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ORIGINAL ARTICLE - NEUROSURGERY TRAINING

Meditation music improved the quality of suturing in an experimental bypass procedure

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Abstract

Background Neurosurgeons are vulnerable to additional noise in their natural operating environment. Noise exposure is associated with reduced cognitive function, inability to concentrate, and nervousness. Mediation music provides an opportunity to create a calmer environment which may reduce stress during surgery.

Methods A pilot study was performed to find a suitable task, meditation music of surgeon's choice, and operation noise and to reach a certain level of training. For the main experiment, two neurosurgeons with different microsurgical experience used real operation noise and meditation music with delta waves as mediating music. Each surgeon performed 10 training bypasses (five with noise and five with music) with 16 stitches in each bypass. The total time to complete 16 stitches, a number of unachieved movements (N.U.Ms), length of thread consumed, and distribution of the stitches were quantified from the recorded videos and compared in both groups.

Results A N.U.Ms were significantly reduced from 109 ± 38 with operation room (OR) noise to 38 ± 13 ($p < 0.05$) with meditating music in novice surgeon. Similar results were found in the experienced surgeon performing the same task [from 29 ± 6.94 to 14 ± 3.36 ($p < 0.05$)]. The total time utilized for the sixteen stitches was slightly improved (not significantly) in the novice surgeon and unchanged in the experienced surgeon. However, the thread length used for 16 stitches was significantly different with OR noise in comparison to meditating music in both surgeons. The distribution stitches showed a non-significant trend toward a uniform distribution with meditation music in both surgeons.

Conclusions Meditation music of surgeon's choice is a simple method that improved quality of bypass suturing in an experimental bypass procedure.

Keywords Operation room · Noise · Meditation · Music · Neurovascular · Bypass

Introduction

Neurosurgery includes many highly skill-demanding and stressful procedures, such as bypass surgery. The "stress rate" and drivers of stress are different for each neurosurgical procedure and for each neurosurgeon. Stitching during bypass surgery is one of the procedures, which holds a high level of stress. It necessitates a focused attention to achieve good quality in optimal time. The goal of high-quality stitching in a short period of time can lead to stress and anxiety [12].

Environment, including the noise, in the operation room is an important factor especially in distracting surgeon's concentration and increasing the stress [14]. Stress is known to influence the heart beat variability and other vegetative function [33]. Hence, the strategies to reduce distraction and anxiety and to release the stress of the surgeon may be helpful to improve the quality of surgery.

Meditating music may help to circumvent the debilitating effect of stress on the fine motor skills of the neurosurgeon. Meditation and meditating music has been shown to relieve stress and improve learning [1, 26]. There is increasing evidence that music attenuates symptoms in a variety of diseases including Parkinson's disease, dementia, and attention deficit syndrome [23]. Intense pleasure in response to music activates the dopaminergic system in striatum and mesolimbic system.

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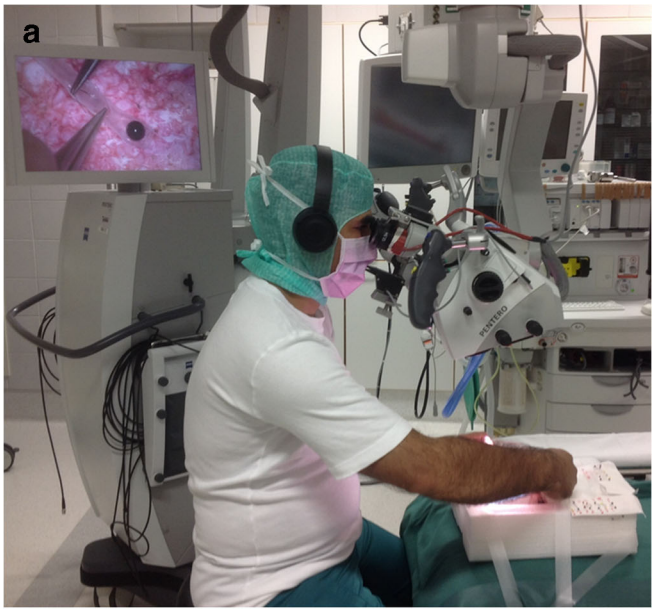

