Noise in the Operating Room

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“Unnecessary noise is the most cruel absence of care which can be inflicted either on sick or on well.”
—Florence Nightingale, 1859

As recently as the 1960s, hospitals were famous for their quiet and serene environment. Noise restrictions were zealously enforced internally by uniformed nurses and externally by street signs around the perimeter declaring “Hospital—Quiet Zone.”

Hospitals and especially operating rooms are no longer quiet.1 In 1972, before the introduction of much of the noisy equipment now routinely used during surgical procedures, it was observed that noise levels in operating rooms frequently exceed those of a busy highway.2 The authors labeled noise as the “third pollution” along with air and water pollution. Others have described the noise in critical care areas as equivalent to the cafeteria at noon and only slightly less noisy than in the boiler room.

More recent studies have reaffirmed the escalation of the noisy atmosphere of hospitals and operating rooms. Average noise levels commonly are greater than federal limits for occupational noise exposure and frequently exceed those considered a hazard to health.

Noise levels of this intensity have wide-spread implications for healthcare workers and their patients. In the following report, we will examine the common sources and possible consequences of excessive operating room noise and suggest some remedies.

Materials and Methods

A literature search was conducted during the period from October 2013 to January 2014 searching for the following terms: noise, noise pollution, occupational noise, auditory perception, hospital, operating room, and music. Searches were conducted using PubMed, Ovid, and Google Scholar. The reference lists of all articles discovered in these searches were examined for additional references.

Regulation of Occupational Noise

Several federal agencies, including the Occupational Safety and Health Administration, National Institute for Occupational Safety and Health, and the Environmental Protection Agency, have developed guidelines and recommendations for safe levels of noise in the workplace. These differ considerably in large part because of differences in the formulae used to determine harmful exposure. For example, the guidelines from the National Institute for Occupational Safety and Health are most conservative in that they begin with a time-weighted average of 85 decibels (A) (dBA) (the allowable continuous exposure for an 8-h work day) and use a 3-dBA time/intensity exchange rate in which the permissible time of exposure is halved for each 3 dBA increase in sound (the “3 dBA rule”) (fig. 1). The limits established by the Occupational Safety and Health Administration begin at 90 dBA for an 8-h work day and use a 5-dBA exchange rate in recognition of the fact that in most workplaces interruptions in noise exposure occur throughout the day.† Specifically within hospitals, average noise levels of 45 dBA or less are recommended. Both National Institute for Occupational Safety and Health and Occupational Safety and Health Administration guidelines agree that the peak level for impulsive noise (characterized by a steep rise in the sound level to a high peak followed by a rapid decay) should not exceed 140 dBA.

These noise exposure regulations represent a compromise between practicality and hearing protection. They are not...
designed to protect every worker from experiencing any noise-induced hearing loss and they do not address other noise-associated health and performance hazards. Many authorities believe that a workplace noise limit of approximately 55 dBA would be necessary to ensure universally safe conditions.

**Sources of Noise in the Operating Room**

Noise within operating rooms comes from both staff and equipment. Staff-related activities and conversations are a major component of operating room noise and can produce noise levels as high as 78 dBA. Equipment-related noises as great as 120 dBA are caused by movement of equipment, clanging and dropping of metal instruments, and use of electric or air-powered surgical instruments, hammers, suction apparatus, anesthetic monitors, and alarms. Forced air warming units alone add as much as 84 dBA to the background noise (Jonathan D. Katz, M.D., Noise from forced air patient warming units. Unpublished data. Data collected in November, 2013).

The monitors in a modern operating room are host to a great many alarms and alerts which are commonly cited as the most intrusive of operating room noises. These alarms frequently provide extraneous, ambiguous, or false information that has no therapeutic significance. In one study conducted during cardiac surgery, there was an average of $359 \pm 158$ alarms ($1.2 \text{ min}^{-1}$), 80% of which had no therapeutic significance. All of these false alarms can desensitize the staff so that true alarms go unrecognized. In many cases, the alarms are so annoying and distracting that they are turned off. This practice is discouraged in the Standards for Basic Anesthetic Monitoring of the American Society of Anesthesiologists which suggest only “brief” interruptions of monitoring in “rare or unusual circumstances.”

Music is also a frequent contributor to operating room noise. The exact noise levels resulting from background music in operating rooms have not been quantitated but can be extrapolated from a report citing noise levels as high as 87 dBA that are commonly generated by music played on home audio equipment.

