ORIGINAL ARTICLE

AHI EVRAN MEDICAL JOURNAL
E-ISSN: 2619 - 9203

Evaluation of Tracheal Aspirate Cultures of Patients Followed with Home Mechanical Ventilators

Ev Tipi Mekanik Ventilatör ile Takip Edilen Hastalarda Trakeal Aspirat Kültürlerinin Değerlendirilmesi

Esra AKYÜZ ÖZKAN[1] Demet GÜR VURAL[2]

ÖZ

Amaç: Evde mekanik ventilator (EMV) ile takip edilen hastaların altta yatan hastalıkları, başvuru şikayetleri, trakeal aspirat (TA) kültürlerinden alınan örneklerden izole edilen mikroorganizmalar ve antibiyotiklere dirençlerinin araştırılması amaçlandı.
Araçlar ve Yöntem: 1 Ocak 2020 – 1 Ocak 2021 tarihleri arasında TA kültürleri, bakterilerin tanımlanması ve antibiyotik duyarlılıkları VITEK 2 (bioMeriux, Fransa) otomatik tanımlama sistemi ile değerlendirildi. Hasta dosyalarından hastaların yaşı, cinsiyeti, altta yatan hastalıkları, evde ventilatör kullanım süreleri, şikayetleri ve laboratuvar verileri incelendi.
Bulgular: Çalışmada incelenen 91 ventilatör ilişkili pnömoni (VİP) hastalarının 72'si (%79) erkek ve ortalama yaş 91.64 ± 64.07 ay idi. En sık başvuru nedeni ateş ve nefes darlığı olup, hastaların %43.76'sı serebral palsi/epilepsi ve %10.4'ü sendrom tanısı aldı.
Örneklerden; 12'si (%13.3) Gram pozitif, 79'u (%86.7) Gram negatif olarak tanımlandı. 44 (%48.4) örnekte *Pseudomonas aeruginosa*, 9 (%9.9) örnekte *Serratia marcescens*, 8 (%8.8) örnekte *Klebsiella spp*, 12 (%13.3) örnekte *Staphylococcus* aureus tespit edildi. Karbapenem direnci *Pseudomonas aeruginosa* için %18.75, *Klebsiella spp* için %16, *Escherichia* coli için %12.5 ve *Acinetobacter baumannii için %12 idi.*
Sonuç: Ateş ve solunum sıkıntısı gibi enfeksiyon bulguları ile başvuran EMV hastalardan TA kültürü alınmalı ve sonuca göre tedavi düzenlenmelidir. Evde EMV ile takip edilen hastaların TA kültürü antibiyotik direnç oranlarının literatürdeki yoğun bakımda yatan hastalardan gönderilen TA kültürlerine göre daha düşük olduğu gözlendi.

Anahtar Kelimeler: antibiyotik direnci; evde mekanik ventilasyon; pediatric; trakeal aspirat

ABSTRACT

Purpose: To investigate the underlying diseases, and complaints of patients upon admission, isolated microorganisms from tracheal aspirate (TA) samples and their resistance to antibiotics in patients followed up with a home mechanic ventilator (HMV).
Materials and Methods: Between January 1, 2020 and January 1, 2021, TA cultures, identification of bacteria and their antibiotic susceptibilities were evaluated by VITEK 2 (bioMeriux, France) automated identification system. The patients' age, gender, underlying diseases, duration of home ventilator use, complaints, and laboratory data were reviewed.
Results: Of the 91 prediagnosed ventilator-associated pneumonia (VAP) patients, 72 (79%) were male and mean age was 91.64 ± 64.07 months. The most common reason for referral was fever and dyspnea and 43.76% of the patients were diagnosed with cerebral palsy/epilepsy and 10.4% with syndromes.
Of the samples; 12 (13.3%) were defined as Gram-positive and 79 (86.7%) as Gram-negative. Pseudomonas aeruginosa was detected in 44 (48.4%) samples, *Serratia* marcescens in 9 (9.9%), *Klebsiella spp.* in 8 (8.8%) and *Staphylococcus* aureus was in 12 (13.3%) samples. Carbapenem resistance was 18.75% for *Pseudomonas aeruginosa*, 16% for *Klebsiella spp*, 12.5 for *Escherichia* coli and 12% for *Acinetobacter baumannii.*
Conclusion: TA culture should be taken from patients with HMV who were admitted with signs of infection such as fever and respiratory distress and treatment should be arranged according to the result. It was observed that the TA culture antibiotic resistance rates of the patients with HMV were lower than the TA cultures sent from the patients hospitalized in the intensive care unit in the literature.

