Does Listening to Music during Tonsillectomy Affect Sevoflurane Consumption?

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Significance of the Study

- Music is known to have healing and curative effects. This study was aimed at ascertaining whether or not listening to music during surgery can reduce perioperative pain as well as the consumption of the anesthetic drug sevoflurane. We observed that music is effective in reducing postoperative pain and decreasing the need for additional intraoperative analgesia. The consumption of sevoflurane was not significantly affected.

Keywords

Children · Music · Anesthesia

Abstract

Objective: The aim of this study was to investigate the effect of listening to music on the consumption of an anesthetic agent as well as postoperative recovery and pain in children undergoing elective tonsillectomy. **Materials and Methods:** Fifty patients were randomized into those to whom music was played during surgery (group M) and a control group to whom music was not played (group C). The depth of anesthesia was provided by entropy levels of 50 ± 5 in both groups. Demographic characteristics and hemodynamic parameters were recorded perioperatively. The duration of surgery, sevoflurane consumption, eye opening time, and extubation time were also recorded. $p < 0.05$ was considered sta-

tistically significant. **Results:** Surgical pleth index values measured intraoperatively were statistically lower in group M than in group C. In the postanesthesia care unit children in the music group felt less pain than those in the control group according to the Wong-Baker Faces Pain Rating Scale ($p = 0.035$). The heart rates of the patients in the music group were statistically lower at 30 min intraoperatively and at the end of the procedure compared to the values of the control group ($p = 0.015$). The consumption of sevoflurane was lower in group M than in group C but the difference was not statistically significant. The need for additional fentanyl was significantly lower in group M than in group C. **Conclusion:** In this study, the children exposed to music intraoperatively needed less analgesia during surgery, and reported less pain postoperatively, but there was no difference in sevoflurane requirements.

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Introduction

The curative and healing properties of music have been known for a long time [1]. It is a nonpharmacological technique that is not expensive, is noninvasive, and has no side-effects [2]. The use of music therapy had been shown to reduce pain, anxiety, and physiological parameters in patients undergoing surgical procedures [2–4]. Anxiolytic effects have been reported in preoperative music played as a treatment modality in the removal of anxiety in anesthesia practice [5]. In a study conducted on patients undergoing colonoscopy, the level of pain and anxiety was lower in patients who listened to music compared to those who did not [3]. It had also been shown that patients receiving regional anesthesia and listening to music need less sedation intraoperatively [4].

There is further evidence that listening to music during anesthesia might improve postoperative recovery and reduce the need for analgesia [6, 7]. However, some studies did not confirm these benefits of intraoperative auditory stimuli [8, 9], and Migneult et al. [10] found that music did not reduce the noroendocrine response to stress or the perioperative consumption of opioids.

Entropy is one of the methods employed to measure the depth of anesthesia, based on electroencephalography (EEG) and frontal electromyography data. The EEG signal can be calculated as 2 spectral parameters: state entropy (frequency band 0–32 Hz) and response entropy (0–47 Hz), which also includes muscle activity. The recommended depth of anesthesia with entropy is 40–60

[11]. Using entropy monitoring, it was possible to interpret the effect of music more easily by providing a close depth of anesthesia in both groups. The aim of this study was to investigate the effect of listening to music on the consumption of sevoflurane as well as postoperative recovery and pain by providing entropy levels of 50 ± 5 in children undergoing elective tonsillectomy.

Materials and Methods

This study was approved by the Institutional Ethics Committee; written informed consent was obtained from all of the parents/legal guardians of the children. Fifty patients with an American Society of Anesthesiologists physical status of I–II, aged 3–10 years, undergoing tonsillectomy were enrolled. The patients were allocated randomly to 2 equal groups, i.e., children who listened to music (group M) and those who did not (group C), using a sealed envelope system. Patients with hearing impairment or a psychiatric or neurological illness were excluded from this study.

On the morning of the surgery, standardized premedication with 0.5 mg/kg oral midazolam was administered to all of the patients. They were continuously monitored during the surgery via electrocardiogram and for noninvasive blood pressure, heart rate (HR), oxygen saturation, exhaled CO₂ (end-tidal capnography), the surgical pleth index (SPI), and entropy (Carescape Monitor B650; GE Healthcare, Finland). Anesthesia was induced with sevoflurane in 100% oxygen, fentanyl at 2.0 µg/kg, and rocuronium at 0.6 mg/kg and maintained with sevoflurane. Sevoflurane was titrated to maintain entropy around 50 (range 45–55). The general strategy was to increase the inspired sevoflurane concentration by 0.1% for each unit that entropy increased above 50, and to comparably decrease sevoflurane administration when entropy was <50.

