Turkish Archives of Otolaryngology
Türk Otolarengoloji Arşivi

Turk Arch Otolaryngol 2014; 52: 47-51

# Middle Ear Pressure and Factors Affecting It in Intubated Patients Hospitalized in Intensive Care

Original Investigation

Mehmet Akdağ[1], Müzeyyen Çetin[1], Zeynep Yıldırım Baysal[2], Ali Kemal Kadiroğlu[3], Mehmet Yusuf Çelik[4], Faruk Meriç[1]

[1]Department of Otolaryngology, Dicle University Faculty of Medicine, Diyarbakır, Turkey
[2]Department of Anaesthesiology and Reanimation, Dicle University Faculty of Medicine, Diyarbakır, Turkey
[3]Department of Internal Medicine Intensive Care, Dicle University Faculty of Medicine, Diyarbakır, Turkey
[4]Department of Statistics, Dicle University Faculty of Medicine, Diyarbakır, Turkey

Abstract

**Objective:** To assess the probable agents affecting middle ear pressure in intubated patients hospitalized in intensive care units with various diagnoses.

**Methods:** Middle ear pressure of 38 patients hospitalized in intensive care units within our faculty hospital was measured using portable tympanograms and acoustic reflectometry. The mode of the device to which each patient was attached and patients' blood pressure, Glasgow Coma Score, and additional disease parameters other than admission diagnosis were recorded. All data collected were subjected to statistical analysis to determine whether or not they affected middle ear pressure.

**Results:** Septal deviation, survey, and mode of automatic respiratory device emerged as factors affecting middle ear pressure (odds coefficient 4.796, 3.745, 2.557, respectively, with 95% CI). Although aged over 60, additional disease and nasogastric tube also compromised middle ear pressure; the levels involved were not statistically significant.

**Conclusion:** Middle ear pressure in patients hospitalized in intensive care units may change, particularly after the seventh day. This may particularly involve septal deviation, survey, and mode of automatic respiratory device, and tympanograms and reflectometry may be added to the patient-monitoring protocol in terms of changes in middle ear pressure.

**Key Words:** Middle ear pressure, intubation, intensive care

## Introduction

Patient monitoring and treatment are important for patients in intensive care units, and they require a multidisciplinary approach. Because these patients, who are mostly attached to respiratory devices, can not communicate, some organs, like the ears, may be ignored while monitoring life-threatening respiratory, cardiac, and cerebral activities. In this case, hearing loss may become functional and complicated and lead to vital problems, like brain abscess (1).

Otitis media (OM) is a pathology that is common among children but rare in adults. The Eustachian tube's being shorter and horizontal and less mature in children than in adults can be considered one of the causes of this frequent incidence (2, 3). As for adults, only nasopharynx tumors; secondary problems, such as rhinosinusitis; and persistent otitis media existing since childhood years can lead to middle ear pressure and effusion (4). Although otitis media decreases with antibiotic therapy, the occurrence rate of intracranial complications, such as meningitis and brain abscess, is quite high, as are extracranial complications, like hearing loss and tinnitus (5, 6).

While acute OM or middle ear effusion (MEE) occurs at a rate of 25%-43.3% in intensive care patients, this ratio increases to 80%, especially in the patients with nasal intubation (3, 7). In intensive care patients, effusion is affected by factors, including nasogastric intubation, age, and consciousness status, in addition to changes in the middle ear (7). The number of studies related to these factors is limited. In addition, there is no prospective study that has been conducted with multiple factor analysis, including supportive factors except gender, the mode of the artificial ventilation device, septal pathology, whole blood, blood pressure, and hospitalization diagnosis. Consequently, our purpose in this study is to evaluate middle ear pressure and the factors affecting this pressure in intubated patients hospitalized in the intensive care units due to various diagnoses.