Keywords: antibiotic resistance; home mechanical ventilation; pediatrics; tracheal aspirate

Received: 21.10.2022; Accepted: 22.05.2023

[1]Ondokuz Mayıs University Medical Faculty, Department of Pediatrics, Samsun, Türkiye.
[2]Ondokuz Mayıs University Medical Faculty, Department of Microbiology, Samsun, Türkiye.

Corresponding Author: Esra Akyüz Özkan, Ondokuz Mayıs University Medical Faculty, Department of Pediatrics, Samsun, Türkiye. e-mail: uzdresra@gmail.com

How to cite: Akyüz Özkan E, Gür Vural D. Evaluation of tracheal aspirate cultures of patients followed with home mechanical ventilators. Ahi Evran Med J. 2023;7(3):340-345. DOI: 10.46332/aemj.1192753

INTRODUCTION

Tracheotomy, which is a very old surgical procedure, is applied to open airway obstruction in children, to meet the need for mechanical ventilation in chronic diseases and for pulmonary care.[1] It has been reported that prolonged intubation is the first indication of tracheotomy in children.[2] Prolonged hospitalizations due to chronic diseases in intensive care units cause both economic losses and increased in patient burden in intensive care units. There are advantages to continuing the care of pediatric patients whose condition has stabilized in intensive care units at home.

It is known that the number of children receiving home mechanical ventilation (HMV) has increased in the last 25 years.[3] Children are dependent on long-term ventilation for a variety of reasons, which may include chronic lung disease due to prematurity, congenital airway malformations, hypoventilation syndrome, neuromuscular diseases, and spinal cord injuries.[4]

According to the physiological abnormalities of the cases who are candidates for the use of mechanical ventilation at home can be evaluated in three categories as those with diseases that increase the respiratory workload as a result of obstructive and restrictive disorders of the respiratory system, conditions with respiratory muscle weakness-pump failure, and those with impaired neurological control of respiration.[5]

Ventilator-associated pneumonia (VAP) is the most common infection acquired in mechanically ventilated patients.[6] VAP is associated with longer ventilation duration, increased risk of morbidity and mortality, and higher costs.[7]

Sampling of tracheal aspirate (TA) cultures is the most widely used noninvasive microbiological diagnostic method in airway sampling worldwide. The sensitivity of TA for the diagnosis of VAP varies between 38-100% and specificity between 14-100%.[8] In patients with suspected VAP, empirical antibiotic therapy should be started without waiting for the culture result.[3,6] Knowing the local causative bacteria and the antibiotic resistance profile in the unit for appropriate antibiotic use will both guide empirical antibiotic selection and contribute to reducing resistance rates.[9]

In this study, we aimed to examine the distribution of microorganisms isolated as suspected pathogens from TA cultures and their antibiotic resistance profiles in children who were followed up at home with mechanical ventilators and presented to the pediatric emergency department with signs of infections.

MATERIALS and METHODS

In this study, the culture results of TA samples sent to the laboratory from patients who applied to the pediatric emergency department of Ondokuz Mayıs University Medical Faculty Hospital and were followed up with HMV between January 2020 and January 2021 were evaluated retrospectively. The study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 28/09/2022 and OMU KAEK number: 2022/432). TA samples were obtained by aspirating using special catheters designed for sample collection under sterile conditions. The growths obtained from the repeated ETA samples of the patients were excluded from the evaluation.