Table 1. Comparison of patient characteristics and anesthetic data

	Group M ^a	Group C ^b	<i>p</i>
Age, years	6.60±2.95	6.24±3.38	0.487*
Gender (female/male)	11 (44%)/14 (56%)	4 (16%)/21 (84%)	0.031 [#]
Weight, kg	24.92±10.32	25.52±11.90	0.868*
Height, cm	117.04±17.73	115.12±19.84	0.573*
ASA physical status (I/II)	22 (88%)/3 (12%)	23 (92%)/2 (8%)	1.000 [€]
Anesthesia history (yes/no)	2 (8%)/23 (92%)	0 (0%)/25 (100%)	0.490 [€]
Mode of delivery (normal/Cesarean)	11 (44%)/14 (56%)	13 (52%)/12 (48%)	0.571 [#]
Duration of anesthesia, min	48.68±12.29	50.92±16.91	0.992*
Sevoflurane consumption, mL	25.68±9.16	31.36±11.54	0.060 ^{&}
Time to eye opening ^c , min	7.72±3.00	7.32±3.77	0.428*
Extubation time, min	9.28±3.28	8.88±3.95	0.585*
Additional fentanyl (yes/no)	4 (16%)/21 (84%)	18 (72%)/7(28%)	<0.001 [#]

Values are presented as means ± SD unless otherwise stated. ASA, American Society of Anesthesiologists physical status. * Mann-Whitney U test. & Student *t* test. [#] χ^2 test. [€] Fisher exact test. ^a Music; *n* = 25. ^b Control; *n* = 25. ^c Time from cessation of sevoflurane to eye-opening command.

The SPI is a dimensionless number between 0 (low stress) and 100 (high stress) that is calculated from the HR and the pulse wave amplitude obtained with a finger clip, which simultaneously measures transcutaneous oxygen saturation, HR, and pulse-induced volume changes. Adequate “depth” was equated with adequate analgesia assessed according to the SPI values, which were to be between 20 and 50. Fentanyl (0.5 mg/kg) was given if the SPI value changed suddenly by more than 10.

The patients were randomly assigned either to the music-listening group or to the control group and wore headphones throughout the surgery. The designated sounds (music or no music) started 5 min after the induction of anesthesia and continued until sevoflurane administration was stopped at the end of the surgery. The patients listened to quiet gentle instrumental music like a lullaby. Sound volumes were not high enough to be detected by the anesthesiologist (A.Y.) unless he brought his ear very close to the headphone. The patients were subsequently extubated and transferred to the recovery unit. In the postanesthesia care unit (PACU), the patients were assessed for pain using the Wong-Baker Faces Pain Rating Scale (Appendix 1). The patients were also assessed for sedation using the Richmond Agitation-Sedation Scale (Appendix 2). These evaluations (pain and agitation) were assessed and recorded at the entrance to the recovery room and again at 10 and 30 min by an anesthesiologist (H.A.) who was blinded to group allocation. Intravenous paracetamol at a dose of 15 mg/kg was used as rescue analgesia if the face scale score was >3.

The demographic characteristics of all of the patients were noted. The hemodynamic parameters of saturation (SpO₂), HR and mean arterial pressure, SPI values, and entropy values were recorded before the procedure (T1), at 5 min (T2), 10 min (T3), and 30 min (T4) intraoperatively, and at the end of the procedure (just after extubation; T5). The duration of the surgery, sevoflurane consumption, eye opening time, and extubation time were also recorded. The time to eye opening was considered to be the time from cessation of sevoflurane until the patient opened his or her eyes in response to a verbal command.

Statistical Analysis

SPSS software version 18.0 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA) was used for all statistical analysis. Conformity of the data to a normal distribution was assessed by the Kolmogorov-Smirnov test. Data are presented as means $\pm$ SD or numbers and percentages when appropriate. Comparisons between groups were made with the Student *t* test or the Mann-Whitney U test as appropriate. The Fisher exact test or the χ^2 test was used to assess group differences for categorical variables. $p < 0.05$ was considered statistically significant.

Results

The patients' characteristics and anesthetic data are summarized in Table 1. With the exception of gender, there were no statistically significant differences between the groups. Male gender was statistically dominant in the control group ($p = 0.031$; Table 1). The sevoflurane consumption was 25.68 mL in group M and 31.36 mL in

group C, but there was no statistical difference ($p = 0.060$; Table 1). A significantly lower number of children required additional intraoperative fentanyl in group M (16%) compared to group C (72%) ($p = 0.000$; Table 1).

