Anesthesiology
1998; 89:300–6
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The Sedative and Analgesic Sparing Effect of Music

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Background: To determine whether music influences intraoperative sedative and analgesic requirements, two randomized controlled trials were performed.

Methods: In phase 1, 35 adults undergoing urologic procedures with spinal anesthesia and patient-controlled intravenous propofol sedation were randomly assigned to hear favorable intraoperative music _via_ headset or to have no music. In phase 2, 43 adults undergoing lithotripsy treatment of renal or ureteral calculi and receiving patient-controlled intravenous opioid analgesia were randomly assigned to either a music or no-music group. The effect of music on sedatives and analgesics requirements, recovery room duration, and adverse outcomes was assessed.

Results: In phase 1, patients in the music group required significantly less propofol for sedation than patients in the control group (0 [0–150] mg _vs._ 90 [0–240] mg, median[range]; $P < 0.001$). These findings persisted after adjusting for duration of surgery (0.3 ± 0.1 mg/min _vs._ 1.6 ± 0.4 mg/min; $P < 0.001$). Similarly, in phase 2, patients who listened to music had a significant reduction in alfentanil requirements (1,600 [0–4,250] μg _vs._ 3,900 [0–7,200] μg; $P = 0.005$). This persisted after adjusting for duration of surgery (52 ± 9 μg/min _vs._ 119 ± 16 μg/min, mean ± SD, $P < 0.001$). Duration of stay in the postanesthesia care unit and the rate of adverse events was similar in both groups (P = NS).

Conclusions: Use of intraoperative music in awake patients decreases patient-controlled sedative and analgesic requirements. It should be noted, however, that patients in the no-music group did not use a headset during operation. Thus, the decrease in sedative and analgesic requirements could be caused by elimination of ambient operating room noise and not by the effects of music. (Key words: Analgesia; anesthesia; sedation.)

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 9A.

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Received from the Departments of Anesthesiology, Pediatrics, Medicine, and Surgery, Yale University School of Medicine, New Haven, Connecticut. Submitted for publication July 29, 1996. Accepted for publication March 31, 1998. Presented in part at the annual meeting of the American Society of Anesthesiologists, October 20, 1996, New Orleans, Louisiana.

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PERIOPERATIVE anxiety is directly related to fear surrounding an unfamiliar environment, of loss of control, and of death and disfigurement.[1] Stimuli that emphasize these issues for patients will heighten anxiety, and stimuli that divert patient attention from these concerns will lessen anxiety.[2] Music is widely used to help persons relax and divert their attention from unpleasant and stressful situations. Kane,[3] in 1914, was the first person to provide intraoperative music to distract patients from "the horror of surgery." By the late 1930s, Farr[4] advocated the use of intraoperative music during surgical procedures for patients administered local anesthesia. It was not until approximately 1960, however, that a group of dentists reported the routine use of music during dental surgery; 65% to 90% of their patients needed little or no anesthesia for dental extractions.[5,6]

Surgical procedures performed using regional anesthesia techniques or monitored anesthesia care present a special challenge to anesthesiologists because patients are awake and exposed to multiple anxiety-provoking visual and auditory stimuli. We hypothesized *a priori* that intraoperative music chosen by a patient may provide a familiar auditory environment and may distract the patient's attention from upsetting issues such as discussion about surgical techniques or disease.[1,7] The first phase of this study investigated how music influenced the sedative requirements for patients who received spinal anesthesia for urologic procedures. In the second phase, we tried to determine whether patients undergoing lithotripsy treatment who listened to music needed less opioid to achieve a similar degree of analgesia than control patients.

