,2].

An operating room is preferably a quiet and silent environment, but what is seen today is the production of medium and high sound intensity. Noise can be described as non-periodic acoustic signals, originating from the overlapping of various movements with different vibration frequencies, which bear no relation to each other. The overlap of these noises can reach more than 80 dB, which is considered a moderately high sound.

The effects of noise on performance are dependent on the type of task carried out [3]. Levels similar to those found in operating rooms affect the short-term memory and cause distractions during critical periods [4]. Tasks that require a high degree of attention, such as anesthesia, are deeply affected.

NOISE GENERATING SOURCES

The noise produced by the operation of multiple devices (monitors, anesthesia machines, ventilators, air conditioners, aspirators, and surgical instruments) combined with the sounds of alarms, conversation among professionals, and procedure peculiarities make up the noise pollution. Noise can also spread to adjacent sites, such as transfer and hand scrubbing areas and the post anesthesia care unit.

Regarding the noise produced by the equipment, the most expressive is generated during the triggering of certain alarms (60-85 dB), fans running at normal speed (60 to 65 dB), vacuum aspiration system (50 to 60 dB), followed by the "beep" of cardiac monitors (50 to 55 dB).

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Alarms are used for patient monitoring, to warn the occurrence of critical and non-critical events, and to make the user aware of the device operation. Alarms can be found in operating rooms, intensive care units, and other areas of a hospital.

In a study involving 1,000 anesthetic incidents, audible alarms have been recognized as one of the most important factors in minimizing the severity of these incidents [5].

However, the increased variety of the multiparameter monitoring equipments available led to a need for greater number of audible alarms. The goal of manufacturers is to condition the alarm of monitors to volumes and harmonies that ensure the user an appropriate and pleasant alert [6,7]. The alarm sounds used on most monitors and equipments are often strident, too high and not distinguishable; being difficult to identify which medical device is signaling [8-10].

The purpose of regulatory standards is to specify the components of the audible alarm signals to be used in order to draw attention to the detection of problems through medical devices and indicate the degree of urgency. Currently, the standards for alarm sounds are developed with the collaboration of doctors, engineers and psychologists, and any change in patterns involving the monitoring of audible alarms will be based on consensus and cooperation between anesthesiologists and monitor manufactures. This approach intends to rationalize the current situation and limit the proliferation of different sounds in order to avoid confusion.

Some of the considered criteria during the development of alarm sounds include optimal signal recognition in a relatively noisy environment, maximum transmission of information at the lowest practicable sound pressure level, easy to learn and be assimilated by operators who need to respond to various signals and discern the urgency of sounds.

Modern alarms have been designated with a harmonic tone so that their sources may be located in rooms where the walls can reflect the sounds and ceiling mounts, folding screens or alike can block them. The sounds of these alarms should not be confused with those of common equipment or non-medical devices (e.g., bells, intercom sounds, and pagers).

Despite the logic that the use of audible signs increases the anesthesiologist vigilance, the reality is that these sounds can be perceived as distracting, leading to the condemned and bad practice of silencing the alarms [7]. The major contributing factor to this practice is that over the years the industry produced devices that emit unpleasant sounds, which gradually became annoying to users. Due to the need to escape the tyranny of the usual shrill and persistent alarm sounds, usually mutually discordant, many professionals first militated against the activation of alarms and their proper use when activated. In addition, they reported that audible alarms may not provide valid physiological information and be linked to interventions and events already known to the anesthesiologist. One study suggested that the lack of confidence in audible alarms ended up compromising their usefulness [11].

With that in mind, one of the objectives of the Joint Commission on Accreditation of Healthcare Organization (JCAHO) is to improve the effectiveness of clinical alarms. This institution states the following recommendation: to develop and implement policies that prevent alarm turn-off [12].

The adoption by the American Society of Anesthesiologists (ASA) of the Standards for Basic Anesthesia Monitoring in 1986 improved the monitoring technology and consensus among anesthesiologists, which was reflected in these standards update in 1998. Since then, the development and availability of audible alarms as part of physiological monitors continued to evolve [13].

The monitoring of patient's physiological functions during anesthesia aims to facilitate, and not to replace, the anesthesiologist constant vigilance. In line with this, monitors can be seen as an additional safety network for anesthesia monitoring.

Some attempts to correlate physiological parameters with mnemonic musical alarms were frustrated by the persistent confusion during the learning process [14-16].