Clinical specimens were cultivated on 5% sheep blood agar and EMB agar media. The cultivated samples were evaluated after incubation at 37°C for 24 hours. Vitek MS (BioMérieux, France) automated systems were used to identify bacterial species and Vitek2 Compact (BioMérieux, France) automated systems were used to determine antibiotic susceptibility of bacteria. EUCAST (The European Committee on Antimicrobial Susceptibility Testing) criteria were used to evaluate the antibiotic susceptibility of the isolates.

The patients' age, gender, underlying diseases, duration of home ventilator use, complaints, and laboratory data were reviewed retrospectively from the patient files.

Statistical Analysis

For the analysis of the data, version 25.0 of IBM SPSS (Statistical Package for the Social Sciences) was used. Descriptive statistics were presented as mean (±) standard deviation and frequency (n) and percentage (%).

RESULTS

The identification and susceptibility results of the 91 pre-diagnosed VAP patients examined in the study, 72 (79%) were male and 19 (21%) were female. The ages of the patients ranged from 5 to 212 months, with a mean age of 91,64±64,07 month. The most common reason for referral was fever and dyspnea and 43.76% of the patients were diagnosed with CP/Epilepsy and 10.4% with syndromes (Table 1,2).

Table 1. Primary diseases of pediatric patients followed up with home mechanical ventilator.

Disease	n	%
CP/Epilepsy	21	43.76
HIE	2	4.17
SMA	3	6.26
Metabolic diseases	2	4.17
Syndromes	5	10.4
Neurodegenerative diseases	4	8.34
Mitochondrial disease	2	4.16
Infantile spasm	2	4.16
Post arrest	1	2.09
Brain tumor	2	4.16
Neurometabolic disease	3	6.25
Meningomyelocele	1	2.08
Total	48	100

CP: cerebral palsy, HIE: hypoxic ischemic encephalopathy, SMA: spinal muscular atrophy

TA results of 91 patients were evaluated over a 1-year period. Of the samples; 12 (13.3%) were defined as Gram-positive and 79 (86.7%) as Gram-negative. Pseudomonas aeruginosa was detected in 44 (48.4%) samples, Serratia marcescens in 9 (9.9%) and Klebsiella spp in 8 (8.8%) samples. Staphylococcus aureus was detected in 12 (13.3%) samples (Table 3). The resistance rates of the detected Gram-negative and Gram-positive microorganisms to various antibiotics are given in Table 4.

The laboratory findings of the patients are given in Table 3. While 36.2% of the patients had high CRP values, the rate of WBC elevation was 38.4%.

Table 2. The complaints and laboratory parameters of pediatric patients followed up with home mechanical ventilator.

Complaint	n (%)
Fever	42 (46.2)
Dyspnea	31 (34.1)
Tachycardia	4 (4.4)
Restlessness	4 (4.4)
Convulsion	6 (6.6)
Desaturation	4 (4.4)
Total	91 (100)
Laboratory parameters	**Mean+SD**
WBC (/uL)	11.8 ± 5.9
Hemoglobin (g/dL)	11.50 ± 2.23
Platelet (x109/L3)	287.47 ± 152.03
Na (mEq/L)	138.05 ± 6.05
K (mEq/L)	3.95 ± 0.80
BUN (mg/dL)	14.86 ± 16.50
Creatinine (mg/dL)	0.47 ± 0.62
ALT (U/L)	41.26 ± 36.03
AST (U/L)	29.30 ± 25.70
CRP (mg/L)	26.91 ± 34.91
pH	7.40 ± 0.10
pCO2	40.9 ± 16.2
Lactate (mmol/L)	2.51 ± 1.72

WBC: white blood cell, K: potassium, Na: sodium, BUN: Blood Urea Nitrogen, ALT: Alanine Aminotransferase, AST: Aspartat Aminotransferase, CRP: C-reactive protein

Table 3. Distribution of bacteria isolated from tracheal aspirate cultures.