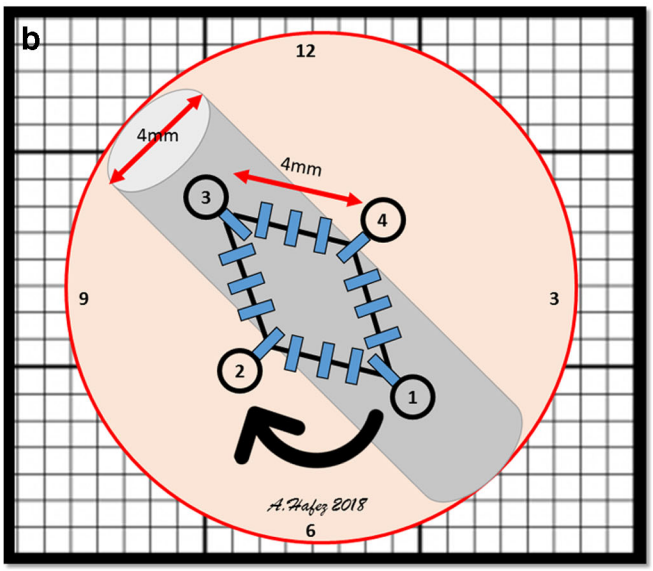

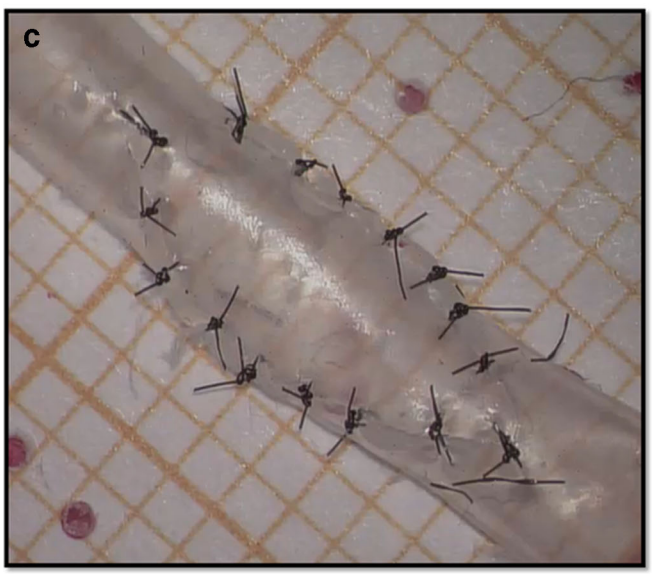

◀ **Fig. 1** **a** Experimental setup and the surgeon and microscope inside the OR. Video recording of bypass suturing, designed task, and silicon tube and suturing instruments are seen on the screen. **b** Schematic view of the suturing task. The diamond-shaped "rhombus" with 4-mm length of its four sides (red arrow). The tube diameter also is 4 mm. The axis located in this direction. The numbers (1, 2, 3, and 4) were sutured first in order and then starting from number 1 clockwise (black curved arrow) to complete the 16 stitches at the end. The background of the design is a millimeter paper which was used after suturing to analysis the result. **c** Suturing sample captured from a recorded video; after completion of the experiment, we used the millimeter paper to examine the distribution of the stitches

Dopamine release in the central nervous system has an implication in combating stress [28, 29]. The dopaminergic and serotoninergic deep nuclei are linked to the motor cortex supporting the possibility that fine motor skills might be influenced by the meditating music. Evidence from the literature supports the notion that sound, the auditory system, and the motor system are interconnected and hence may control the fine motor movements [10, 37].

We aim to investigate the influence of meditating music and compared it with the influence of operation room noise on surgical performance. We introduced meditating music on our already-established experimental bypass surgery to investigate the difference in the quality of suturing during OR noise and meditation music of surgeons' choice.

Materials and methods

We recorded the videos of stitching artificial vessels and investigated different parameters to quantify the quality of bypass suturing. These parameters included unachieved movements of surgeon, distribution of the stitches, time utilized, and total length of thread used for sixteen microsurgical stitches. These parameters were evaluated in an environment with routine operation room noise in comparison to meditating music. We investigated the above-mentioned parameters in two surgeons with different training experience. The experiment was conducted at the Neurosurgical Department in the Helsinki University Hospital, using an OPMI PENTERO 900 ZEISS inside an OR (Fig. 1a).