**Address for Correspondence:**
Mehmet Akdağ, Department of Otolaryngology, Dicle University Faculty of Medicine, Diyarbakır, Turkey
**Phone:** +90 532 455 62 38
**E-mail:** drmehmetakdag@hotmail.com

**Received Date:** 07.04.2014
**Accepted Date:** 18.04.2014



www.turkarchotolaryngol.net
DOI:10.5152/tao.2014.576

## Methods

After ethics committee approval was received for this study from the ethics committee of Dicle University Faculty of Medicine (Ethics committee: 17.12.2012/33), 38 patients hospitalized with various diagnoses in the intensive care units of surgery, internal medicine, neurology and anesthesiology in Dicle University Medical Faculty Hospital between the years of 2012 and 2013 were intubated, and the presence of middle ear pressure and effusion was investigated. Before examining the patients and measuring middle ear pressures, written informed consent was obtained from the families. Otoscopic examinations of patients were first performed. If there was a plug in the external auditory canal, it was removed with clar head light and portcotton or curette, and then, the structure and flexibility of the tympanum were evaluated with pneumatic otoscopy. On the 1st, 7th, and 14th days after intubation, middle ear pressure was measured with a portable tympanogram, named MT10, and acoustic reflectometry (Interacoustic, DIC 5610, Assens, Denmark), and the appearance of the tympanum was assessed with otoscopy.

Type A and spectral gradient angle above 95 degrees were evaluated as normal ear examination.

Middle ear effusion is characterized by the occurrence of fluid concentration in the posterior tympanum, with type B tympanogram and spectral gradient being lower than 70 degrees. Type C is in tympanic cavities, in which peak values are negative in consistency with negative pressure, and it is characterized by spectral gradient lower than 70 degrees.

The patients who were younger than 18 years, who had otitis media and underwent ear operation in their medical histories, and who had head and neck tumors, particularly in the nasopharynx, were excluded from the study. Other patients apart from these conditions were included in the study.

Moreover, ages, genders, and diagnoses of the patients; presence of accompanying additional diseases; intubation and nasogastric tube numbers; and mode of the respiratory devices were identified. The survey of the patients was evaluated with Glasgow Coma Scale and then recorded.

### Statistical Analysis

Descriptive statistics of continuous variables were demonstrated in the values of mean and standard deviation (SD). Discrete variables were converted into crosstables and analyzed with Yates corrected chi-square test. The mean values of the variables were evaluated with student's t-test. Odds coefficients for the risk variables, such as intubation catheter, Glasgow Coma Scale, nasogastric catheter, septal pathology, age, whole blood, and mode of respiratory device, were measured with binary logistic regression method. While applying the method, all variables were included in the model, and backward method was implemented for analysis. The hypotheses were bilateral, and the value of p≤0.05 was considered to be statistically significant. Statistical analyses were performed using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA).

**Table 1.** Distribution of age and gender

| Age | | MEP | Total | | |
|---|---|---|---|---|---|
| | | Female | Male | | P |
| <60 | n | 4 | 14 | 18 | |
| | % | 22.2 | 77.8 | 100.0 | |
| >60 | n | 4 | 16 | 20 | >0.05 |
| | % | 20.0 | 80.0 | 100.0 | |
| **Total** | n | 8 | 30 | 38 | |
| | % | 21.1 | 78.9 | 100.0 | |

MEP: Middle ear pressure

**Table 2.** Statistically significant factors affecting middle ear pressure

| | β | S.E | Odds | 95% CI | Wald | p |
|---|---|---|---|---|---|---|
| Septal Deviation | 1.568 | 0.391 | 4.796 | 2.22-10.32 | 16.08 | <0.001 |
| Survey | 1.010 | 0.304 | 3.745 | 1.51-4.98 | 11.03 | <0.001 |
| Mod | 0.939 | 0.299 | 2.557 | 1.42-4.59 | 9.86 | <0.001 |

β: regression coefficient; S.E: standard error of regression coefficient; Odds: odds coefficient; 95% CI: 95% confidence interval for odds coefficient; Wald: Wald statistical test for odds coefficient; P: significance value

## Results

The mean age of the patients was 58.8±21.5 years. Of them, 25 were female and 13 were male. The relationship between gender and middle ear pressure variables was not found to be significant (p=0.343) (Table 1). The factors affecting middle ear pressure were septal deviation, survey, and mode of respiratory device. Odds coefficients in the confidence interval of 95% were 4.796, 3.745, and 2.557, respectively, which were significant and effective (Table 2). Respiration rate, blood pressure, Glasgow Coma Scale, application of nasogastric catheter, and number of nasogastric catheters were not statistically significant (p>0.05) (Table 3).