Materials and Methods

Phase 1: Sedative Sparing Effects of Music

After approval from the Yale Human Investigations Committee, patients provided informed consent by tele-

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Table 1. Level of Sedation Scale*

Responsiveness	
0	Unresponsive
1	No purposeful response to mild prodding
2	Response only after mild prodding or shaking
3	Slow response only to name spoken loudly
4	Slow response to name spoken in normal tone
5	Immediate response to name spoken in normal tone
Speech	
0	No verbal response
1	Prominent slurring or few recognizable words
2	Moderate slurring or slowing
3	Mild slurring or slowing
4	Normal
Facial expression	
0	Asleep
1	Marked jaw relaxation
2	Mild jaw relaxation
3	Normal
Eyes	
0	Asleep
1	Glazed and ptosis greater than half the eye
2	Glazed and ptosis less than half the eye
3	Clear
Pain†	
0	None
1	Mild
2	Moderate
3	Severe

* Adapted from Cork *et al.*[8]

† For Phase II (Analgesia Sparing Effects of Music) pain score was recorded separately.

phone the evening before surgery. At this time they were told that they might or might not have an opportunity to actually listen to their music. All participants were asked to bring their favorite compact disc to the hospital on the morning of surgery. A suitable substitution was provided for those patients who did not have access to their favorite compact disc. The study population (n = 35) consisted of unpremedicated outpatients classified as American Society of Anesthesiologists physical status 1 to 3 who were scheduled to undergo urologic procedures using spinal anesthesia.

On the morning of surgery, demographic data were obtained, a baseline sedation score was determined, and all patients were instructed about the proper use of a patient-controlled sedation device. At this time the patients were informed again that they may or may not have an opportunity to listen to their music. Patients were randomized into either a control or a music group using a table of random numbers. Next, sedation scores were determined using a level-of-sedation scale (table 1). The scale was adapted from a recent investigation by Cork *et al.*[8] that explored the sedative effects of propofol delivered *via* a patient-controlled delivery device. The scale consists of four categories: responsiveness, speech, facial expression, and eye signs. The final score was the sum of the score in each category.

In the operating room, patients were positioned and the anesthesiologist administered an appropriate dose of intrathecal lidocaine, bupivacaine, or tetracaine for the particular procedure. After an adequate dermatomal level of anesthesia for the particular procedure was confirmed, patients received an intravenous loading dose of 1 μg/kg fentanyl citrate and 0.5 mg/kg propofol for 5 min. After cardiorespiratory stability was ensured, all patients were attached to an intravenous patient-controlled sedation pump (Bard Ambulatory PCA; C.R. Bard, North Reading, MA) that was set to deliver 30 mg propofol as often as every 3 min. Before surgical preparation, patients assigned to the music group had their favorite music delivered to occlusive headsets with the volume adjusted to mask any outside auditory input, whereas the control group did not wear headphones and listened to the regular operating room noise. Thus, the observer was not blinded to group assignment. Music was administered by a compact disc player (Discman ESP; Sony Corp., Tokyo, Japan) provided by the investigators. Blood pressure (BP), heart rate (HR), and subjective level of sedation score were recorded every 10 min, as were the number of patient-controlled demands and deliveries. Pulse oximetry (SpO_2) was monitored continuously, and the rate of critical respiratory events (SpO_2 <90% for more than 5 s) was recorded. The music was discontinued temporarily while sedation scores were determined. In the postanesthesia care unit (PACU), sedation scores, BP, HR, SpO_2, and duration of PACU stay were recorded.

Phase 2: The Analgesic Sparing Effects of Music

After the Human Investigations Committee provided approval, 43 patients classified as American Society of Anesthesiologists physical status 1–3 and scheduled for lithotripsy treatment of renal calculi using the Dornier 3 or Dornier 4 lithotriptor (Dornier Medical Systems, Inc., Kennesaw, GA) provided telephone consent to participate the evening before the procedure. All patients were instructed to bring their favorite compact disc with them the day of surgery and were familiarized with the concept of patient-controlled analgesia. Similar to the procedure of phase 1, patients were told that they may or may not have an opportunity to listen to their music.