In this experimental study, all training tasks simulating bypass suturing were end-to-side procedures. The tasks were performed by the first author (S.M), a fully trained EU board–certified neurosurgeon (2017) who worked as a clinical fellow in neurovascular and skull base microneurosurgery for 1 year (2018), and the last author (A.H), who finished his residency 20 years ago and who has performed 1500 different experimental bypass procedures over the past four years, between June 2014 and July 2017, in the Department of Neurosurgery, Helsinki University Hospital, Helsinki, Finland.

Table 1 Video analysis of different factors to quantify the quality of bypass procedure for novice surgeon and experienced surgeon, using a recording of real operation noise and meditating music

	Novice neurosurgeon		Experienced neurosurgeon	
	Operation noise	Meditating music	Operation noise	Meditating music
Time (mean) minutes/ SD	22/ 4.26	19.30/3.38	13.75/1.17	13.35/0.58
Thread (cm)/ SD	5.68/ 1.47	5.68/0.46	9.40/042	7.30/0.45
Time to thread relation/SD	2.74/0.87	3.43/0.73	1.46/012	1.84/0.16
N.U.M*(mean) /SD	109.60/ 38.12	38.00/13.47	29.20/6.94	14.40/3.36
Stitch distribution (mean)/SD	3/1	2.60/1.14	0.84	2/1

**N.U.M*, number of unachieved movements; *SD*, standard deviation

Experiment design

A vessel wall suturing procedure was simulated. The two participants were asked to suture an already-cut scaphoid-shaped silicon tube. They were required to distribute 16 stitches with four knots.

We designed our model by developing a shape similar to the shape of bypass suturing end-side interrupted stitching. The shape was developed using a millimeter paper (Fig. 1b). We chose the 4-mm-diameter tube and 16 stitches to be used with four corner stations, which allow measuring the distances between stitches, which perfectly supposed to be 1 mm (Fig. 1c).

The participants were asked to suture in the same order; the numbers (1 to 4) in the model were used to keep participants' direction and order of suturing (Fig. 1b). The magnification during suturing was (8 times) in all 20 cases.

We used same 9–0 suturing material (PROLENE, 13 cm, 5.0 mm, 3/8c, ETHICON) and same micro-instruments (i.e., scissors, needle holder, and forceps) in all procedures (Fig. 1a).

All videos were analyzed blindly after finishing all the cases. Suturing time was measured from videos. The length of thread consumed by the procedures was measured by measuring the length of the remaining thread. The repeated movements, which did not achieve the intended goal (e.g., catching the needle, catching the tube wall with tweezers), were counted carefully from videos. The distribution of stitches was quantified by giving a score based on the uniformity of distribution (distance between each stitch) of 16 stitches on the vessel wall (Fig. 1c).

Statistical analysis

The data were analyzed using GraphPad Prism 5.00 (GraphPad Software, San Diego, CA, USA). After testing for normality, unpaired *t* test and welch, a correction was performed in case of a non-normal distribution to compare two groups.

Data is expressed as mean ± SEM; a p value < 0.05 was considered as a significant difference.

Results

Results of video analysis of the procedures for novice surgeon and experienced surgeon using original operation noise and meditating music are summarized in Table 1. Interesting, a number of unachieved movements (N.U.Ms) were significantly reduced from 109 ± 38 with OR noise to 38 ± 13 ($p < 0.05$) with meditating music in the novice surgeon (Fig. 2b). Similar results were found in the experienced surgeon performing the