**Noise Levels in Operating Rooms**

Noise levels in operating rooms frequently exceed the limits established by federal regulatory agencies. In 1972, Shapiro and Berland reported noise levels as high as 85 dBA in the operating room during a routine cholecystectomy. Twenty years later, Hodge and Thompson reported intermittent sounds to 108 dBA during a “typical major surgical procedure.” Forty years after Shapiro’s report, Fritsch et al. reported noise levels as high as 131 dBA during simulated otolaryngeal surgery.

Operating rooms are noisy even when unoccupied due in part to their high-capacity air conditioning systems. Noise increases progressively with the entry of staff and patient. Once surgery commences, peak levels can exceed 120 dBA. Levels remain greater than 100 dBA for greater than 40% of the time during some particularly noisy procedures, such as orthopedics, neurosurgery, and extracorporeal shock wave lithotripsy. The beginning and the end of surgery, which coincide with anesthetic induction and emergence, are especially noisy periods. At these times, surgical equipment is being prepared or dismantled and conversations unrelated to direct patient care occur between staff members.

**Impact of Noise Pollution in the Operating Room**

**Occupational Health**

Exposure to occupational noise levels as low as 75 dBA can have both short- and long-term adverse effects on health.

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Predisposing individual factors such as age, comorbid medical conditions, medications, and lifetime total cumulative noise exposure also play a role in how and to what extent an individual responds to noise.

The most commonly reported health consequences of chronic exposure to high noise levels are tinnitus and hearing loss. The nature and severity of the hearing impairment is a direct function of the intensity and frequency of the sound pressure and duration and pattern of exposure.

There is growing evidence that nurses and surgeons who consistently work in noisy operating rooms are susceptible to noise-induced hearing loss. Substantial hearing loss has also been demonstrated among anesthesiologists. In a study conducted by Wallace et al., 66% of anesthesiologists had abnormal audiograms and those younger than 55 yr had a hearing acuity significantly worse than the general population.

Anesthetized patients may be particularly vulnerable to acoustic trauma after long exposure to noisy surgical equipment. Anesthetic drugs weaken the stapedius muscle, which normally contracts and protects the cochlea when exposed to loud sounds. In the absence of this protective reflex, hearing impairment may occur, especially among vulnerable populations such as the elderly.

Noise, especially unexpected high-intensity sounds, acts as a biologic stressor that can produce a startle reaction and activate the fight or flight response of the autonomic and endocrine systems. Chronic exposure to excessive noise has been associated with increases in heart rate, blood pressure, peripheral vascular resistance, and an increased prevalence of various forms of cardiovascular diseases, including hypertension, angina pectoris, myocardial infarction, and premature death.

Cognition

Chronic noise exposure, even at moderate intensity, can hamper psychomotor, intellectual, attention, and memory functions. This impairment is especially apparent when an individual is exposed to "irrelevant speech" while engaged in mental activities that rely heavily on working memory, such as during multitasking. The impact of this detrimental effect of noise on anesthesiologists was demonstrated in a study in which deterioration of mental efficiency and short-term memory was observed among anesthesia residents exposed to a recording of typical operating room noises.

Communication

One of the most harmful of the acute effects of noise pollution in the operating room is the interference it imposes on verbal communication. Communication among staff members is a key component of patient safety. However, communication failures during surgery are common and have been identified as one of the leading root causes of error and poor patient outcomes by The Joint Commission. The ability of noise to disrupt operating room communication was demonstrated in a study in which the auditory processing functions of surgeons were significantly diminished by music and operating room noise.

Performance

Activities that require a high degree of information processing and concentration are particularly susceptible to the adverse effects of noise. There have been conflicting reports on the impact of noise on surgical performance, explained in part by variables in experimental design. The complexity of the task and the experience of the surgeon play a significant role in how noise affects surgical tasks.

There is little evidence to demonstrate a direct association between excessive operating room noise and poor surgical outcomes. In one study, a correlation was identified between increased sound levels during surgery and surgical-site infections. The authors hypothesized that the increased sound levels might be a surrogate marker indicating distraction or difficulty encountered during the procedure.

Anesthesiologists are especially affected by a noisy operating room because of their continuous presence in the room, their close proximity to noisy equipment, and the fact that the noisiest times occur during the critical anesthesia components of a case. In one study, 84% of anesthesiologists reported that the noise levels in their operating rooms negatively affected their work.