On the day of surgery, baseline vital signs were re-

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corded and patients were informed again that they may or may not have an opportunity to listen to their music. Situational and baseline anxiety were noted using Spielberger's self-report state and trait anxiety inventory (STAI) to ensure that neither group was more or less predisposed to anxiety. The STAI is a widely used self-reporting instrument that estimates situational and baseline anxiety in adults based on responses to 40 statements.‖ Patients are asked to respond using a four-point scale; total scores for situational and baseline questions separately ranged from 20 to 80, with higher scores denoting higher levels of anxiety. Test-retest correlations for the STAI are high, ranging from 0.73 to 0.86. Reliability of the STAI is based on results in three groups of college students. The students retested after 1 h were exposed to the following experimental conditions: a brief period of relaxation training, a difficult intelligence quotient test, and a film depicting several accidents that resulted in serious injury. Validity was evaluated in two studies in which the STAI was administered in high- and low-stress conditions to large samples of students. The correlation coefficient value ranged from 0.83 to 0.94, suggesting very good construct validity (regardless of whether a scale accurately measures the construct its intended to measure). In our study, after completing the inventory, baseline pain and sedation scores were recorded using a self-reported visual analog scale, with O denoting no pain or anxiety and 10 signifying excruciating pain.[9] In addition, separate baseline subjective-level-of-sedation scores were determined using a modified version of the scale noted in phase 1.[8] That is, pain scores were recorded separately. The patients again were instructed concerning the proper use of patient-controlled analgesia before the procedure began.

After being positioned on the lithotriptor table, patients received 20 μg/kg intravenous midazolam, 10 mg metoclopramide, and 10 μg/kg alfentanil during a period of 5 min. They were attached to an intravenous patient-controlled analgesia pump (Pain Management Provider; Abbott Laboratories, North Chicago, IL) set to deliver 10 μg/kg alfentanil with an effective lockout period of 3 min. The music group had occlusive headphones as described in phase 1, and the control group listened to the ambient noise present in the lithotriptor suite. The BP, HR, self-reported visual analog scale pain and sedation scores, level-of-sedation scale scores, and the average stimulus load (summation of power in kilovolts times corresponding frequency in Hertz) to which the patient was exposed from the lithotriptor shock-wave generator were recorded every 15 min. The music was stopped temporarily while sedation and pain scores were determined. After operation, time in the PACU, sedation scores, BP, HR, and SpO_2 were recorded.

Data were analyzed with the use of SPSS version 6.1.1 (SPSS Inc., Chicago, IL). Demographic data are summarized as the mean ± standard deviation or median with corresponding range and by cross-tabulation for nominal data. Categoric items were analyzed by frequency distributions and chi-square analysis. Because some of the data did not show a normal distribution, nonparametric analysis was used when appropriate. Means between groups were compared using the unpaired sample Student's *t* test, the Mann–Whitney U test, or the Mann–Whitney rank sum test. Statistical significance was assumed for $P \leq 0.05$. Data are presented as mean ± SD or median (range).

Table 2. Baseline Characteristics of Phase I Subjects*

	Control (n = 15)	Music (n = 19)
Age (yr) †	53 ± 12	54 ± 15
Gender M/F (%)	87/13	85/15
ASA physical status [median (range)]	2 (1–3)	2 (1–3)
Duration of surgery (min)†	68 ± 28	65 ± 28
Systolic blood pressure (mmHg)†	153 ± 18	149 ± 23
Diastolic blood pressure (mmHg)	91 ± 29	85 ± 13
Heart rate (beats/min)†	71 ± 13	79 ± 16
Baseline level of sedation‡	15 (15)	15 (15)
Spinal anesthetic (%)		
Bupivacaine	60	72
Lidocaine	33	28
Tetracaine	7	0
Dermatome of anesthesia (%)		
T3		1 (5%)
T4		1 (5%)
T5		
T6	1 (6%)	5 (25%)
T7	6 (40%)	1 (5%)
T8	4 (27%)	7 (35%)
T9		3 (15%)
T10	4 (27%)	2 (10%)

* There were no significant differences between groups.
† Mean ± SD.
‡ Measured by level of sedation scale.[8]

‖ Spielberger CD: Manual for the State-Trait Anxiety Inventory (STAI: Form Y). Palo Alto, CA, Consulting Psychologists Press, 1983

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Table 3. Phase I: Intraoperative and Postoperative Variables and Outcomes

	Control (n = 15)	Music (n = 19)	*P* Value
Systolic blood pressure (mmHg)*	125 ± 16	129 ± 19	NS
Diastolic blood pressure (mmHg)*	70 ± 8	72 ± 10	NS
Heart rate (beats/min)*	61 ± 8	66 ± 11	NS
Level of sedation†	14 (7–15)	15 (11–15)	NS
Propofol requirements (mg)*	94 ± 70	17 ± 36	<0.001
Median (range)	90 (0–240)	0 (0–150)	
Propofol requirements (mg/min)*	1.6 ± 0.4	0.3 ± 0.1	<0.001
Post-anesthesia care Unit duration (min)*	111 ± 55	105 ± 47	NS
Desaturation rate (%)‡	13%	5%	NS

NS = not significant.