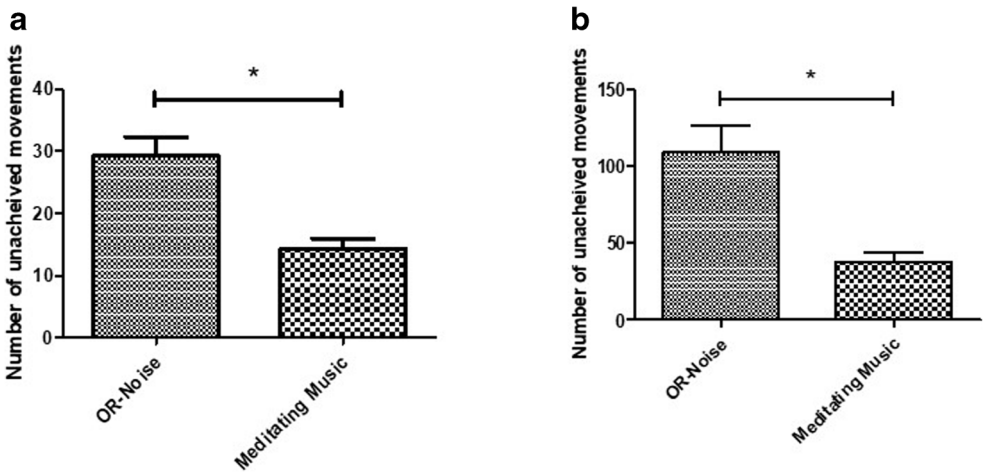

Fig. 2 Number of unachieved movements with operation noise and after meditating music in both; experienced surgeon (**a**), $n = 5$, unpaired *t* test ($p = 0.0027$) and novice surgeon (**b**), $n = 5$, unpaired *t* test ($p = 0.017$)

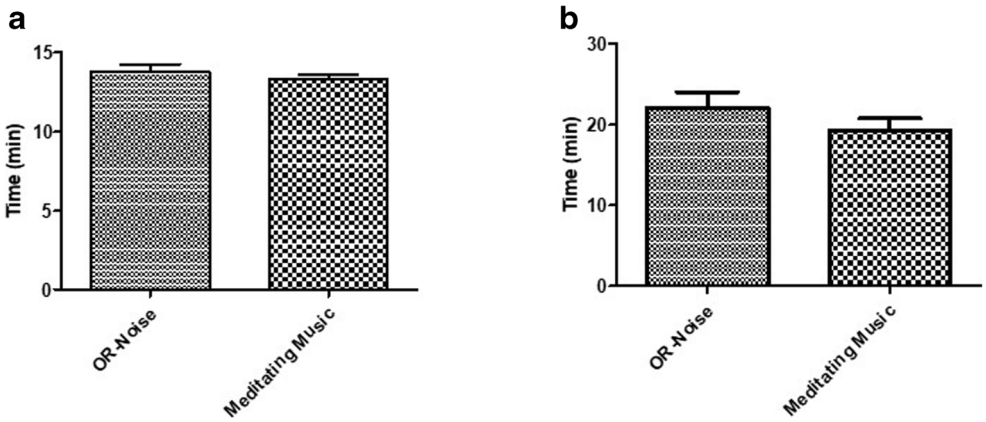

Fig. 3 Time of suturing with operation noise and after meditating music in the experienced surgeon (**a**), $n = 5$, unpaired t test ($p = 0.52$) and novice surgeon (**b**), $n = 5$, unpaired t test ($p = 0.27$)

same task. The N.U.Ms was reduced from 29 ± 7 to 14 ± 3 ($p < 0.05$) showing that meditation influenced positively the surgeons' motor skills independent of experience and training (Fig. 2a and b). Stitch distribution did not differ significantly (Fig. 5a and b).

Moreover, the length of thread used for the sixteen stitched was significantly reduced from 8 ± 1 cm with OR noise to 5 ± 0.46 ($p < 0.05$) with meditating music in the novice surgeon (Fig. 4b). Similar results with significantly less use of thread for 16 stitches were quantified in the experienced surgeon (Fig. 4a) showing a reduced length of thread needed for 16 stitches from 9 ± 0.42 to 7 ± 0.45 cm ($p < 0.05$) (Fig. 4a and b). The total time utilized for the sixteen stitches was slightly improved (not significantly) in the novice surgeon (Fig. 3b) and unchanged in the experienced surgeon (Fig. 3a). Interestingly, the N.U.Ms fluctuated during the OR noise and there were less fluctuations with meditating music over the time of five repeated experiments (Table 1).

Discussion

This study assessed the influence of meditating music on the performance of the neurosurgeons, recruiting the highly demanding procedure: the bypass.

Meditation may reduce the stress and influence the motor skills of surgeons. However, music and task is a complex field and may depend on the personality of a surgeon, choice of music, and many other factors. Up to our knowledge, this is the first study showing an improvement in the quality of stitching with music in an experimental setting.

Previous studies showed the intervention of external distraction on the neurosurgical performance [13, 14]. Noise is a known health hazard leading to stress and decreased concentration [15, 30]. A relaxing atmosphere of the operation room might be a factor, which helps surgeons achieve better performance.

The meditation has been shown in various studies to influence different brain areas [5, 9, 33, 35]. It has been used to reduce stress, anxiety, and depression in patients and in healthy individuals [21, 31]. Music is known to have an influence on the mood and physiological responses [2, 28]. It has been used as an independent nursing intervention preoperatively in patients having a day surgery [7].