In some special situations, in which the presence of an anesthesiologist is required, there is a sum of background sounds. For instance, in otolaryngological surgery, particularly mastoidectomy in which specific drills are used, the noise reaches levels above 75 dB [17]. The nuclear magnetic resonance apparatus is an important source of noise that interferes with the proper interpretation of sounds emitted by monitors and anesthesia devices [18.19]. Extracorporeal shock wave lithotripsy can produce a noise up to 110 dB [20].

A study performed at Johns Hopkins Hospital showed the prevalence of noise by surgical specialty. The rooms were monitored before, during, and after the intervention. It was found that the quietest rooms were those performing gastrointestinal and thoracic surgical procedures. However, orthopedic surgery and neurosurgery produced noise levels exceeding 100 dB in 40% of the time monitored [21].

Concern about exposure to high intensity noise in orthopedic surgery and its impact is examined in many studies [22-28].

EFFECTS OF NOISE POLLUTION

Excessive noise can have physiological and psychological effects on all professionals and increase the rates of adverse events [29].

An unexpected noise or some noise coming from an unknown source can cause various reactions. In temporary exposure, the body returns to normal, corresponding to the primary reaction. If the noise source is maintained or alternated persistent changes may occur. In addition to the auditory symptoms, noise affects various body functions with different reactions.

In skill tests, it was shown that upon exposure to continuous noise there is a reduction in performance and efficiency, increasing the number of errors and probably of accidents due to the reduced ability. Activities that require a high degree of attention or information processing, such as laparoscopic and robotic surgery, are affected by noise [30-34].

Regarding neurological disorders, changes such as the appearance of hand tremors, decreased reaction to visual stimuli, pupillary dilation, eye motility and tremors, changes in visual perception of colors, and onset or worsening of epileptic seizures may occur.

During noise exposure or even after it, many people have vestibular changes typically described as vertigo, which may or may not be accompanied by nausea, vomiting and cold sweats, making it difficult to balance and walk, nystagmus, loss of consciousness and pupil dilation.

It may be found a decreased peristalsis and gastric secretion, with increased acidity, followed by nausea, vomiting, loss of appetite, epigastric pain, gastritis and ulcers and changes that result in diarrhea or constipation.

Individuals subjected to sounds above 70 dB can undergo vasoconstriction, tachycardia and blood pressure variations [35].

Stress hormone production is altered when individuals are subjected to tension in environments with high noise levels, increasing the serum levels of cortisol and adrenaline, which can trigger the onset of diabetes and increased prolactin levels.

Noise produces neuropsychiatric alterations, with changes in behavior and mood, lack of attention and concentration, fatigue, insomnia, poor appetite, headache, reduced sexual potency, anxiety, depression, and stress.

Noise can cause accidents, as it hinders the hearing and proper understanding by the professionals, masking the sound of equipment and monitor warning signs, distracting these professionals and contributing to work-related stress, which increases the cognitive load, thus increasing the likelihood of errors. The lack of supervision accounted for 30% of reported serious problems occurring during anesthesia [36].

In the operating room, an effective communication is crucial. To have a good oral communication it is necessary that the emission level (in the receiver's ear) is higher than the background noise level by at least 10 dB.

Noise pollution is often felt as a disturbance of oral communication, especially if the noise is permanent or if the listener has already a hearing loss, or if the conversation occurs in a language other than the language of the listener; or if the listener physical or mental state is altered by health problems, fatigue, or an excessive workload. The impact of these factors on work safety varies according to the work conditions. For example, an oral instruction may be poorly understood among professionals and may result in harmful effects to the patient.

The background noise in the operating room can cause stress, even at levels that do not produce hearing loss; for example, the frequent ringing of a phone, an aspirator hiss, or the permanent vibration of an air conditioning unit.

Hearing loss induced by noise is usually caused by prolonged exposure to high sound levels. Generally, the first symptom is the inability to hear those high sounds. If the problem of excessive noise is not solved, the hearing will continue to deteriorate, with loss of ability to hear low sounds. The hearing loss damages induced are permanent.

In a survey completed by 144 Scottish anesthesiologists, 51% reported that music was a distraction, especially in times of crisis, and 26% preferred to work in silence [37]. During a simulated monitoring, they reached the conclusion that, under conditions of relatively low workload, music at moderate levels can improve the detection of trends in vital signs, although many practitioners say they prefer to work without music [38].

LEGISLATION

The Brazilian Federal Law does not allow more than 85 dB at the workplace in an eight-hour shift. However, the noise can exceed these levels and reach up to 100 dB or more (uncomfortable sounds) as it occurs during operation of equipment or during a discussion among professionals present in the operating room [38]. The walls of modern operating rooms are impervious to water and act as sound reflecting surface, greatly increasing the noise level.

