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ORIGINAL RESEARCH

The effect of dexmedetomidine on middle ear pressure

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OBJECTIVE: Dexmedetomidine is a preferred anesthetic agent in otological surgery because it provides controlled hypotension and good surgical field visibility. The aim of this study was to evaluate the influence of this novel agent on middle ear pressure.
STUDY DESIGN AND SETTING: This prospective clinical trial was performed in 60 patients who were scheduled for elective surgery. They received dexmedetomidine or saline infusion for 20 minutes before induction of anesthesia. Tympanometric measurements were recorded for both ears at preoperative, intraoperative, and postoperative states.
RESULTS: Mean difference of tympanometric peak pressure from baseline was statistically significant between dexmedetomidine and control group at the 30th minute of operation (24.8 daPa, $P = 0.003$ for right ear; 20.5 daPa, $P = 0.02$ for left ear) and at the end of the operation (25.8 daPa, $P = 0.01$ for right ear; 28.1 daPa, $P = 0.004$ for left ear).
CONCLUSIONS: Dexmedetomidine anesthesia raises the tympanometric parameters, but they never exceed the limits of normal.

α2-Adrenoceptor agonists have several beneficial actions during the perioperative period. They exert a central sympatholytic action, thus improving hemodynamic instability in response to endotracheal intubations and surgical stress. Consequently, this action reduces anesthetic and opioid requirements, and causes sedation, anxiolysis and analgesia.[1-3] Dexmedetomidine is a second-generation α2-adrenoceptor agonist. It has shorter duration of action and shorter elimination half-life, and possesses full agonist properties with a high selectivity for α2-adrenoceptors compared with α1-adrenoceptors. It was approved in the United States at the end of 1999 for sedation and analgesia in the intensive care unit.[3] It shows good hemodynamic stability and controlled hypotension, and there is no evidence of respiratory depression at clinical concentrations.[4-6] Dexmedetomidine not only reduces anesthetic requirements, it also induces anesthesia by itself and is a new concept for the administration of anesthesia.[3]

Dexmedetomidine is a preferred agent for the otolaryngological anesthesia for the reasons mentioned in Discussion. In middle ear microsurgery, it provides controlled hypotension and good surgical field visibility.[5,7] In middle ear microsurgery, during the tympanic graft insertion, outer atmospheric pressure and middle ear cavity pressure need to be equal. Up to now, we did not know the effect of dexmedetomidine on intratympanic pressure. In this study we evaluated the influence of dexmedetomidine on middle ear pressure parameters.

MATERIALS AND METHODS

Approval from the local ethics committee was obtained. Patients who were scheduled for elective surgery under general anesthesia were included in the study group. We informed all the subjects about the anesthetic assessment including side effects of dexmedetomidine. All subjects gave informed and written consent to participate in this pharmacodynamic study.

Clinical Assessment

Consenting subjects were first evaluated by an anesthesiologist, and American Society of Anesthesiologists (ASA) physical status III or IV were excluded from the study group. Afterwards, the otolaryngological examinations including otoscopic examination and tympanometry in both ears were carried out in the operating room. Participation was defined after the confirmation of absence of any middle ear pathology or middle ear pressure abnormality.

Group Design

Patients were assigned to dexmedetomidine group (n = 30) and control group (n = 30). Dexmedetomidine or saline was randomly administered to patients under double-blind conditions. Both groups were well-matched for age, sex, weight, operation and anesthesia time, ASA physical status, and type of surgical procedure.

Anesthetic Measurements

All anesthetics were administered by the same anesthesiologists with a standardized protocol for sedation, induction,

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and maintenance. After an 8-hour fast and the starting of standard anesthesia monitoring using a Capnomac 2 (Datex Capnomac, Instrumentatrium, Helsinki, Finland), baseline measurements were recorded (systolic, diastolic, and mean arterial blood pressure, heart rate, and oxygen saturation by pulse oximeter [SpO2]). Patients received dexmedetomidine or saline 20 minutes before induction of anesthesia. In the dexmedetomidine group, following the initial loading dose of 0.8mg/kg/h over 10 minutes, infusion was applied with a dose of 0.4mg/kg/h for 10 minutes. In the control group, infusion of saline was applied with a dose of 0.8 mg/kg for 20 minutes. After dexmedetomidine or saline infusion, induction of anesthesia was administered with thiopental (5-7 mg/kg), fentanyl (1 μg/kg), and vecuronium (0.1 mg/kg). Hemodynamic variables were recorded every five minutes for the first 30 minutes. Anesthesia was maintained with 2 percent end-tidal sevoflurane and fentanyl 5 μg/kg.