Bacteria	n	%
Pseudomonas aeruginosa	44	48.4
Klebsiella spp.	8	8.8
Staphylococcus aureus	12	13.3
Escherichia coli	4	4.4
Acinetobacter baumannii	4	4.4
Proteus mirabilis	1	1
Serratia marcescens	9	9.9
Moraxella catarrhalis	1	1
Others	8	8.8
Total	91	100

Table 4. The resistance to antibiotics in gram-negative and gram-positive bacteria isolated from tracheal aspirates (%).

Gram Neg.	Amikacin	Meropenem	Piperacillin tazobactam	Ceftazidime	Ciprofloxacin	Cefepime
P. aeruginosa	6.2	18.75	31.25	12.5	18.75	12.5
A. baumannii	33	33	12.5	52	33	22
E.coli	25	12.5	22	25	32	32
Klebsiella spp.	16	16	66	72	50	75
S. marcencens	10	22	12.5	12	33	12.5
P. mirabilis	4	2.5	2.5	2.5	50	50
M. catarrhalis	0	0	0	0	0	0
Gram Pos.	**Penicillin**	**Teicoplanin**	**Vancomycin**	**Linezolid**	**Trimethoprim sulfamethoxazole**	**Ciprofloxacin**
S. aureus	88	0	0	0	0	4

DISCUSSION

The practice of mechanical ventilation at HMV is an application that is becoming increasingly common all over the world, especially in developed countries.[10] In a study conducted in England, it was reported that while the number of children followed up with HMV dependency was 35 in 1990, this number reached 933 in 2008.[11] While there

were only 13 HMV dependent and 2 tracheotomy pediatric patients in the follow-up of home health services in Samsun in 2015, it was increased to 25 pediatric patients, 23 HMV dependent and 2 tracheotomies, in June 2019.[12] Gowans et al.[13] found in their study that there was little change in the prevalence of children who underwent invasive HMV between 1996 and 2004 in Utah (5.0/100.000 in 1996 and 6.3/100.000 in 2004) and they reported the mean age of the children was 6.5 months when their HMV was started. The most common HMV indications were; abnormal respiratory control (47%), chronic lung disease (25%), airway anomalies (16%) and neuromuscular weakness (13%) in the same study.[13]

In this study, the mean age at which patients started to use HMV was 38±49 months (2-168 months) and the most common indications were cerebral palsy/epilepsy and syndromes.

Ertugrul et al.,[14] in their study they analyzed the results of 61 patients who underwent EMV; found that 60% of these patients were younger than 12 months, with a mean age of 8.5 months (2-196 months). They determined that the decision to apply EMV was made in the most common neuromuscular and central nervous system diseases (94%). Can et al.[15] reported the most common indication for tracheostomy less than 1 year of age was neuromuscular diseases (42.4%) and neurological diseases (63.3%). Palfrey et al.[16] evaluated 117 pediatric patients; 31.3% of them had congenital anomalies, 27.3% had organ failure, 16% had perinatal disease, 13.3% had neurological disease and 12% had motor mental retardation syndrome (MMR).

In a review of the literature on complications developing in children who had tracheostomy in the last 30 years; in order of decreasing frequency, the most common complications were reported to be granuloma formation, infection, cannula occlusion, involuntary decannulation, and tracheocutaneous fistula development after decannulation.[17]

The risk of developing pneumonia is 6-20 times higher in mechanically ventilated patients. VAP develops in 8-28% of mechanically ventilated patients, and the mortality rate has been reported as 20-71%.[18] The general conditions of the patient, the underlying disease, the length of hospital stay play an important role in the development of VAP and increase mortality. The characteristics of the causative microorganisms also affect mortality. Invasive methods applied to the patient are effective in the development of infection. However, the most important factor in the development of VAP was aspiration.[19]

In our study, the distribution of possible VAP agents were P. aeruginosa (48.4%), S. aureus (13.3%), S. marcescens (9.9%), Klebsiella spp (8.8%), A. baumannii (4.4%), E coli (4.4%).

