

OTOLOGY

Comparing the effects of desflurane and isoflurane on middle ear pressure

Confronto tra gli effetti del desflurano e dell'isoflurano sulla pressione dell'orecchio medio

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SUMMARY

The aim of this study was to determine middle ear pressure changes during the operation performed under anaesthesia induced by isoflurane or desflurane. This was a prospective, case-control study. A total of 38 children with no middle ear pathology scheduled for inguinal hernia surgery were included in the study. Group I ($n = 22$) received isoflurane and Group II ($n = 16$) received desflurane. Baseline tympanometry was performed before the anaesthesia on both ears, and tympanometry was repeated 5, 10 and 15 minutes after the administration and 10 and 30 minutes after the withdrawal of anaesthetic agents. Data were analyzed using the Mann-Whitney U (inter-group) and the Wilcoxon test (intra-group) procedures. The mean middle ear pressure values in the 44 ears of the 22 children in Group I and the 32 ears of the 16 children in Group II did not show any significant difference before the anaesthesia by either anaesthetic agent ($p > 0.05$). Increase in the mean middle ear pressure values at the 5th and 10th minute of the operation was significant different between both groups (2.84 and 5.80 daPa for isoflurane; 59.06 and 72.81 daPa for desflurane; $p \leq 0.05$). Desflurane is more increased than isoflurane on intra-tympanic pressure and isoflurane may be used more safely than desflurane in middle ear operations. The low effect of isoflurane on intra-tympanic pressure can be explained by the high blood/gas partition coefficient compared to desflurane.

KEY WORDS: Middle ear surgery • Middle ear pressure • Inhalant anaesthesia • Isoflurane • Desflurane

RIASSUNTO

Scopo del presente studio è stata la determinazione delle variazioni della pressione dell'orecchio medio durante gli interventi chirurgici eseguiti in anestesia generale indotta con isoflurano o desflurano. È stato realizzato uno studio prospettico caso-controllo su 28 bambini, privi di patologia dell'orecchio medio, sottoposti ad intervento per ernia inguinale. Il Gruppo I ($n = 22$) ha ricevuto isoflurano, mentre il Gruppo II ($n = 16$) ha ricevuto desflurano. La timpanometria basale è stata eseguita bilateralmente prima dell'induzione dell'anestesia, ed è stata ripetuta rispettivamente al 5°, 10° e 15° minuto dopo la somministrazione del farmaco e al 10° e 30° minuto dopo la sospensione dell'agente anestetico. I dati sono stati analizzati utilizzando il Mann-Whitney U (inter-group) e il Wilcoxon test (intra-group). I valori medi di pressione dell'orecchio medio delle 44 orecchie del Gruppo I non sono risultati significativamente differenti dai valori medi delle 32 orecchie del Gruppo II prima dell'induzione dell'anestesia ($p > 0,05$). Invece i valori medi di pressione dell'orecchio medio sono risultati più elevati in modo statisticamente significativo 5 e 10 minuti dopo l'induzione dell'anestesia nel Gruppo II rispetto al Gruppo I (2,84 e 5,80 daPa per isoflurano; 59,06 e 72,81 daPa per il desflurano; $p \leq 0,05$). In conclusione, il desflurano induce un aumento di pressione dell'orecchio medio più elevato rispetto all'isoflurano, quest'ultimo risulta pertanto più indicato per essere utilizzato nella chirurgia dell'orecchio medio. Gli scarsi effetti dell'isoflurano sulla pressione intratimpanica possono essere spiegati con il più alto coefficiente di partizione sangue/gas rispetto al desflurano.

