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Relaxing intraoperative natural sound blunts haemodynamic change at the emergence from propofol general anaesthesia and increases the acceptability of anaesthesia to the patient

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Background: It is known that auditory input, such as comforting music or sound, blunts the human response to surgical stress in conscious patients under regional anaesthesia. As auditory perception has been demonstrated to remain active under general anaesthesia, playing comforting sounds to patients under general anaesthesia might also modulate the response of these patients to surgical stress.
Methods: Fifty-nine patients scheduled for laparoscopic cholecystectomy were anaesthetized with propofol general anaesthesia in combination with epidural anaesthesia. Natural sounds, chosen preoperatively by each patient as being comforting, were played to 29 patients using headphones during surgery (S group) and the remainder of the patients ($n = 30$) were fitted with dummy open-type headphones (N group). We compared the haemodynamic change during anaesthesia and the acceptability of anaesthetic practice between the two groups in a randomized double-blind design.
Results: There were no differences in haemodynamics between the S and N groups during surgery. During the emergence from anaesthesia, the mean blood pressure and heart rate gradually increased; both parameters were significantly higher in the N group than in the S group. Postoperatively, patients in the S group perceived the experience of anaesthesia as significantly more acceptable than did those in the N group.
Conclusion: These findings indicate that allowing patients comforting background sounds during general anaesthesia may blunt haemodynamic changes upon emergence from general anaesthesia and increase the acceptability of the experience of anaesthesia.

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Key words: Acceptability; emergence; haemodynamics; natural sound; propofol; psychological stress.

It has been well documented that music and sound have therapeutic effects in various clinical situations (1, 2). In this context, clinical interest has developed in the use of music and sound for intraoperative and postoperative sedative and nociception control. Several studies have demonstrated that there may be a decrease in sedative and analgesic requirements when some kinds of music or sound are played during surgical procedures, indicating that auditory input may modulate the human response to surgical stress (3–5). However, most of these results have been obtained in conscious or lightly sedated patients. Less information is available regarding unconscious patients under general anaesthesia.

Several studies, however, have revealed that subconscious memory through auditory input may exist following general anaesthesia. Block et al. have shown that when patients under general anaesthesia receive suggestions to touch their ears, they will have a tendency to touch their ears more often in postoperative interviews (6), while Evance et al. have shown that therapeutic suggestions during general anaesthesia result in positive postoperative effects (7). These findings suggest that auditory processing functions remain active under general anaesthesia to a greater extent than was previously recognized. It is not unreasonable to suggest that manipulation of patients' auditory input under general anaesthesia may also modulate their responses to surgical stress in a manner similar to that demonstrated in conscious patients.

In the present study, we investigated haemodynamic changes during general anaesthesia, including the emergence period, and also evaluated the acceptability of anaesthesia to patients who had listened to comforting, calming, natural sounds intraoperatively, as compared with patients receiving normal auditory input.

Subjects and methods

Patients

After receiving approval from the Ethics Committee, informed and consenting patients (ASA I–II) who were scheduled for elective laparoscopic cholecystectomy were allocated randomly to either an intraoperative sound (S) group or a non-sound (N) group using computer-generated random numbers just before being transferred to the operating theatre. Patients with pre-existing complications of angina, essential hypertension, and auditory perception were excluded in advance. A preliminary study had demonstrated that the mean arterial pressure is 95 ± 12 mmHg and the mean heart rate is 70 ± 12 b.p.m. for patients scheduled for elective laparoscopic cholecystectomy in our hospital. A power analysis indicated that a sample size of 27 subjects in each group (54 total) is sufficient to detect differences of 10 mmHg in mean arterial pressure and 10 b.p.m. in heart rate with a power of 0.85 and α of 0.05 (Instat 3, GraphPad Software Inc. San Diego, CA). Based on this power analysis, and taking into consideration that some subjects might drop out, 64 patients were investigated in a double-blind fashion, as described later.

Methods of general anaesthesia

Each patient was premedicated with 0.08 mg kg^{-1} of midazolam i.m. 60 min before surgery. Before intubation, an epidural catheter was inserted at T9–T10. Anaesthesia was induced by 3–4 mg kg^{-1} of propofol, 0.004 mg kg^{-1} of fentanyl and 0.15 mg kg^{-1} of vecuronium in combination with topical anaesthesia of the larynx with 4% lidocaine, then 5 ml of 1.5% lidocaine with 0.1 mg of fentanyl as an initial loading dose was injected through the epidural catheter. Before the skin incision, a small amount of lidocaine was injected into the incision area. Anaesthesia was maintained with 5–8 mg kg^{-1} h^{-1} of propofol at bispectral index (BIS) levels less than 60, and a continuous epidural infusion of 1.5% lidocaine at a rate of 5 ml h^{-1}. All patients were mechanically ventilated with 100% oxygen to an end tidal carbon dioxide level of 35–38 mmHg. Arterial blood pressure was monitored non-invasively. The infusion of propofol was stopped at closure of the abdominal incision. When the patients responded well to verbal commands, they were extubated. Antihypertensive agent was given to patients who had greater than 180 mmHg of systolic pressure. After extubation, they were transferred to the postanaesthesia care unit (PACU), where they remained for 20 min. Epidural infusion of lidocaine was continued until the patients left the PACU. Patients who received a blood transfusion or who had a change in operation method were excluded from the study subjects. Patients for whom the analgesia level of epidural anaesthesia did not expand to within the range from T4 to T12, as evaluated by testing by a pinprick method in the PACU, were also excluded from the study subjects.