The trainees experience different levels of stress and anxiety before and during surgical procedures [3, 11, 22]. Neurosurgical operations hold a high level of anxiety and demand a certain level of hand-eye coordination and fine manipulation [4, 6, 8, 17, 36].

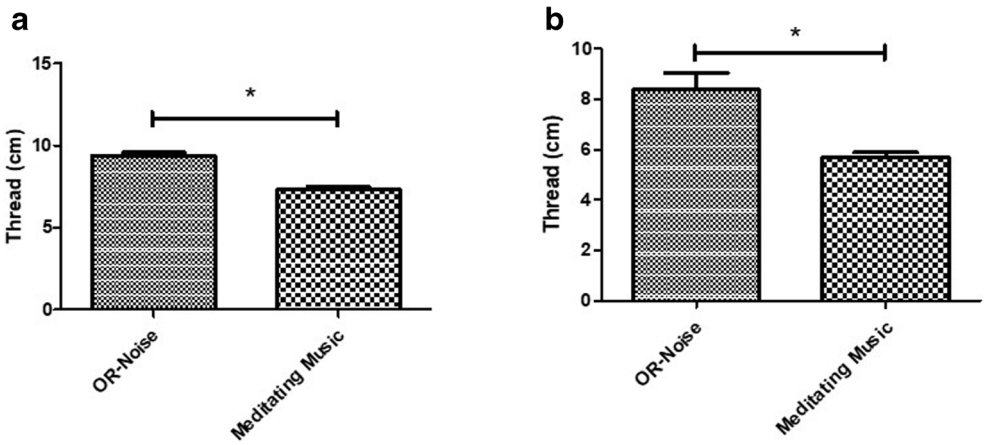

Fig. 4 Length of thread used with operation noise and after meditating music in the experienced surgeon (**a**), $n = 5$, unpaired t test ($p = 0.0001$) and novice surgeon (**b**), $n = 5$, unpaired t test ($p = 0.017$)

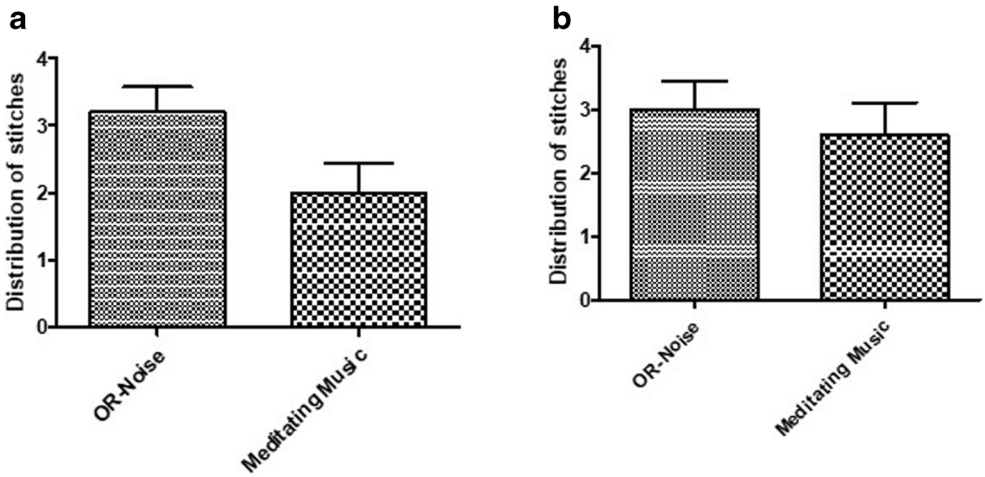

Fig. 5 Distribution of stitches with operation noise and after meditating music in the experienced surgeon (**a**), $n = 5$, unpaired t test ($p = 0.073$) and novice surgeon (**b**), $n = 5$, unpaired t test ($p = 0.57$)

The senior and expert neurosurgeons compete better with complex surgeries and stressful situation than the novice ones [5, 16]. By contrast, at the time of new resident, the operation room noise and movement levels are changed dramatically. Opposite to the norm and trend, in which the seniors get a calmer atmosphere, the novice and less experience neurosurgeons in need of a more comfortable and less noisy operation room [14].