Tympanometry Recordings

Tympanometry was performed with a Madsen Electronics type Zodiac 901 Middle Ear Analyzer (Zodiac 901; Madsen Electronics, Copenhagen, Denmark). Subjects with an intact mobile tympanic membrane on otoscopy and a Jerger type A curve on tympanometry with tympanometric peak pressure (TPP) between −100 and +100 daPa, and tympanometric width (TW) between 50 to 110 daPa (mean 80 daPa) were considered to have normal middle ear pressure.[8] In the event of failure, subjects were referred to the otolaryngology department for medical consultation and excluded from the study group. The middle ear pressures were measured while the patient was lying down, with the head of the bed raised at 30° to avoid the effects of intraoperative factors. For both ears, TPP and TW were assessed before the operation, at the 10th min of dexmedetomidine or saline infusion, immediately after intubation, at the 30th minute of operation, at the end of operation, and at the postoperative 15th minute.

Statistical Analysis

Statistical data entry and analysis were performed with SPSS, version 13 (SPSS Inc, Chicago, IL). All data were reported as means ± SD. Normality for continued variables in groups was determined by the Shapiro-Wilk test. The variables showed normal distribution ($P > 0.05$). Changes in pressure values from baseline were analyzed by paired *t* test in groups for each time interval. Further analysis was made for intervals in which the differences from the baseline were statistically significant in both groups. Unpaired *t* test was used in the comparison between groups. A value of $P < 0.05$ was considered significant.

RESULTS

All volunteers were between 18 and 60 years old, weighed 60 to 100 kg, and were classified as ASA physical status I or II. There were no statistically significant differences between dexmedetomidine and control groups with respect to age, sex, weight, ASA physical status, operation time, and anesthesia duration ($P > 0.05$). These patient characteristics are shown in Table 1.

Middle ear TPP and TW values are shown in Table 2 and Figures 1 through 4. All middle ear pressure recordings in both groups were within the limit of normal according to the Jerger classification before, during, and after surgery.[8]

The alteration of middle ear pressure values from baseline was analyzed in both groups. Then further analysis was made for intervals (given below) in which the differences from the baseline were statistically significant in both groups. In the right ear, mean difference of TPP from preoperative state was statistically significant in both groups at the first minute of intubation (23.5 daPa, $P = 0.0001$ for dexmedetomidine; 21.3 daPa, $P = 0.0001$ for control group), at the 30th minute of operation (54.3 daPa, $P = 0.0001$ for dexmedetomidine; 29.5 daPa, $P = 0.0001$ for control group), and at the end of the operation (67.1 daPa,

Table 1
Patient characteristics

	Dexmedetomidine group (mean ± SD)	Control group (mean ± SD)	*P* value
N	30	30	
Sex (women/men)	13/17	12/18	
Age (y)	37.0 ± 10.8	35.7 ± 12.1	0.79
Weight (kg)	72.4 ± 13.5	73.1 ± 11.4	
Operation time (min)	93.8 ± 38.6	108.0 ± 42.5	0.67
Anesthesia duration (min)	122.6 ± 38.6	135.8 ± 43.3	
ASA physical status (I/II)	26/4	25/5	0.82
Surgical procedure (n)			
Head and neck	11	13	0.18
Plastic-reconstructive	9	7	
Urology	3	3	0.21
Gynecology	7	6	0.72
Orthopedic	0	1	

ASA, American Society of Anesthesiologists.