It was observed that middle ear pressure (MEP) began to change negatively as of the 5th-7th days, and it reached the maximum level in 7-10 days. The mean intubation time was 15-152 days (mean: 44 days). Following these negative pressure changes in the middle ear beginning from the 7th day, effusion began to occur on the 14th day. In 8 of these patients, effusion was detected in both ears simultaneously. Twelve patients did not have effusion and negative pressure. Six patients had unilateral effusion. In 12 patients, negative pressure was found, which varied between -100 and -400 daPa (Table 4). In 6 of 8 patients with bilateral effusion, both septal deviation and nasogastric catheter were found. Although 10 of 12 patients having only negative pressure had a nasogastric catheter, they were the patients who

**Table 3.** Non-statistically significant factors affecting middle ear pressure

| Middle ear pressure | | Mean | SD | t | p |
|---|---|---|---|---|---|
| Respiration rate | 0 | 17.37 | 4.39 | 2.304 | 0.028 |
| | 1 | 22.46 | 6.70 | | |
| Arterial tension | 0 | 119.50 | 26.73 | -.404 | .689 |
| | 1 | 123.40 | 23.61 | | |
| Venous tension | 0 | 70.25 | 14.28 | .321 | .750 |
| | 1 | 68.36 | 14.84 | | |
| Glasgow Coma Scale | 0 | 6.25 | 2.31 | 2.0100 | 0.037 |
| | 1 | 8.37 | 3.13 | | |
| NGC | 0 | 15.25 | 1.83 | .220 | .827 |
| | 1 | 15.03 | 2.60 | | |
| NGC Number | 0 | 7.71 | .48 | -.292 | .772 |
| | 1 | 7.76 | .42 | | |

MEP: middle ear pressure; NGC: nasogastric catheter; INT: intubation tube

**Table 4.** Degree of middle ear pressure and ear side

| n | One ear | Two ears | Effusion (Type B Tymp) | Negative pressure (-100/-400) |
|---|---|---|---|---|
| 8 | - | + | + | - |
| 12 | - | - | - | + |
| 6 | + | - | + | - |
| 12 | - | - | - | - |

(+): existent (-): non-existent

were extubated early. In 2 other patients, mode of respiratory device was synchronized with intermittent mandatory ventilation (SMIV). Also, because the general surveys of these patients were good, they were extubated early.

Despite the fact that those aged over 60 years constituted a greater risk group, this risk was not statistically significant ($p>0.05$). In 8 of the patients older than 60 years, MEE (middle ear effusion) occurred.

Twenty-two patients were intubated approximately after the 21st day, and MEP was disrupted in all of them except 2 patients. Of 10 patients who had a nasogastric catheter, 3 patients displayed unilateral MEP and 2 displayed bilateral MEP. In 5 of these patients, MEP was not affected. Moreover, no statistical relationship was detected between intubation tube number and MEP ($p>0.05$).

## Discussion

The results of this study revealed that middle ear pressure was influenced, and the incidence rates of OM and MEE were high in intubated patients hospitalized in the intensive care unit for more than 14 days who underwent septum deviation and had poor general medical condition. This made us think that possible local and systemic causes of endotracheal intubation emerged as the result of insufficient mechanical and metabolic ventilation by mucosal hypoxia. Both Christensen (3) and Cavaliere (6) stated that Eustachian tube dysfunction and migration of pathogenic flora from the nasopharynx to the middle ear had a role in the pathology of middle ear pressure. Eustachian tube dysfunction can make middle ear pressure negative and can cause aspiration of nasopharyngeal material. There are some factors affecting the mechanism of Eustachian tube dysfunction. First, in intubated patients, mechanical ventilation (air flow dynamic change) increases the mucus viscosity by influencing mucociliary function and thus creates secretion accumulation or drainage impairment (3, 6). Moreover, mechanical ventilation usually leads to moderate hypocapnia and inhibits spontaneous respiration. Hypocapnia affects middle ear pressure in a negative way (9). The second cause is that the patient's loss of consciousness or intake of sedative drugs contributes to the nasopharyngeal tube dysfunction by influencing the neuromuscular system or disrupting swallowing function, which causes negative middle ear pressure and effusion (7, 9). In our study, middle ear pressure changed in intubated patients, and OM or MEE developed in the presence of an additional factor.