The entropy levels and mean arterial pressures of the patients were similar during surgery in both groups and showed no significant differences (Table 2). The HR in group M patients was significantly lower than that in group C patients at 30 min intraoperatively (126.08 ± 13.11 vs. 132.48 ± 20.08 , $p = 0.047$) and at the end of the procedure (124.40 ± 13.25 vs. 134.76 ± 20.98 , $p = 0.015$; Table 2). The SPI values measured intraoperatively at

Table 2. Comparison of mean arterial pressure, heart rate, surgical pleth index, and entropy values

	Group M ^a	Group C ^b	<i>p</i>
Mean arterial pressure			
T1	75.64 $\pm$ 10.61	70.08 $\pm$ 8.96	0.051 ^{&}
T2	72.92 $\pm$ 11.44	70.32 $\pm$ 8.94	0.705*
T3	71.64 $\pm$ 12.34	71.00 $\pm$ 12.34	0.892*
T4	71.40 $\pm$ 11.82	69.24 $\pm$ 9.98	0.560*
T5	74.68 $\pm$ 10.16	76.48 $\pm$ 8.64	0.503 ^{&}
Heart rate			
T1	122.92 $\pm$ 17.94	119.20 $\pm$ 22.85	0.525 ^{&}
T2	120.32 $\pm$ 16.31	122.76 $\pm$ 19.06	0.629 ^{&}
T3	125.40 $\pm$ 14.90	133.12 $\pm$ 27.47	0.225 ^{&}
T4	126.08 $\pm$ 13.11	132.48 $\pm$ 20.08	0.047*
T5	124.40 $\pm$ 13.25	134.76 $\pm$ 20.98	0.015*
Surgical pleth index			
T1	77.12 $\pm$ 5.87	76.72 $\pm$ 10.49	0.128*
T2	42.28 $\pm$ 9.51	50.44 $\pm$ 6.61	0.002*
T3	41.12 $\pm$ 8.18	50.24 $\pm$ 7.89	0.001*
T4	37.44 $\pm$ 9.35	51.60 $\pm$ 8.44	0.000 ^{&}
T5	76.20 $\pm$ 7.98	77.80 $\pm$ 6.58	0.189*
Response entropy			
T1	87.44 $\pm$ 6.31	88.48 $\pm$ 5.27	0.530 ^{&}
T2	50.96 $\pm$ 10.73	46.24 $\pm$ 9.40	0.105 ^{&}
T3	46.64 $\pm$ 6.15	45.68 $\pm$ 8.00	0.637 ^{&}
T4	48.72 $\pm$ 8.14	48.24 $\pm$ 7.40	0.496*
T5	90.12 $\pm$ 4.00	88.64 $\pm$ 6.70	0.495*
State entropy			
T1	80.20 $\pm$ 9.46	81.16 $\pm$ 4.94	0.938*
T2	44.20 $\pm$ 10.96	41.68 $\pm$ 12.20	0.281*
T3	45.68 $\pm$ 8.25	42.28 $\pm$ 7.59	0.054 ^{&}
T4	43.76 $\pm$ 7.50	42.28 $\pm$ 7.59	0.492 ^{&}
T5	82.28 $\pm$ 4.51	83.28 $\pm$ 7.02	0.519*

T1, measured value preoperatively; T2, measured value at 5 min intraoperatively; T3, measured value at 10 min intraoperatively; T4, measured value at 30 min intraoperatively; T5, measured value at the end of the procedure. * Mann-Whitney U test. [&] Student *t* test. ^a Music; $n = 25$. ^b Control; $n = 25$.

Table 3. Frequency distribution of the patients with regard to sedation in the PACU

RASS	Group M ^a	Group C ^b	<i>p</i>
Demeanor upon PACU entrance			
Alert and calm	1 (4)	2 (8)	0.622*
Restless	10 (40)	10 (40)	
Agitated	7 (28)	8 (32)	
Very agitated	2 (8)	0 (0)	
Combative	0 (0)	1 (4)	
Drowsy	5 (20)	4 (16)	
Demeanor after 10 min in the PACU			
Alert and calm	9 (36)	10 (40)	0.745*
Restless	10 (40)	12 (48)	
Agitated	2 (8)	1 (4)	
Drowsy	4 (16)	2 (8)	
Demeanor after 30 min in the PACU			
Alert and calm	18 (72)	18 (72)	0.497*
Restless	4 (16)	6 (24)	
Drowsy	3 (12)	1 (4)	

Values are presented as numbers (%). RASS, Richmond Agitation-Sedation Scale; PACU, postoperative anesthesia care unit. * χ^2 test. ^a Music; *n* = 25. ^b Control; *n* = 25.