Table 2
Middle ear pressure values of dexmedetomidine and control group (mean ± SD)

	TPP (daPa)		TW (daPa)	
	Dex group	Control group	Dex group	Control group
Left ears (n = 30)				
Before operation	−4.6 ± 1.5	−3.0 ± 13.1	78.9 ± 17.5	76.3 ± 12.5
At 10th min of infusion	−1.6 ± 9.4	−0.6 ± 11.7	76.3 ± 25.2	66.0 ± 11.7
At 1st min of intubation	3.5 ± 45.4	12.6 ± 14.8	83.6 ± 18.3	82.6 ± 62.6
At 30th min of operation	42.8 ± 27.8	24.0 ± 28.0	81.9 ± 21.5	64.0 ± 87.1
At end of operation	61.1 ± 29.8	34.6 ± 33.9	77.3 ± 23.6	64.9 ± 83.2
At postoperative 15th min	7.8 ± 39.1	9.3 ± 13.3	72.8 ± 27.9	99.5 ± 73.2
Right ears (n = 30)				
Before operation	−1.3 ± 9.0	−5.0 ± 13.6	68.1 ± 19.1	76.1 ± 12.6
At 10th min of infusion	−3.1 ± 14.1	2.6 ± 10.8	73.2 ± 14.17	86.3 ± 18.3
At 1st min of intubation	22.1 ± 23.6	16.3 ± 15.4	85.4 ± 23.1	86.3 ± 15.4
At 30th min of operation	53.0 ± 28.2	24.5 ± 26.1	71.9 ± 76.4	74.7 ± 76.4
At end of operation	65.8 ± 34.8	36.3 ± 35.4	75.3 ± 13.2	84.1 ± 68.2
At postoperative 15th min	4.6 ± 28.0	4.3 ± 13.5	81.2 ± 11.9	64.9 ± 73.8

TPP, Tympanometric peak pressure; *TW,* tympanometric width; *Dex,* dexmedetomidine.

$P = 0.0001$ for dexmedetomidine; 41.3 daPa, $P = 0.0001$ for control group). In the left ear, it was significant at the 30th minute of operation (47.5 daPa, $P = 0.0001$ for dexmedetomidine; 27 daPa, $P = 0.0001$ for control group) and at the end of the operation (65.8 daPa, $P = 0.0001$ for dexmedetomidine; 37.6 daPa, $P = 0.0001$ for control group).

When we evaluated the TW recordings in both groups: The alteration of TW from preoperative state was statistically significant at the 10th minute of infusion (−5.7 daPa, $P = 0.05$ for dexmedetomidine; 10.4 daPa, $P = 0.001$ for control group), at the first minute of intubation (17.5 daPa, $P = 0.0001$ for dexmedetomidine; 10.5 daPa, $P = 0.001$ for control group), and at the postoperative 15th minute (14 daPa, $P = 0.001$ for dexmedetomidine; −11.4 daPa, $P = 0.001$ for control group) in the right ear. In the left ear, it was only significant at the first minute of intubation (6.9 daPa, $P = 0.005$ for dexmedetomidine;7 daPa, $P = 0.03$ for control group).

The mean pressure alterations of dexmedetomidine and control group were compared in the above-mentioned statistically significant situations. At the 30th minute and at the end of the operation, there was a statistically significant elevation in TPP in both ears in the dexmedetomidine group compared with controls (Table 3). With dexmedetomidine infusion, an additional mean TPP elevation of 24.8 daPa at the 30th minute and 25.8 daPa at the end of the operation over the control recording were noted in the right ear. In the left ear, again the mean elevation was higher following infusion at these time intervals: 20.5 daPa and 28.1 daPa over controls at the 30th minute and the end of the operation, respectively. When we compared the mean TW alteration noted in both groups, we observed a statistically significant alternation for right ears only at the first minute of the operation and the postoperative state (Table 4). With dexmedetomidine

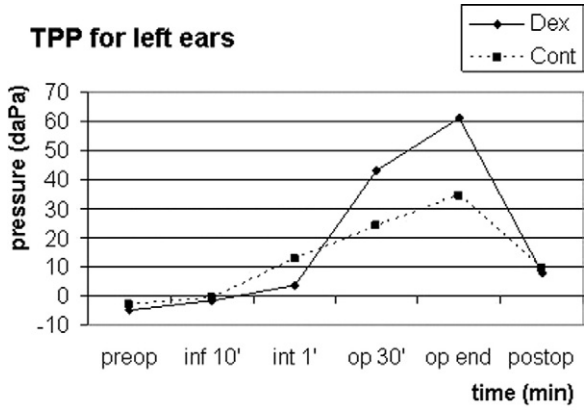

Figure 1 TPP values of dexmedetomidine and control groups for left ears.