On the day following surgery, the patients were asked the following two questions:

1. Do you remember anything from the operation?
2. Do you think that you heard any sound during the operation?

Then, to determine the patients' experience of anaesthesia, they were asked to mark a line on a scale. The line was marked with the word 'acceptable' at one end, with a score of 10, and 'not acceptable' at the other end, with a score of 0, and the results were evaluated in a manner similar to the visual analogue pain scale (8).

Method of playing natural sound

For this study, two sets of identical-looking headphones were prepared. One was a conventional semi-closed headphone for patients in the S group, while the other was for patients in the N group. This second set had the same outer shape, but the inner speaker unit had been removed and small multiple holes had been inconspicuously made at its centre, through which outside noise could be freely heard. Both sets of headphones had long connection cables leading to a music player placed in a separate room, which was hidden from view of the anaesthesiologist in the theatre.

Preoperatively, each patient was asked to choose a set of sounds they felt to be calming and comforting. These sounds included various environmental sounds with which many Japanese are familiar, including sounds of a ripple, a small stream, a soft wind, and a twitter. They were then asked to listen to their selected sounds using headphones to determine a comforting sound volume. They listened to their chosen sounds for at least 30 min to further familiarize themselves with the sounds. On arrival in the operating theatre, anaesthesia was induced as described earlier. Then, the chosen sound was played continuously to the S group patients through the conventional headphones until the last suture of surgery at the sound volume that they had preoperatively selected. The patients in the N group who wore the dummy headphones were exposed to normal surgical background noise and voices in the operating theatre through the small multiple holes made at the centre of the headphones.

Both sets of headphones had an identical outer shape, and playing of sounds for the S group was completely controlled from outside the theatre. Furthermore, sound volumes were not high enough to be detected by the anaesthesiologist unless he brought his ear very close to the headphone. To guard against this possibility, the behaviour of the anaesthesiologists was monitored during the entire course of anaesthesia on a TV that was located in a separate room. Thus, for each surgery we are certain that the anaesthesiologist in charge was unaware of the patient's group allocation.

Data analysis

Patient characteristics were compared with analysis of variance (ANOVA). Haemodynamic change was compared by repeated measures or factorial ANOVA with the Turkey-Kramer multiple comparison test. Differences in the acceptability of anaesthesia between the two groups were analyzed using an unpaired *t*-test. Differences in incidence of antihypertensive treatment and restlessness during recovery from anaesthesia between the two groups were analyzed using a chi-square test. A *P*-value of less than 5% was considered significant. All values are expressed as mean ± SD (standard deviation).

Results

Five patients were excluded from the study due to changes in operation method, blood transfusion or insufficient epidural analgesia level, and the remaining 59 patients (30 patients in the N group and 29 patients in the S group) were investigated. Patient age, height, and weight were 66 ± 9 years, 156 ± 8 cm and 53 ± 9 kg, respectively, in the N group, and 65 ± 10 years, 159 ± 8 cm and 56 ± 9 kg, respectively, in the S group. There were no significant differences in these characteristics between the two groups. The duration of anaesthesia, the time required for extubation after termination of propofol infusion, and the total infused dose of propofol were 179 ± 105 min, 21 ± 7.9 min and 907 ± 118 mg, respectively, in the N group, and 188 ± 99 min, 24 ± 8.1 min and 924 ± 113 mg, respectively, in the S group. There were no significant differences in these values between the two groups.

Mean blood pressure and heart rate during anaesthesia (at the start of surgery, during gallbladder removal, and at the end of surgery) were not significantly different between the two groups (Fig. 1). As recovery from anaesthesia progressed, both parameters gradually increased. Before extubation, the mean blood pressure and heart rate of the S group patients were significantly lower than those of the N group. During this recovery period, there was no requirement for antihypertensive agents or development of restlessness in the S group. For the N group, an antihypertensive agent was given to six patients (a significantly higher incidence with a *P*-value of 0.039), and restlessness was observed in three patients (not significant). In the PACU, blood pressure and heart rate decreased in both groups to near the level at the start of anaesthesia.

On the day following surgery, after complete recovery from anaesthesia, none of the patients had any explicit memories of the operation itself, and patients in the S group perceived the experience of anaesthesia as significantly more acceptable than did those in the N group (Table 1).