5 (42.28 ± 9.51 vs. 50.44 ± 6.61 , $p = 0.002$), 10 (41.12 ± 8.18 vs. 50.24 ± 7.89 , $p = 0.001$), and 30 min (37.44 ± 9.35 vs. 51.60 ± 8.44 , $p = 0.000$) were significantly lower in group M than in group C (Table 2). There was no statistically significant difference between the music group and the control group regarding the sedation scales in the PACU (Table 3).

The comparison of the pain scales in the PACU is shown in Table 4. There was no significant difference between the groups regarding the pain scales ($p = 0.13$) when they entered the PACU. Although the percentage of children who indicated a higher level of pain with the “hurts even more” face was lower in the music group (1.4%) than in the control group (7.28%), this difference was not statistically significant ($p = 0.070$; Table 4). At 30 min in the PACU the percentage of children who felt it “hurts even more” was statistically significantly lower in the music group (0%) than in the control group (24%) ($p = 0.035$; Table 4).

Discussion

The main findings of the current study are as follows: (1) SPI values measured intraoperatively were significantly lower in the music group, (2) the need for additional

Table 4. Frequency distribution of patients with regard to the Wong-Baker Faces Pain Scale in the PACU

Pain score	Group M	Group C	<i>p</i>
PACU entrance			
Does not hurt	4 (16)	0 (0)	0.129*
Hurts a little bit	4 (16)	7 (28)	
Hurts a little bit more	9 (36)	7 (28)	
Hurts even more	8 (32)	9 (36)	
Hurts a whole lot	0 (0)	2 (8)	
At 10 min in the PACU			
Does not hurt	7 (28)	7 (28)	0.070*
Hurts a little bit	7 (28)	7 (28)	
Hurts a little bit more	10 (40)	4 (16)	
Hurts even more	1 (4)	7 (28)	
At 30 min in PACU			
Does not hurt	12 (48)	13 (52)	0.035*
Hurts a little bit	9 (36)	4 (16)	
Hurts a little bit more	4 (16)	2 (8)	
Hurts even more	0 (0)	6 (24)	

Values are presented as numbers (%). PACU, postoperative anesthesia care unit. * χ^2 test. ^a Music; *n* = 25. ^b Control; *n* = 25.

fentanyl was significantly lower in group M than in group C, (3) at 30 min in the PACU the percentage of children who felt it “hurts even more” was statistically lower in the music group than in the control group, (4) the HR values of the patients in group M were significantly lower at 30 min intraoperatively and at the end of the procedure, and (5) the consumption of sevoflurane tended to be lower in the music group than in the control group although the difference was not statistically significant.

Many studies have reported significant effects of music interventions on the reduction of stress, anxiety, and pain in patients undergoing procedures under sedation or regional anesthesia [12–15]. Premendran et al. [14] investigated the efficacy of music in lowering the intraoperative requirement of sedation and recall of the intraoperative process in patients undergoing elective surgery under regional anesthesia, and it was found that those who listened to music during surgery needed a lower dosage of intraoperative sedatives and had a reduced recall of the intraoperative process. Simavlı et al. [16]. evaluated the effect of music on relief from labor pain, anxiety levels, and the postpartum analgesic requirement and showed that mothers in the music therapy group had a lower level of pain and anxiety compared to those in the control group at all stages of labor. Not only was the postpartum analgesic requirement significantly decreased in the mu-

sis therapy group but a significant difference was also observed between the 2 groups in terms of maternal hemodynamics and the fetal rate after intervention in that study [16]. Similarly, Cepeda et al. [15] showed that perioperative psychological and music intervention could reduce anxiety and postoperative pain in elderly patients undergoing spinal anesthesia. However, there have been few studies on significant effects of music during general anesthesia. Abd-Elshafy et al. [17] studied the effects of music therapy on the physiological and psychological behavior of children undergoing repair of congenital heart disease, and while significant differences were determined in terms of pain scores, sedation scores, and the occurrence of negative postoperative behavior there were no significant differences in vital signs. In contrast to those results, we found no significant difference in postoperative sedation scores and pain scores between the groups; however, the pain scores at 30 min in the PACU were significantly lower in the music group, and heart rates were significantly lower at 30 min intraoperatively and at extubation. Similarly, Fancourt et al. [18] and Sandstrom and Russo [19] examined the effects of music recorded at 4 different tempos and moods; they observed that peaceful low-tempo music led to reductions in HR and a decreased respiratory rate.