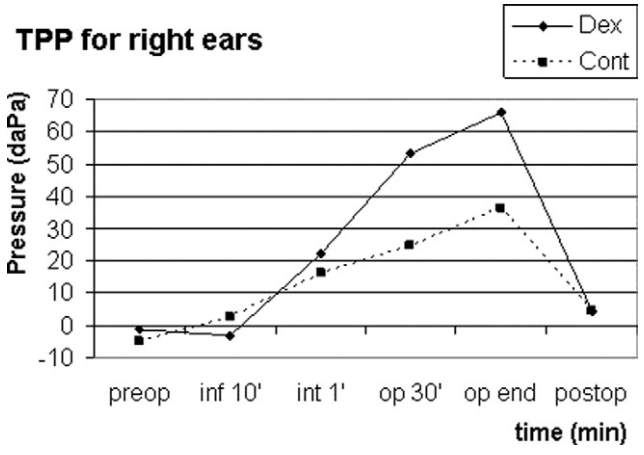

Figure 2 TPP values of dexmedetomidine and control groups for right ears.

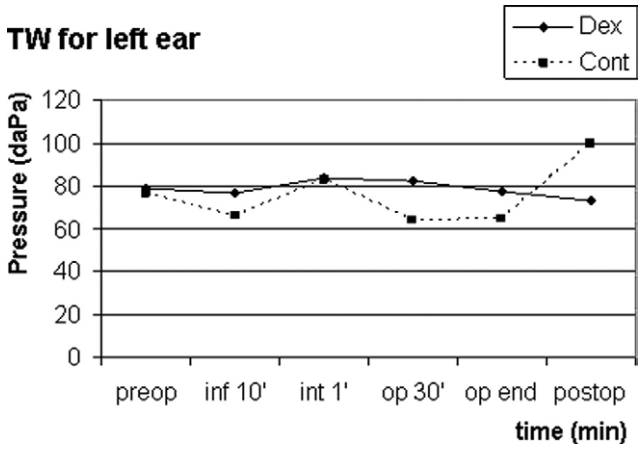

Figure 3 TW values of dexmedetomidine and control groups for left ears.

infusion, mean TW elevation over controls was 7 daPa and 25.4 daPa at the first minute of operation and the postoperative state, respectively.

Hemodynamic measurements were recorded in every five minutes during the first 30 minutes of the operation. While baseline systolic blood pressure (SBP) values were similar for both groups (SBP/diastolic blood pressure (DBP): 127 ± 15/74 ± 7 in dexmedetomidine, 127 ± 11/78 ± 11 in control group), SBP values tended to be less after injection in the dexmedetomidine group (123 ± 18, 122 ± 14, 119 ± 13, 122 ± 11, 122 ± 11 at the 5th, 10th, 20th, 25th, and 30th minute of infusion, respectively; $P < 0.05$). No statistically significant descent was noted in the SBP of the control group. DBP was significantly lower in the dexmedetomidine group compared with controls at the 5th and 25th minute of injection (71 ± 11 vs 78 ± 11, $P = 0.03$; 70 ± 8 vs 74 ± 9, $P = 0.04$). Heart rate values tended to increase in the dexmedetomidine group compared with the control group at the 20th, 25th, and 30th minute of operation (84 ± 10 vs 77 ± 11, $P = 0.02$; 85 ± 11 vs 77 ± 10, $P = 0.01$; and 86 ± 11 vs 78 ± 9, $P = 0.001$).

DISCUSSION

The anesthetic technique is especially important in middle ear surgical procedures because hemodynamic stability, good surgical field visibility, and minimal postoperative nausea and vomiting are required. In addition, stable intratympanic pressure is acceptable during the anesthetic act and after its discontinuation. Therefore, the anesthesiologist must use a technique that provides a sufficiently deep level of anesthesia with minimal intraoperative movement, rapid emergence, good hemodynamic control, and tympanometric stability.