* Mean ± SD.

† Measured by level of sedation scale.[8]

‡ Sp_{O_2} ≤ 90% for > 5 s.

Results

Phase 1: Sedative Sparing Effects of Music

Table 2 presents baseline and demographic variables. There were no significant differences between the control and intervention groups regarding age; gender; American Society of Anesthesiologists physical status; and baseline BP, HR, and baseline level of sedation scores. Two patients were removed from the study secondary to the need for general anesthesia and inadvertent departure from the study design.

Intrathecal bupivacaine, lidocaine, and tetracaine were used with similar frequency in both groups, and the resultant maximum dermatome of anesthesia was achieved (table 2). Intraoperative data revealed no significant differences between the control and music groups with respect to hemodynamic variables measured, such as mean intraoperative BP, HR, and SpO_2 (table 3).

In phase 1, patients in the music group required on average significantly less propofol for sedation than did patients in the control group (0 [0–150] mg *vs.* 90 [0–240] mg; $P < 0.001$; table 3). Because of the wide variation in case duration (range, 15 to 135 min), we normalized the sedative requirements by time. That is, patient-controlled analgesia use for each patient was normalized to their duration of use, and then the average of these values was compared. Patients in the music group required significantly less propofol to achieve a similar degree of sedation (0.3 ± 0.1 mg/min *vs.* 1.6 ± 0.4 mg/min; $P < 0.001$; table 3). We have also evaluated the influence of time on our analysis. That is, we plotted the dose of propofol per patient in time intervals of 10 min (fig. 1). Patients in the music group required less propofol than patients in the nonmusic group. We did not observe that patients who did not have music were extremely anxious in the beginning and used a lot of propofol and then used less in the end (fig. 1). Finally, patients who listened to music were no less or more likely to suffer a critical respiratory event.

Phase 2: Analgesic Sparing Effects of Music

The control and music groups were similar with respect to age; weight; American Society of Anesthesiologists physical status classification; and baseline BP, HR, and SpO_2 (table 4). The STAI scores did not reveal that either group was more inclined to have an anxious personality, and both groups were similar with respect to the subjective level of sedation score and self-reported anxiety and pain scores (table 4).

Intraoperative data revealed no significant difference in BP, HR, SpO_2, and lithotriptor stimulus loads (table 5). The mean intraoperative level of sedation score was similar for both groups, as were the mean self-reported visual analog scale sedation and pain scores (table 5). As in phase 1, patients who listened to music had a significant reduction in alfentanil requirements (1,600 [0–4,250] μg *vs.* 3,900 [0–7,200] μg; $P = 0.005$; table 5). Next, we adjusted the analgesic requirement for time because of the wide variation in case duration (range, 20 to 47 min). Patients who listened to music had an average 44% reduction in overall alfentanil requirements per 15-min time interval (52 ± 9 μg/min *vs.* 119 ± 16 μg/min; $P < 0.001$). As in phase 1, we plotted the accumulative dose of alfentanil per patient in time intervals of 15 min (fig. 2).

A similar percentage of patients in each group had desaturation episodes, and postoperative nausea or emesis occurred with equal frequency in both groups (*P* = not significant; table 5). Finally, PACU duration of stay was similar in both groups, and none of the patients in either group had hemodynamic or respiratory compromise in the PACU (table 5).

Discussion

In phase 1 of this investigation, we found that patients who listened to music or who heard less operating room

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noise required significantly less propofol to achieve the same level of sedation as control patients. In phase 2 of our study, patients who listened to music reduced their average opioid requirements to 44% that of controls. It should be noted, however, that the no-music group did not use a headset during operation. Therefore, the decrease in sedative requirements could result from elimination of ambient operating room noise, such as discussion about surgical techniques, and not as a result of the calming effects of music.