Meditation and meditating music is becoming increasingly popular and achieving scientific support [20]. It could help in stressful circumstances and overcoming part of the anxiety associated with surgical procedures. Our study showed that meditating music improved the quality of bypass independent of training level. Fortunately, not all neurosurgical procedures hold such a high level of challenge with associated anxiety and stress. Hence, the result could be less dominant in simple routine and daily procedures.

The comfort and relaxed hearing voice (meditating music) may improve efficiency and decrease the operative time. Our results showed improved efficiency measured by a number of unachieved movements during surgery (Fig. 2a and b). However, our result showed only a trend toward improved time (Fig. 3a and b). The comfortable voice and experience of the surgeons are directly related, and the lack of experience would translate directly to slower, more hesitating movement and less flexibility. In our experimental task, the less experience neurosurgeons saved more length of the thread but consumed extra time and repeated more unachieved movements (Figs. 4 and 5 and Table 1).

Meditating music is well established as a way of adjusting animal and human behaviors [19, 32, 34]. However, different meditation forms could affect different cognitive processes [20]. Using meditating music could calm body movements and optimizes movements, which helps in achieving better motor performance [24].

Music acts as non-pharmacological intervention that attenuates a variety of symptoms in various diseases, such as Parkinson's disease, atrial hypertension, dementia, and attention-deficit/hyperactivity disorder [23]. It changes the concentrations of dopamine and serotonin in deep brain nuclei linked to the motor area [37]. The relationship among sound, auditory circuit, and motor systems which control the fine movements is well established in the literature [37]. The hearing stimuli has a remarkable ability to drive rhythmic, metrically organized motor behavior [25, 27].

There are inevitable background noise and distractions in operation rooms [18]. Our older study proved the difficulty of engaging in a secondary task during surgery and the negative impact of voice distraction [14]. The experienced neurosurgeons could compensate for the stress of operation atmosphere including the noise. However, the type and the level of distraction on the one hand and the level of the complexity of the procedure on the other hand cannot be ignored. When the procedure is highly skill-demanding, such as bypass neurosurgery, the external stimulation becomes crucial.

Our data with some limitations show that performance was worse during practicing bypass under the influence of operation room noise compared to the meditating music. The effect was different between the two subjects (neurosurgeons), based on the past experience with the procedure. Even with extra attention paid by neurosurgeons to complete the task, trying to ignore the sound of the operation room, still, the irritating sound reflected the performance as well as laid its effect on the results. The price of the noise and the benefit from the meditating music are reflected on the number of unnecessary movements before achieving the intentional goal (Fig. 2a and b), for example, penetrating the wall of the tube, tight the stitch, and holding the needle.

Finally, even with a small number of procedures, learning curve and adaptation with the noisy operating sounds were noticed in our trial. The individual endurance level of tension and ability to cope with noise distraction stands behind differences in handling such matter in our field.

Limitations

The main limitation is that this study includes a limited number of surgeons; only two surgeons were involved and no randomization of the exercises. Therefore, the results might partially reflect their personal traits and the different volume of bypass training they underwent previously. Moreover, repeating the task and learning effect (learning curve theory) could influence the result.

Although it is an attractive study with important findings, it is less realistic than naturalistic observation. Although the suturing style and designed task are recruited from the bypass procedure, this task does not simulate all the bypass steps. This study covers a narrow corner in everyday neurosurgical practice. However, it is part of a series of studies focusing on the training quality in neurosurgery.

Conclusions

We conclude that the noise influenced the performance of the surgeon, especially when performing a complex task such as a bypass procedure. Meditating music could positively impact the automaticity of surgical performance. Level of noise and experience of the neurosurgeons can affect the outcome of the surgery. To achieve a better outcome, the noise level inside the operation room and the use of individual meditating music may be considered.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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Comments Control of the surgical environment, management of the team, and discipline in the operating theater are the responsibilities and duties of the lead surgeon. In my years of surgery, I always prefer a sterile environment, no music, no extraneous noise, total concentration, and silence as much as possible. To me, this is the best thing for the patient. I am well aware that many of my colleagues have different preferences, and I respect their choices.

Now, this manuscript demonstrates with some authority that in their laboratory, measured performance on a complex bypass task is improved by the playing of soothing "meditation music." Again, I respect the methods, the rigor of the analysis, and the results. I am sure this works well for their team, and I believe their paper is a valid one for the reader's thoughtful consideration. As for me, no disrespect at all, but I will stay with the sterile environment.

Christopher Loftus
PA, USA