PAROLE CHIAVE: Chirurgia dell'orecchio medio • Pressione dell'orecchio medio • Agenti anestetici inalanti • Isoflurano • Desflurano

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Introduction

In middle ear surgical procedures, preferred anaesthetic agents may be important to change the middle ear status, haemo-tympanum, serous otitis, temporary or permanent hearing loss, may dislocate tympanic membrane grafts, or may cause failure in the ossicular chain¹⁻⁴. Therefore, the anaesthesiologist should use an anaesthetic agent that would result in a minimal intra-tympanic pressure. Middle

ear pressure (MEP) variations due to inhalant anaesthesia have been reported by several investigators. Previous investigations have mostly been performed with nitrous oxide, halothane, sevoflurane, desflurane and total intravenous anaesthetics with propofol⁵⁻⁷. These studies have suggested that most anaesthetic agents cause an increase in middle ear pressure.

Desflurane is a volatile anaesthetic agent with low solubil-

ity that allows rapid induction and fast emergence from anaesthesia. Another volatile anaesthetic, isoflurane, also has a higher solubility than desflurane.

The aim of this study was to investigate MEP changes during inguinal hernia surgery performed under anaesthesia induced by either isoflurane or desflurane.

Material and methods

After having obtained the approval from the Institutional Review Board, 38 children (age range 2-13 years) undergoing elective inguinal hernia surgery were enrolled in the study. Content was obtained from the parents or legal guardians of the patients, and approval was obtained from children older than 7 years after explanation of the study rationale. Physical ENT examinations were then carried out on each participant.

Exclusion criteria

Exclusion criteria were as follows:

- 1) nasal septal deviation;
- 2) adeno-tonsillar hypertrophy;
- 3) otoscopic evidence of a perforated tympanic membrane or other middle-ear pathology, such as effusion;
- 4) a flat tympanogram, or absence of acoustic reflexes at 1 kHz with contra-lateral stimulation.

The patients were equally divided and randomly assigned to one of two groups. All patients received an anaesthetic composed of thiopental 5 mg/kg, fentanyl 3 µg/kg IV for induction of anaesthesia, and rocuronium bromide 0.6 mg/kg for intubation. After intubation, the maintenance anaesthesia was provided for Group I (10 female, 12 male) by isoflurane 2-3%, And for Group II, (8 female, 8 male)

desflurane 6-9%. Fresh gas flows were 5 litres/minute in a 50% air/oxygen mixture. Neither group received inhalation induction. The patients had an oro-gastric tube to decompress the stomach.

Tympanometric functions were performed by an audiometrist using a Tymistar Version 2 Middle Ear Analyzer (Grason Stadler) clinical impedance meter Denmark to check the standard immittance screening of the middle ear of the patient. Tympanometric tests were determined using a Jerger type A curve on normal middle ear pressure ranges between -100 and +50 decapascals (daPa)⁸.

Baseline tympanometry reading was performed on each ear just before the anaesthesia in supine position. For both groups, tympanometric measurements were assessed 5, 10 and 15 minutes after administration and 10 and 30 minutes after withdrawal of the anaesthetic agents.

Statistical analyses were performed using the SPSS 15.0 for Windows. The data were analyzed using the Mann-Whitney U (inter-group) and Wilcoxon tests (intra-group). P values < 0.05 were considered significant.

Results

There were no demographic or surgical differences between groups as far as concerns sex, operation time, and duration of anaesthesia ($p > 0.05$), except for age. The patient demographics are shown in Table I. No significant difference was found between the MEP values of the two groups before the anaesthesia ($p > 0.05$). Mean MEP values in the desflurane group, at pre-operative measurements were -0.16 ± 39.1 daPa and they increased to 59.06 ± 74.4 daPa and 72.81 ± 79.8 at the 5th and 10th minute of sur-

Table I. Patient demographics.

	Isoflurane group n = 22	Desflurane group n = 16	p
Sex (Female/Male)	10/12	8/8	0.697
Age (yrs)	4 ± 2.0	8.91 ± 4.0	0.002
Operation time (min)	32.45 ± 13.6	32.55 ± 10.4	0.933
Anaesthesia duration (min)	40.55 ± 12.9	39.73 ± 10.0	0.750

Table II. Middle ear pressure values in isoflurane and desflurane group (daPa)+SD.