Nurses and other operating room personnel who work in close quarters with surgeons and anesthesiologists are subject to the same noise-induced handicaps.

Patient safety and comfort can be adversely affected by noise pollution. Noise is a top complaint among hospital patients and consistently gets the worst marks on Medicare patient surveys. In a study of patients undergoing elective surgery, 52% reported that it was noisy during the induction and/or emergence of anesthesia and 16% found the noise to be distressing. In addition, higher doses of propofol are necessary to achieve the desired bispectral index in a noisy operating room.

Music

Music is a special type of noise. Carefully selected music has a well-known calming effect during stressful situations. However, the role of music in the operating room remains controversial. Music can add 87 dBA or more to the already considerable ambient noise levels in the operating room. Depending on a number of circumstances, including coexistent environmental factors, personal taste, and the required task, an individual’s response to music can vary from soothed to distressed.

Music has variously been shown to have a positive, neutral, or negative effect on different measures of surgeons’ performance. In one frequently cited study, Allen and Blascovich found that autonomic reactivity was reduced and mental task performance increased in surgeons listening to a recording of typical operating room noises.
to self-selected music as compared with no music and to
generic stress reduction background music. It is important
to note that the volunteers in this study were all self-reported
music enthusiasts, the music was self-selected, the study was
conducted in a sound-proof laboratory, and the task tested
was an arithmetic exercise.

Others have reported a detrimental effect of music on
surgical performance, especially among less experienced
surgeons. For example, in one randomized controlled trial
of novice surgeons, music during training procedures was
shown to cause distraction and impaired performance.21

The impact of music on anesthesiologists is also unclear.
Carefully selected and modulated music can improve vigilance
and monitoring performance. However, many anesthesiolo-
gists feel that music can reduce the ease and accuracy of per-
forming their tasks. In one study, 26% of anesthesiologists felt
that music reduced their vigilance and impaired their commu-
nication with other staff and 51% felt that music was distract-
ing when a problem was encountered.22 Seventy-eight percent
felt that music that they disliked was the most distracting. On
the contrary, a subsequent study by the same group failed to
identify any adverse effect of self-selected or classical music
on psychomotor tests (testing numeric vigilance, tracking, and
reaction time) performed by residents in anesthesiology.23

Patients are also affected by music in the operating room.
Carefully selected music can have an anxiolytic and sedative
effect on patients before, during, and after surgery. This benefi-
cial effect seems to be independent of the additional advantage
provided by blocking out ambient operating room noises.24

For all personnel in the operating room, it is apparent
that the selection of the music and the manner in which it is
delivered play a key role in its effect.

Suggested Remedies

The adverse effects of noise pollution can be ameliorated by
either blocking the production of the noise or the entry of
noise into the ear. The easiest and most effective solution is
to minimize the noise production.

Because the operating room staff is the source of a large
component of the noise pollution, efforts can be directed
toward minimizing irrelevant conversation, especially during
critical times. One approach that has been advocated is to
adapt a “sterile cockpit” environment, as used in the aviation
industry, which also requires use of standardized nomencla-
ture and a structured format for communication.25

A second approach is to develop a behavior modification
program to educate staff members about the sources and
potential harm of noise pollution. This educational program
should focus on common and easily remedied sources of
extraneous operating room noise. The effectiveness of this
approach has been demonstrated on acute inpatient hospital
wards and in intensive care units.26

Consideration should be given to noise when decisions
are made concerning supplies and operating room design.
Noisy equipment such as speakers should be placed as far
as possible from the anesthetizing location. Substitution of
plastic bowls and trays for metallic ones can minimize noise
from clanging of these implements. Installation of sound
insulation and avoidance of sound-reflective floor, wall, and
ceiling surfaces would be significant factors in limiting echoing
and reverberation of unavoidable noises.

Conclusion

The noise levels in hospitals and operating rooms are con-
sistently above the limits established by federal regulatory
agencies, in many cases by as much as 40 dBA. These noise
levels have been associated with adverse consequences on
the health and performance of staff and on patient safety.
Much of this noise is generated by operating room person-
nel and is avoidable. Some corrective measures can be taken
at little expense and inconvenience to staff. Additional
research is needed to identify materials and design to further
limit equipment-related noise.

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Competing Interests

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