The National Institute for Occupational Safety and Health (NIOSH) recommends that the intensity of noise does not exceed 85 dB for a working period of eight hours, and that hospitals should not exceed 35 dB during night-time and 40 dB during day-time [4].

The Directive 2003/10/EC of the European Parliament was adopted in 2003, which concerned the minimum requirements for health and safety regarding the exposure of workers to risks derived from physical agents (noise). The directive states that, taking into account technical progress and availability of control measures, the risks resulting from exposure to noise shall be eliminated at source or reduced to a minimum. The directive also established an exposure limit of 87 dB in a workday.

The Law No. 11291 of April 26, 2006, states that the manufacturer or importer of electrical and electronic equipment for sound wave generation and propagation must include a conspicuous and easy to understand warning text, which brings information regarding the occurrence of any eventual damage to the auditory system exposed to sound level higher than 85 dB.

The Regulatory Norms (NR from Portuguese) on safety and occupational health related to noise pollution are as follows: NR 6 (protective equipment); NR 9 (program for prevention of environmental risks); NR 15 (unhealthy activities and operations); and NR 17 (deals with ergonomic and sets the limit for acoustic comfort in jobs requiring a minimum of mental concentration) [39-42].

NR 15 provides a table with the limits for permitted daily exposure to different levels of continuous or intermittent noise. Continuous exposure to noise above 85 dB can cause permanent hearing loss and, with an increase of only 5 dB, the time of exposure is reduced by half. However, these levels are applied to workplaces in which intellectual activities requiring prompt and constant attention are not performed.

In places such as control rooms, laboratories, offices and others, the NR 17 which deals with ergonomics recommends the noise levels indicated by the Brazilian Standard NBR 10152 (Noise Levels for Acoustic Comfort) [43]. This NBR determines that the noise level in operating rooms should be between 35 and 45 dB (any level above the threshold is considered uncomfortable), without necessarily implying a risk of harm to health.

The alarm signals for anesthesia monitoring equipments must comply with the priority guidelines established by NBR in which each alarm condition announces a priority. The priorities are set on high, medium, and remote, according to the individual's risk. Current studies are focused on improving the performance in the use of alarms as an important aid in the safety of anesthesia, defining as optimum the capacity of a human being to acknowledge a maximum of six types of sounds generated by alarms.

The project 26:002.02-013/2 of the *Associação Brasileira de Normas Técnicas* (Brazilian Association of Technical Standards; ABNT) specifies the audible component of alarm system with temporal and pulse-train characteristics [44]. This standard limits to 120 seconds the time allowed for the function "turn-off" the high priority alarm and to 4 minutes the time allowed for low priority. This attitude will probably change the behavior towards the understanding that alarms promote a safety benefit greater than the irritability or confusion caused by them, which usually leads anesthesiologists to turn them off during the procedure [45].

CONCLUSION

Anesthesiologists, and other professionals working in operating rooms, are routinely exposed to high noise levels outside the surgery theater and this may cause a gradual deterioration in these professionals hearing ability. Additionally, it is true that the noise in operating rooms significantly degrade communication among medical team, which can be detrimental in situations requiring great attention.

The level of daily exposure to noise should be kept as low as possible. This is accomplished by isolating the sources of noise, placing noise barriers, increasing absorption of walls and ceilings, or decreasing the time exposure of professionals involved.

Workplaces where levels of daily exposure to noise exceed 85 dB should be subjected to interventions to reduce those levels. Furthermore, workers exposed to these conditions should undergo audiometry to detect possible hearing loss.

The anesthesiologist in particular cannot be deprived of his senses and cannot use earplugs either. However, all aforementioned preventive measures must be adopted to control and minimize the risks.

Prolonged exposure to noise is insidious and, unlike other occupational hazards, leaves no residue. It is not transported by natural sources and is perceived by only one sense (hearing), which leads many professionals to underestimate its effects. However, it is well known that excessive noise can lead to physical exhaustion and also to chemical, metabolic, and mechanical changes in the sense of hearing. Consequently, exposure to noise leads to stress, resulting in sleep disorders, respiratory, behavioral, endocrine, and neurological problems, among others, becoming a disease-causing agent.

The effects of background noise affect the human body either directly or indirectly, considering the frequency, intensity, duration, and individual susceptibility to which the person is exposed. It is important to alert the society, especially health and related fields professionals, on the harmful effects of noise pollution. These effects can be mitigated with the development of educational programs and preventive measures for monitoring the levels of background noise.

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