Deterioration of the general medical condition (survey) was the factor affecting middle ear pressure (odds risk factor 3.745). Apart from mechanical factors influencing middle ear pressure, gas absorption, posture, and especially disruption of the microcirculation system of the middle ear can have a role in this result (10). Mode of respiratory device, in accordance with the general medical condition (odds risk factor 2.557), is an important determinant in the formation of middle ear pressure. In our study, we found controlled mandatory ventilation, in which the initiation, maintenance, and completion of inspiration was machine-controlled, as the most common mode associated with negative middle ear pressure. Of course, this mode is used for the conditions in which patients can not breathe spontaneously and severely need respiration and oxygen. Therefore, it can reflect deterioration of the general medical condition.

Intubation lasting for more than 14 days and clouding of consciousness contributed to the formation of middle ear effusion. This result shows the significance of the duration of irritation and edema in the nasopharynx. In the study conducted by Lin et al. (7), after the 7th day, which was considered prolonged intubation, OM developed only in 1 patient. In the patients intubated for 14 days and longer, OM occurred on the 10th day. Their results support those in our study. Similarly, Hsiung et al. (11) reported that the frequency of middle ear pressure decreased from 46% to 22% in the patients for whom intubation was replaced by tracheotomy.

Age over 60 years can improve the existing pathology by affecting the resistance of many body functions. However, we observed that this became more evident in the cases having a poorer general condition. Detection of effusion in 8 of 20 pa-

tients older than 60 years might have been an age-related factor. In the same way, Lin et al. (7) found negative changes in middle ear pressure in 9 of the patients over 60 years old, which is consistent with our study.

Being confined to bed for a long time leads to gastroesophageal reflux and increases passing of probable microorganisms from the nasopharynx into the middle ear (6, 12). Liquid and microorganisms accumulate in the nasopharynx, and they can cause the formation of potential infection extending from the Eustachian tube toward the middle ear (3, 12). Lying position is an important factor disrupting the function of the Eustachian tube (7). In our study, particularly in patients hospitalized for more than 3 weeks, other muscular and neuromuscular disruptions, like compression necrosis related to gravity or impaired circulation associated with vascular stasis, might have increased the frequency of effusion (7).

Application of a nasogastric catheter added to the intubation tube in our study prominently affected middle ear pressure as a factor causing edema. Nasogastric catheter can contribute to occurrence of otitis media by occluding the sinus ostium or forming edema. Additionally, presence of a tube, mucosal irritation, local edema, and potential pathogen carriage can also make a contribution to the occurrence of otitis media due to the nasogastric catheter (6, 10). In our study, left middle ear pressure was influenced in all 3 cases.

Infection is one of the most important parameters of mortality for intensive care patients (13). Rhinosinusitis and otitis media are two major diseases of otorhinolaryngology, which can lead to sepsis, even a little, and which have high potential, especially for intracranial complications (15, 16). Also, in our study, intracranial complication associated with the middle ear was observed in 1 patient.

Although there are different opinions about the relationship between septal pathology and middle ear pressure (16-19), our study revealed that septal deviation affected middle ear pressure in a negative way (odds coefficient 4.796). Hence, Duran et al. (16) found that middle ear pressure decreased at a rate of 30% in patients who underwent septoplasty for septum pathology. In addition, Van Cauwenberge at al. (17) concluded that patients with septal pathology had a higher rate of negative middle ear pressure compared to patients without septal pathology.

## Conclusion

In intubated patients hospitalized in intensive care units for more than 7 days, factors, including septal deviation, survey, and mode of respiratory device, are the important factors affecting middle ear pressure. Monitoring of MEP can be included in the multidisciplinary approaches for intensive care patients. Moreover, early extubation, change in the posture of the patient, medical support affecting the survey positively, and monitoring of the tympanum and middle ear pressure by otoscopy and tympanometry are also important for intensive care patients. Further studies including larger populations and long-term monitoring are needed on this issue.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Dicle University Faculty of Medicine. (17.12.2012/33)

**Informed Consent:** Written informed consent was obtained from relatives of the patient who participated in this study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept - M.A., Z.Y.B.; Design - M.A., Z.Y.B.; Supervision - M.A., F.M.; Funding - M.A., Z.Y.B.; Materials - M.K., A.K.K.; Data Collection and/or Processing - M.A., M.K.; Analysis and/or Interpretation - M.Y.Ç., M.A.; Literature Review - M.A., Z.Y.B.; Writing - M.A., A.K.K.; Critical Review - M.A., F.M.; Other - M.A., F.M.