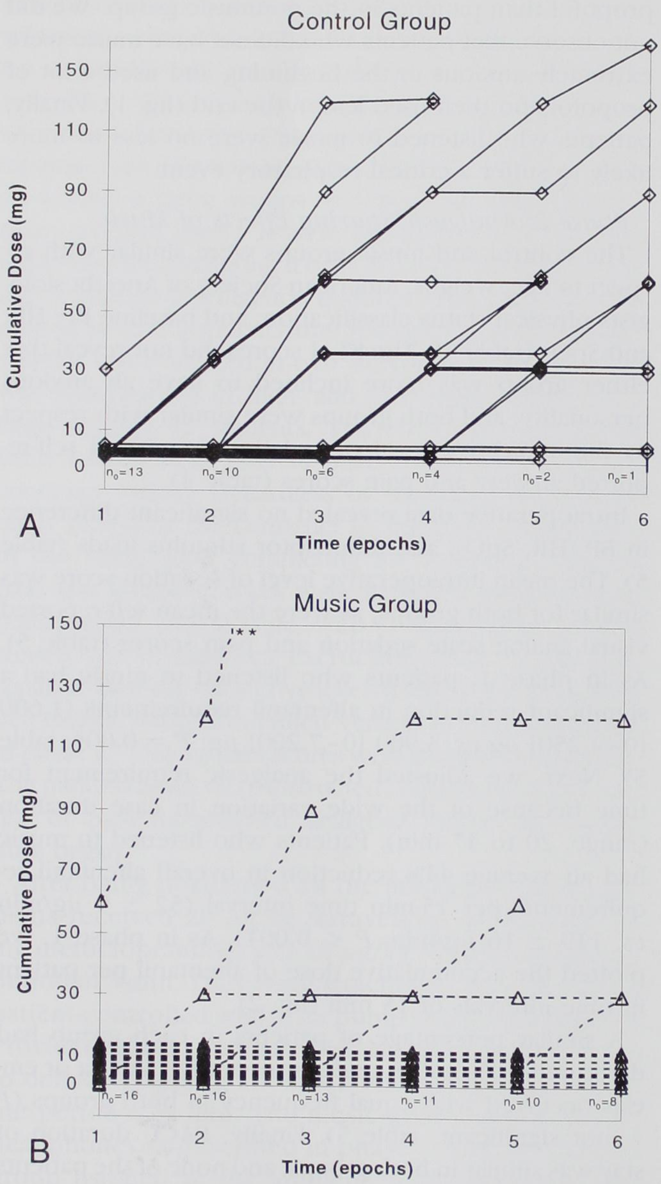

Fig. 1. (*A*) Cumulative doses used by controls in phase 1 of the study. Time epochs were 10 min. n_0 = the number of patients with a cumulative dose of 0 mg. (*B*) Cumulative doses used by patients listening to music in phase 1 of the study. Time epochs are 10 min. n_0 = the number of patients with a cumulative dose of 0 mg. **Values of this patient were 210 mg after three time epochs, 270 mg after four time epochs, 360 mg after five time epochs, and 420 mg after six time epochs.

Table 4. Baseline Characteristics of Phase II Subjects*

	Control (n = 22)	Music (n = 21)
Age (yr)†	53 ± 12	54 ± 15
Gender M/F (%)	44/56	80/20
ASA physical status‡	2 (1–3)	2 (1–3)
Duration of surgery (min)†	30 ± 7	32 ± 5
Systolic blood pressure (mmHg)†	134 ± 22	132 ± 16
Diastolic blood pressure (mmHg)†	81 ± 14	80 ± 11
Heart rate (beats/min)†	80 ± 16	77 ± 11
Sp_{O_2}†	98 ± 1	97 ± 2
Baseline level of sedation score§	14 ± 1	13 ± 3
Baseline Self-Report VAS Sedation¶	3 ± 3	3 ± 3
Baseline Self-Report VAS Pain¶,**	1 ± 2	2 ± 2
State Anxiety Inventory Score†,**	46 ± 8	44 ± 5
Trait Anxiety Inventory Score†,**	45 ± 4	45 ± 5

* There were no significant differences between groups.