	Isoflurane group (n = 44)	Desflurane group (n = 32)	p
Pre-operative	-3.64 ± 47.7	-0.16 ± 39.1	0.912
5 th minute intra-op. (Mean, Median)	2.84 ± 79.3	59.06 ± 74.4	0.014
10 th minute intra-op. (Mean, Median)	5.80 ± 63.2	72.81 ± 79.8	0.003
15 th minute intra-op. (Mean, Median)	31.36 ± 85.6	82.03 ± 80.3	0.069
10 th minute post-op. (Mean, Median)	23.52 ± 76.3	67.34 ± 83.5	0.004
30 th minute post-op. (Mean, Median)	13.06 ± 60.8	46.56 ± 82.8	0.012

SD: standard deviation.

gery, respectively. All these measurements were significantly higher than the starting value ($p < 0.05$). Compared to desflurane, in the isoflurane group, there was no significant increase ($p > 0.05$). At the 5th and 10th minute intra-operatively and 10th and 30th minute post-operatively, there was a significant elevation in MEP in the desflurane group compared to the isoflurane group ($p < 0.05$). The data are presented in Table II.

Discussion

In recent years, selective γ -aminobutyric acid (GABA) antagonists – desflurane, halothane, isoflurane – were used as volatile anaesthetic agents. Volatile agents are frequently used in general anaesthesia practice without complications. Inhalation anaesthetics are less expensive, simpler to use, and offer comparable intra-operative conditions to intravenous anaesthesia techniques⁹.

However, they continue to have adverse effects on intra-tympanic pressure. Anaesthesia with desflurane is associated with a faster emergence and maintenance of a stable surgical field with mild controlled hypotension¹⁰. Previous studies have demonstrated that desflurane may increase the MEP, which is consistent with our results⁷. These findings have raised concerns that using volatile anaesthetic agents may aggravate MEP in middle ear surgical procedures. We found that desflurane is associated with a greater increase in the MEP levels when compared with isoflurane. Isoflurane is a selective GABA_A antagonist. With regard to intra-tympanic pressure effects, it should be stated that experience with isoflurane is more limited than with other anaesthetic agents.

The increase in MEP levels after anaesthesia was seen to be significantly higher in the desflurane group than in the isoflurane group. MEP levels after desflurane anaesthesia were elevated in the intra-operative fifth and tenth minute and post-operative tenth and thirtieth minute; however, there was an increase in MEP levels compared to after isoflurane anaesthesia.

Use of the Laryngeal Mask Airway provides a reliable airway during general anaesthesia without serious complications¹¹. In addition, some studies have demonstrated that the choice of airway device does not influence MEP among airway devices^{12,13}. Therefore, in the present study, no different airway device was used during anaesthesia with desflurane or isoflurane.

The increase in MEP levels with desflurane is theoretically possible due to the low solubility with other inhalation anaesthetics. Lesser et al. have shown a great rate of diffusion of inhaled anaesthetics in the abdominal and thoracic viscera from swine¹⁴. The least soluble agent was desflurane; the most soluble agent was halothane. The blood/gas partition coefficient ratio was the lowest in nitrous oxide. The lowest blood/gas partition coefficient among commonly used volatile anaesthetics is shown by desflurane¹⁵. These results can be explained that desflurane tends towards gas compared with liquid. This means that desflurane prefers to be in air filled spaces, such as alveoli and middle ear. Although an MEP increase has been reported in previous studies on nitrous oxide, desflurane and sevoflurane, the lack of this increase, in our study, for isoflurane is thought to be related to the high blood/gas partition coefficient of anaesthesia gases consequently decreasing its transition into air filled body spaces. The high solubility of anaesthesia gases may not permit the influx in the middle ear space, thus not allowing increased middle ear pressure to be released.

Conclusion

The results from this study have shown that isoflurane has a lower effect compared to desflurane, on intra-tympanic pressure. Isoflurane has an MEP taming effect, in middle ear surgery, and may be preferred if control of MEP is a concern. Further experimental studies are required to prove the diffusion of inhaled anaesthetics to the middle ear.

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