**Acknowledgements:** Authors would like to thank Ass. Doc. Dr. Adalet Arıkanoğlu who is responsible for neurology intensive care of this study.

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study has received no financial support.

## References

1. Sade J, Fuchs C, Luntz M. The pars flaccida middle ear pressure and mastoid pneumatization index. Acta OtoLaryngol 1996; 116: 284-7. [CrossRef]
2. Bluestone CD, Rood RS and Swarts JD. Anaotomy and Physiology of the Eustachian Tube In: Otolaryngngology- Head and Neck Surgery edit by Cummings CW, Fredrickson JM et al. Second edition, chapter 142.pp.2556-9.
3. Christensen L, Schaffer S, Ross SE. Otitis media in adult trauma patients: incidence and clinical significance. J Trauma 1991; 31: 1543-5. [CrossRef]
4. Margaret A. Otitis media with Effusion. In: Byron J. Bailey (Edr.) Head and Neck Surgery-Otolaryngology Kenna B. Lippincott company, Philadelphia,1993.p.1592.
5. Akdag M, Uysal IO, Bakır S, Ozkurt FE, Muderris S, Yorgancılar E, et al. Risk of developing sudden sensorineural hearing loss in patients with acute otitis media: a multicenter retrospective analysis. Otolaryngology 2014; 4: 1-5.
6. Cavaliere F, Masieri S, Liberini L, Proietti R, Magalini SI. Tympanometry for middleear effusion in unconscious ICU patients. Eur J Anaesthesiol 1992; 9: 71-5.
7. Lin CC, Lin CD, Cheng YK, Tsai MH, Chang CS. Middle ear effusion in ICU patients with prolonged endotracheal intubation. Am J Otolaryngol 2006; 27: 109-11. [CrossRef]
8. Jerger J. Clinical experience with impedance audiometry. Arch Otolaryngol 1970; 92: 311-24. [CrossRef]
9. Derkay CS, Bluestone CD, Thompson AE, Kardatske D. Otitis media in the pediatric intensive care unit: a prospective study. Otolaryngol Head Neck Surg 1989; 100: 292-9.
10. Degoute CS, Dubreuil C, Ray MJ, Guitton j, Manchon M, Banssillon V, et al. Effects of posture, hypotensıon and locally

applıed vasoconstrıctıon on the mıddle-ear mıcrocırculatıon ın anesthetızed humans. Eur J Appl Physiol Occup Physiol 1994; 69: 414-20. [CrossRef]
11. Hsiung KC, Ching CL, Chin YW, Chia DL, Ming HT, Chia SC. Improvement in Otitis Media with Effusion in Patients Undergoing Tracheostomy after Prolonged Endotracheal Intubation. Otolaryngol Head Neck Surg 2009; 38: 532-6.
12. Palmisano JM, Moler FW, Revesz SM. Chronic otitis media requiring ventilation tubes in tracheostomized ventilator dependent children. Int J Pediatr Otorhinol 1994; 30: 177-82. [CrossRef]
13. Orucu M, Geyik MF. Yoğun Bakım Ünitesinde Sık Görülen Enfeksiyonlar. Düzce Tıp Fakültesi Dergisi 2008; 1: 4-43.
14. Persico M, Barker GA, Mitchell DP. Purulent otitis media-a silent" source of sepsis in the pediatric intensive care unit. Otolaryngol Head Neck Surg 1985; 93: 330-4.
15. Borman KR, Brown PM, Mezera KK. Occult fever in surgical intensive care unit patients is seldom caused by sinusitis. Am J Surg 1992; 164: 412-5. [CrossRef]
16. Duran K, Fatih Y, Doğan M. Middle ear pressure after septoplasty. J Craniofac Surg 2014; 25: 19-21. [CrossRef]
17. Van Cauwenberge P, Derycke A. The relationship between nasal and middle ear pathology. Acta Otorhinolaryngol Belg 1983; 37: 830-41.
18. Maier W, Krebs A. Is surgery of the inner nose indicated before tympanoplasty? Effects of nasal obstruction and reconstruction on the eustachian tube. Laryngorhinootologie 1998; 77: 682-8. [CrossRef]
19. Schuman TA. Concurrent nasal surgery and tympanoplasty in adults. Ear Nose Throat J 2010; 89: 28-32.