† Mean ± SD.

‡ Median and range.

§ Measured by level of sedation scale.[8]

¶ Visual Analoge Scale (range 0–10).

** State Trait Anxiety Inventory (range 0–80).

Auditory input is a known modulator of the human response to stress.[10] Previous studies in the medical and psychological literature have shown that music may have a therapeutic role in medicine.[11,12] At the onset of this investigation, we hypothesized that the calming effect of music is potent enough to decrease the sedative and analgesic needs of a group of awake patients undergoing surgical procedures. We found that this hypothesis is true. The postulated explanation for this, from a psychological perspective, may involve issues of control and distraction.[7] The factors that add to heightened stress, such as uncomfortable or unfamiliar environment, loss of control, and fear of disfigurement, all may be attenuated by the distracting and calming effects of music.

Several physiologic and biochemical explanations for the calming effects of music are proposed. The gate-

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Table 5. Phase II: Intraoperative and Postoperative Variables and Outcomes

	Control (n = 22)	Music (n = 21)	*P* Value
Systolic blood pressure (mmHg)*	130 ± 16	131 ± 17	NS
Diastolic blood pressure (mmHg)*	76 ± 13	76 ± 11	NS
Heart rate (beats/min)*	82 ± 13	80 ± 11	NS
Sp_{O_2}	97 ± 2	97 ± 2	
Stimulus load, kV · min · 10³*	59 ± 14	65 ± 13	NS
Self-Report VAS Sedation*,†	1 ± 1	1 ± 2	NS
Level of Sedation Score*,‡	12 ± 2	12 ± 1	NS
Self-Report VAS Pain Score#	3 ± 2	3 ± 2	NS
Alfentanil requirements (μg)*	3,637 ± 2,138	1,997 ± 1,409	0.005
Median (range)	3,900 (0–7,200)	1,600 (0–4,250)	
Alfentanil requirements (μg/min)*	119 ± 16	52 ± 9	<0.001
Post-anesthesia care unit duration (min)§	85 (45–240)	70 (45–120)	NS
Desaturation rate¶ (%)	14%	14%	NS

NS = not significant.

* Mean ± SD.

† Visual Analogue Scale (range 0–10).

‡ Measured by level of sedation scale.[8]

§ Median (range).

¶ $Sp_{O_2} \leq 90\%$ for > 5 s.

control theory is based on the premise that pain is the result of an integrated sensory, affective, motivational system that modulates noxious input and attenuates the perception of nociceptive input.[13] It has been suggested that pain and auditory pathways inhibit each other.[5] Perhaps the activation of the auditory pathway during surgery inhibits the central transmission of nociceptive stimuli. The influence of music and acoustic stress on gut hormone levels already has been shown.[14] Studies of other biochemical changes associated with listening to music, such as alterations in endorphin levels, in the future may provide the chemical framework for this inhibition.

Previous studies have documented the sedative and analgesic effects of music in ophthalmologic and podiatric procedures.[13,14] Methodologic flaws in previous studies include important issues such as the lack of controls or involvement of the caregivers in the administration of sedatives.[13] In our study, patients were allowed to self-medicate to a comfortable level of sedation or analgesia, and the anesthesiologist played no role in helping patients attain this state. In addition, in some of the previous studies, participants were coached extensively on the sedative and analgesic potential of music. Our patients were never told explicitly that music would help them relax or lessen their perception of pain.

The relatively high rate of adverse respiratory events seen in phase 2 suggests that further investigation is needed. A reduction in the bolus dose of alfentanil or an increase in the lockout period may diminish this rate. Furthermore, the synergistic effect of midazolam might also have played a role in the rate of desaturation. All patients responded to verbal cues to improve their ventilation.