Noises associated with standard procedures, such as opening a package of surgical instruments and alarms attached to monitors, can be very frightening to the patient. Children are more afraid and sensitive as they are without their parents. Listening to music or sounds in the operating theatre masks such unpleasant ambient noise [20]. In the current study, patients started listening to music after induction of anesthesia and this prevented them from taking advantage of the relaxation effect. There is a broad interindividual variability in pharmacokinetics and pharmacodynamics, and thus standardized anesthetic regimens, even when using age- and weight-adapted dosages, can lead to under- or overdosage [21, 22]. The use of EEG-based monitors of hypnosis such as the bispectral index or spectral entropy may help to optimize hypnotic administration [23, 24]. These monitors have been shown to reduce anesthetic doses, achieve greater hemodynamic stability, reduce the incidence of intraoperative awareness, and shorten recovery times [24, 25]. We used entropy monitoring to apply balanced anesthesia in the 2 groups. Studies have shown a correlation between the activity of the sympathetic nervous system and nociception [26]. The SPI, first introduced in 2007, uses pulse plethysmography and photoplethysmography, both obtained from pulse oximetry monitoring, to provide an index of

nociception-antinociception balance. It correlates with surgical stimuli and dosage of analgesia and predicts the effect of pain stimuli and analgesic therapy with greater certainty than common clinical parameters [27, 28]. Bergmann et al. [29] used the SPI to guide the administration of remifentanyl in outpatient anesthesia and they concluded that adjusting the remifentanyl dosage according to the SPI reduced the consumption of both remifentanyl and propofol, thereby resulting in faster recovery. The adequate SPI range of 20–50 chosen in this study was based on the results of previous studies [27, 28]. If a rapid increase in the SPI occurred, fentanyl at 0.5 mg/kg was added. In the current study, significantly fewer patients in the music group required additional fentanyl. The SPI was high before induction and after extubation in both groups. This high mean value in the absence of painful stimuli may be related to preoperative stress. However, the SPI values were significantly lower in the music group than in the control group during the surgical procedure and therefore this reduced SPI appeared to be associated with listening to music intraoperatively.

Music reduces the stress responses in patients who are awake. However, there is ongoing debate about the role of music during general anesthesia. Szmuk et al. [30] found that listening to music during laparoscopic surgery did not reduce sevoflurane consumption. As in other studies [30, 31], deep anesthesia was avoided in the current study, and entropy around 50 which corresponded to slightly more than 1 MAC was maintained. However, at this modest level of anesthesia it was not possible to show that music significantly reduced the requirement for anesthetic.

Music is used to regulate moods in daily life and increase the sense of well-being in clinical settings. Apart from the effect of pleasurable music on cognition, the esthetic value as experienced by the patient adds to the management of pain and anxiety, e.g., in cardiovascular and surgical patients. Indeed, a growing body of evidence suggests that making music and listening to preferred music is a valuable adjunct to medical practice [32].

Conclusion

Children who listened to music during surgery needed less analgesia during surgery and also reported less pain after the surgery. The consumption of sevoflurane appeared to be lower in patients who listened to music than in those who did not, but this difference was not significant.

Appendix 1

Wong-Baker Faces Pain Scale. Faces pain scale for self-assessment of the severity of pain experienced by children: development, initial validation, and preliminary investigation for ratio scale properties [33].

Appendix 2

Richmond Agitation-Sedation Scale

+4	combative	violent, immediate danger to staff
+3	very agitated	pulls or removes tube(s) or catheter(s); aggressive
+2	agitated	frequent nonpurposeful movement, fights the ventilator
+1	restless	anxious, apprehensive, but movements are not aggressive or vigorous
0	alert and calm	
-1	drowsy	not fully alert but has sustained awakening to voice (eye opening and contact ≥ 10 s)
-2	light sedation	briefly awakens to voice (eye opening and contact < 10 s)
-3	moderate sedation	movement or eye-opening to voice (but no eye contact)
-4	deep sedation	no response to voice but movement or eye opening to physical stimulation
-5	unarousable	no response to voice or physical stimulation

Adapted from Sessler et al. [34].

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