Previous studies have demonstrated that intravenous (IV) anesthesia for otological surgical procedures offers ideal intraoperative conditions, especially for hemodynamic stability.[9-11] Jellish et al[10] evaluated IV anesthesia using propofol/fentanyl or propofol/remifentanyl and compared them with standard inhalational anesthetic for middle ear surgery. They concluded that the IV anesthesia technique provided better hemodynamic control, less movement, and faster emergence. Karabiyik et al[12] investigated the effect of IV anesthesia with propofol-based techniques on middle ear pressure and found out that middle ear pressure values were within normal limits clinically during the intra-anesthetic period. Because of the higher costs associated with these IV techniques, the effect of inhaler anesthetics on the middle ear was investigated.

Chinn et al[13] opposed the conclusion of the above-mentioned studies. They compared inhaler anesthetics with IV ones and showed that both produced similar intraoperative conditions and hemodynamics. Short-acting inhalational anesthetics like desflurane and isoflurane produced excellent operating conditions and reduced costs for otological surgery.[13] But, the effect of inhaler anesthetics on middle ear pressure was controversial in the relevant literature.[13-17] Inhalant anesthetic agents may enter the middle ear space during anesthetic administration and can affect middle ear status by increasing middle ear pressure to a greater extent than anesthesia without inhalant anesthetics.[13] Ozturk et al[16] noted elevated middle ear pressure related to sevoflurane anesthesia. But, their study group of 12 patients was too small for an accurate conclusion. The use of inhalant anesthesia using halothane either alone or with nitrous oxide during middle ear surgery was shown to alter the status of the middle ear.[17] In several studies, changes in middle ear pressure during nitrous oxide inhaler anesthesia had been reported to range from 400 daPa to −500 daPa.[14,15] Nitrous oxide should not be preferred in middle ear surgery. In addition, in reconstructive operations of the tympanic membrane, concentration of an inhalant anesthetic agent should be reduced or discontinued at the time of reposition of the tympanic membrane or insertion of a gelatin sponge to support the graft.

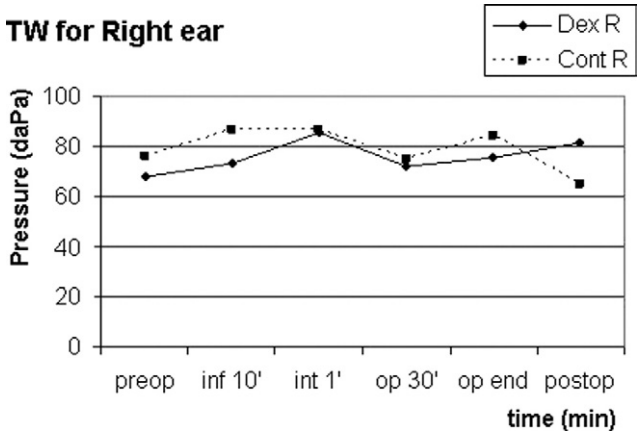

Figure 4 TW values of dexmedetomidine and control groups for right ears.

Table 3
TPP alterations in dexmedetomidine group and control group

TPP (daPa)	Dex group	Control group	MI	*P* value	95% CI Lower	95% CI Upper
Right						
Preop, 1st min of int	23.5 ± 26.2	21.3 ± 24.1	2.1	0.74	−10.8	15.2
Preop, at 30th min of op	54.3 ± 29.3	29.5 ± 33.0	24.8	0.003	8.6	40.9
Preop, at the end of op	67.1 ± 34.1	41.3 ± 40.4	25.8	0.01	6.4	45.1
Left						
Preop, at 30th min of op	47.5 ± 30.9	27.0 ± 35.7	20.5	0.001	3.2	37.7
Preop, at the end of op	65.8 ± 32.0	37.6 ± 39.4	28.1	0.001	9.5	46.7

TPP, Tympanometric peak pressure; *Dex,* dexmedetomidine; *MI,* mean TPP increase for dexmedetomidine group over the control group; *CI,* confidence interval; *preop,* preoperatively; *int,* intubation; *op,* operation.