Finally, several methodologic issues related to this investigation must be addressed. The patients' favorite music was delivered to occlusive headsets with the volume adjusted to mask any outside auditory input, whereas patients in the control group did not wear headphones and listened to the regular operating room noise. Two methodologic issues result from this "flaw" in study design. First, because the no-music group did not use headsets, the decrease in the sedative requirements could be a result of elimination of ambient operating room noise and not a result of the calming effects of music. Second, the observer was not blinded to which patients did or did not listen to music. To reduce the possibility of inadvertent bias, in future investigations, both the music and nonmusic groups should wear occlusive headphones with a switch used to temporarily terminate power to the compact disc player while questions are asked and the sedation score is determined. This change in the protocol would also help to show that the reduction in sedative require-

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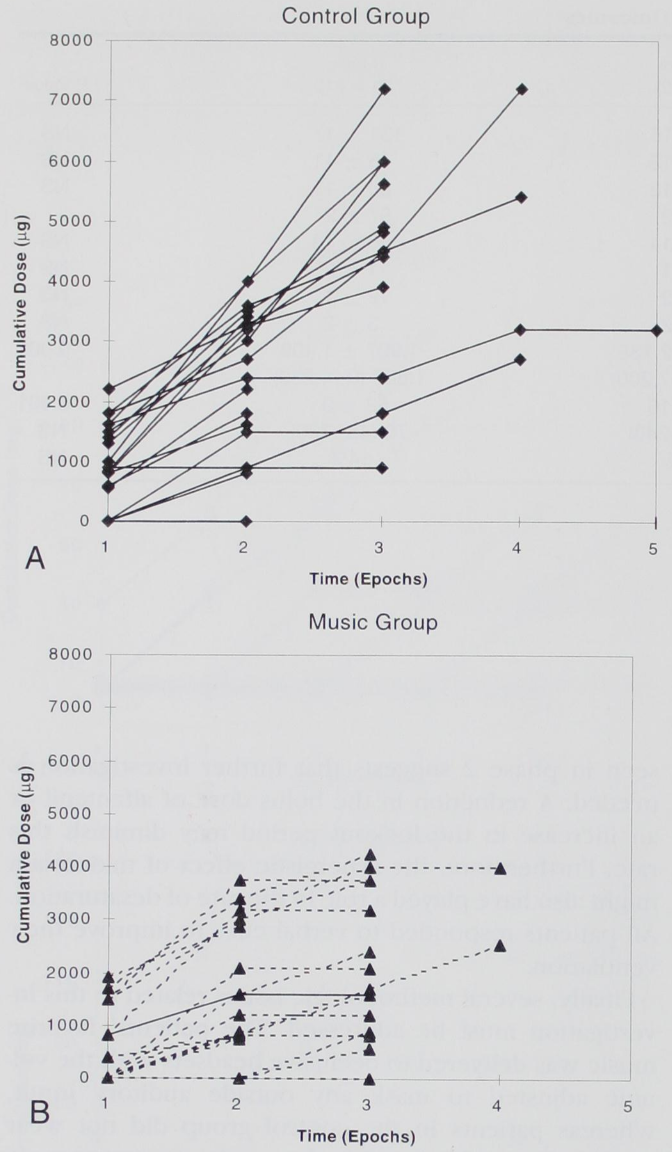

Fig. 2. (*A*) Cumulative doses used by controls in phase 2 of the study. Time epochs are 15 min. (*B*) Cumulative doses used by patients listening to music in phase 2 of the study. Time epochs are 15 min.

ments was a result of music rather than of the elimination of operating room noise.

Second, by inviting patients to bring in their favorite music, it could be argued that we might have created an expectation that was then defeated. Theoretically, this could have played a role in the different requirements seen in the study and control groups. This possibility was minimized by repeatedly informing patients that they were just as likely not to have an opportunity to listen to their favorite music. Future studies might have two additional groups that are not called the evening before and that are offered or not offered music after they arrive in the operating room. Third, in phase 2, we could not control for sedation as completely as we controlled for analgesia in phase 1 *via* a spinal anesthetic. Although we repeatedly instructed patients that the medication in the pump would promote pain relief, it is possible that some patients administered themselves alfentanil to achieve additional sedation rather then to promote analgesia. Choosing a procedure that is less painful and using a medication that has pure analgesic properties may help to clarify this issue in future studies.

In conclusion, we found that intraoperative music may benefit awake patients undergoing urologic procedures during spinal anesthesia and patients undergoing lithotripsy. Subsequent investigations are necessary, however, to determine whether the decrease in sedative requirements results from intraoperative music or the elimination of ambient operating room noise.

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