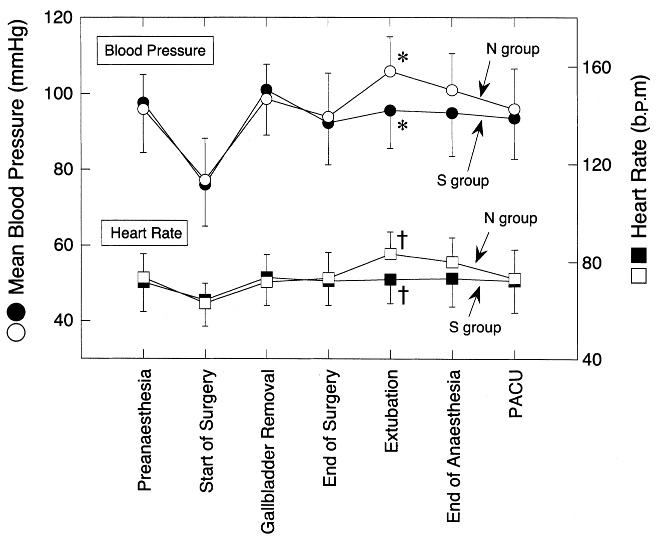

*Fig. 1. Haemodynamic changes (mean blood pressure and heart rate) during the course of anaesthesia with continuous epidural anaesthesia in the intraoperative sound (S) group (●, ■) and non-sound (N) group (○, □). *, † Indicate significant differences between them P < 0.05.*

Table 1

Acceptability score.

N group	S group	*P*-value
6.1 ± 2.1	7.9 ± 2.9	0.0102

Discussion

Several physiological and biochemical explanations for the calming and analgesic effects of music and/or sound have been proposed. It has been suggested that pain and auditory pathways inhibit each other (9). Optimum activation of auditory pathways by external sound might therefore inhibit the central transmission of nociceptive stimuli. The influence of music and acoustic stress on gut hormone levels has been shown (10). Music-induced alterations in endorphin levels have also been demonstrated (11). In addition, for patients undergoing surgery, it should be recognized that they are sometimes subjected to potentially adverse and threatening operating theatre events and conversation. 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 (12). Listening to music or sounds in the operating theatre masks such unpleasant ambient noise.

In the present study, we found that calming intraoperative sound under general anaesthesia blunted haemodynamic changes upon emergence from anaesthesia, and it also resulted in an increase in the perceived acceptability of the experience of anaesthesia. Both of these effects were statistically significant, but were not dramatically strong. These findings indicate that the concept of music or sound as modulators of human response to surgical stress under regional anaesthesia (3–5) may also be valid in unconscious patients who are under general anaesthesia. It has been reported that implicit memories of sounds heard during propofol anaesthesia are easier to recall (13), and propofol has some unique pharmaceutical characteristics (14–16) as compared with conventional inhalation anaesthesia (17–19). In addition, listening to the same sounds that were chosen preoperatively may reduce the subliminal psychological stress originating from the unfamiliar environment of the operating theatre and the presence of strangers there. These factors may have helped to improve the effectiveness of intraoperative sound in the present study.

However, neither the total dose of propofol nor the haemodynamics during surgery were affected by the procedures described. Schwender et al. demonstrated evidence for the preservation of intraoperative auditory perception during general anaesthesia by measuring auditory evoked responses that reflected the integrity of hearing ability (20, 21). They showed that hearing ability is well maintained at clinical concentrations of general anaesthetic agents, which is in good agreement with other clinical findings indicating the presence of subconscious memory through auditory input following general anaesthesia. However, considering the inhibitory properties of anaesthetic agents to various vital responses, it seems logical that the effect of sound is somewhat limited in the middle of the general anaesthesia period, as compared with regional anaesthesia.

Physical and/or psychological stress resulting from surgery becomes obvious with the withdrawal of anaesthetic agents as the patient emerges from anaesthesia. It is well known that arterial hypertension and tachycardia frequently develop in this period via catecholamine release or sympathetic stimulation (22). Aono et al. have demonstrated that preoperative anxiety increases the incidence of excitement at the emergence from anaesthesia, indicating that the emergence from anaesthesia is readily affected by preceding mental stress, as well as by physical injury (23). It may be considered that the patients' vulnerability during emergence from anaesthesia makes the effect of intraoperative sound become obvious during emergence.

In conclusion, there was suppression of the temporary increase in blood pressure and heart rate in those patients who had listened to natural, comforting sounds during general anaesthesia, and these patients reported an increased acceptability of their experience of anaesthesia. This indicates that allowing patients comforting sounds during general anaesthesia may be beneficial. These results raise further interesting as well as practical questions, such as whether the 30-min period of listening to comforting sound preoperatively, which is labour consuming in a busy daily clinical practice, is essential for the beneficial effect. Also, it has not yet been determined whether pleasant sounds are effective if the patient receives them only during the recovery period from anaesthesia, or if some other possible time period will have the same effect. These questions will be addressed in future studies.

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