In recent years, α-2 adrenergic agonists—clonidine, dexmedetomidine, and miverazol—were used as anesthetic agents. Dexmedetomidine is currently used in clinical practice because it provides controlled hypotension and good surgical field visibility. Dexmedetomidine is a selective α2-adrenoceptor agonist. It is an important sedative and analgesic agent, with a unique mechanism of action that differs from that of currently administered sedative agents. α2-Adrenoceptors are located in the central nervous system, vascular smooth muscle, and a variety of other organs. Presynaptic activation of α2-adrenoceptors inhibits the release of norepinephrine. Postsynaptic activation of α2-adrenoceptors in the central nervous system inhibits sympathetic activity, and can decrease blood pressure and heart rate. Analgesia is provided through binding of dexmedetomidine to α2-adrenoceptors in the spinal cord. As a result, sedation and analgesia occur; catecholamine output, heart rate, blood pressure, and cardiac output decrease. The agent causes controlled hypotension, which effectively reduces surgical blood loss and improves surgical conditions by causing controlled hypotension. In addition, it does not cause reflex tachycardia and rebound hypotension.[5-7,18,19]

We investigated the effect of dexmedetomidine on perioperative hemodynamic stability. After the injection and induction of anesthesia, a statistically significant descent was observed in SBP values in the dexmedetomidine group, while there was no significant alteration in the control group. The anesthetic affected SBP more than DBP. Our findings were similar to those of previous studies.[5,18] However, we did not observe bradycardia after injection. In the relevant studies, systolic and diastolic arterial pressures and heart rate were decreased after injection of dexmedetomidine.[6,18,19] The incongruity in heart rate recordings was probably due to the methodological differences.[18] We used dexmedetomidine for only 20 minutes for sedation before the operation; however, it was used for long durations up to 48 hours in other studies.[18] The appearance of low blood pressure without reflex tachycardia is the most fascinating characteristic of dexmedetomidine. Bradycardia within acceptable limits is preferred during the middle ear surgery; however, alert monitoring is needed.

Dexmedetomidine is a well-known analgesic and sedative agent; it may also be used for induction of anesthesia.[20] In middle ear surgery, its advantages contributing to surgical condition are well-known; however, its effects on middle ear status had not been investigated yet. In our study, we used the agent for sedative and analgesic purposes, and we observed inappreciable elevation of middle ear pressure

Table 4
TW alterations in dexmedetomidine group and control group

TW (daPa)	Dex group	Control group	MA	*P* value	95% CI Lower	95% CI Upper
Right						
Preop, at 10th min of inf	−5.7 ± 15.1	10.4 ± 10.6	−4.7	0.16	−11.4	2
Preop, at 1st min of int	17.5 ± 10.4	10.5 ± 10.6	7	0.01	1.6	12.5
Preop, at postoperatively 15th min	14.0 ± 11.1	−11.4 ± 13.2	25.4	0.001	19	31.7
Left						
Preop, at 1st min of int.	6.9 ± 12.6	7.0 ± 16.8	−0.1	0.97	−7.7	7.5

TW, Tympanometric width; *Dex,* dexmedetomidine; *MA,* mean TW alterations for dexmedetomidine group over the control group; *CI,* confidence interval; *preop,* preoperatively; *inf,* infusion; *int,* intubation.

within the limits of normal. With these findings, we can suggest use of this agent in otological operations requiring good surgical field visibility and normal middle ear cavity pressure for a short duration. Further studies should investigate its effect on middle ear pressure for a longer duration.

Our study has some shortcomings. First, we used dexmedetomidine as a sedative agent for a limited duration. Our results may not exactly represent its effects on middle ear pressure for longer durations. Because there are methodological differences, especially in the duration of dexmedetomidine use, our results revealing its effect on heart rate may not correlate with the previous studies.

CONCLUSION

Results from this study provide the first tympanometric data for dexmedetomidine anesthesia. Our recordings are consistent with normative values contained in the literature. Knowing the adverse affects of many approved anesthetic agents on middle ear environment and the benefits of dexmedetomidine including hypotensive anesthesia, it should be preferred in middle ear surgery requiring good surgical field visibility and normal middle ear pressure.

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FINANCIAL DISCLOSURE

None.

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