When the literature was reviewed, it was seen that VAP studies articles were made in intensive care units mostly.

The distribution of bacteria isolated from TA samples sent from intensive care unit (ICU) patients was P. aeruginosa (12-36%), A. baumannii (7-31%), S. aureus (13-25%), Klebsiella spp (4%-8), E. coli (5-7%).[20] In the study of Chawla et al.[21] in Asian countries, while A. baumannii was the main cause of VAP in ICUs, methicillin-resistant S. aureus (MRSA) was not seen as a big problem in western countries. However, in addition to the publications that draw attention to the high frequency of MRSA in Korea and Thailand, there are also publications reporting a 46% higher incidence of Acinetobacter infections in Thailand.[22]

Especially in recent years, high rates of carbapenem resistance have been observed in Acinetobacter, Pseudomonas, and Klebsiella species.[23] Tartar et al.[24] found carbapenem resistance in Acinetobacter, Klebsiella, P. aeruginosa and E. coli species as 97.7%, 58.4%, 70.9% and 20%, respectively. In current study carbapenem resistance was 18.75% for P. aeruginosa, 16% for Klebsiella spp, 12.5 for E.coli and 12% for Acinetobacter baumannii. In the study of Dede et al.,[25] meropenem resistance in P. aeruginosa obtained from TA samples sent from patients in the ICU was found to be 20%. In other studies, this rate was found to be between 27-69% .[20,26]

In current study amikacin resistance was found as 6.2% for P. aeruginosa. In national studies, amikacin resistance has been reported at a rate of 22-69%.[20,26] In our study, resistance to piperacillin-tazobactam, cefepime and ceftazidime was 31.25, 12.5 and 12.5 respectively. In other studies, resistance to piperacillin tazobactam was 27-70%,

cefepime 20% and ceftazidime resistance was 27-80%. Ciprofloxacin resistance was 18.75% in our study and 42-75% in other studies.[20,26] The reason why our resistance rates are lower than other studies is because our patients are followed up at home.

High morbidity and mortality rates detected in MRSA infections increase the importance of these infections. In studies conducted in our country, the rates of MRSA isolated from TA samples were reported to be between 11.4-60%.[25,27] The MRSA rate in our study was 88%, which was similar to the literature.

In conclusion; TA culture should be taken from patients with HMV who were admitted with signs of infection such as fever and respiratory distress and treatment should be arranged according to the result. It was observed that the TA culture antibiotic resistance rates of the patients followed up with HMV was lower than the TA cultures sent from the patients hospitalized in the intensive care unit.

Conflict of Interest

The authors declare that there is not any conflict of interest regarding the publication of this manuscript.

Ethics Committee Permission

The study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 28/09/2022 and OMU KAEK number: 2022/432).

Authors' Contributions

Concept/Design: EAÖ. Data Collection and/or Pro-cessing: EAÖ. Data analysis and interpretation: EAÖ, EAÖ. Literature Search: EAÖ. Draft-ing manuscript: EAÖ, EAÖ. Critical revision of manuscript: EAÖ, EAÖ. Supervisor: EAÖ.

REFECENCES

1. Trachsel D, Hammer J. Indications for tracheostomy in children. Paediatr Respir Rev. 2006;7(3):162-168.
2. Butnaru CS, Colreavy MP, Ayari S, Froehlich P. Tracheotomy in children: evolution in indications. Int J Pediatr Otorhinolaryngol. 2006;70(1):115-119.
3. Brenner M, O'Shea MP, Larkin P, Berry J. Key constituents for integration of care for children assisted with long-term home ventilation: a European study. BMC Pediatr. 2020;20(1):71.
4. Lewarski JS, Gay PC. Current issues in home mechanical ventilation. Chest. 2007;132(2):671-676.
5. King AC. Long-term home mechanical ventilation in the United States. Respir Care. 2012;57(6):921-930.
6. Venkatachalam V, Hendley JO, Willson DF. The diagnostic dilemma of ventilator-associated pneumonia in critically ill children. Pediatr Crit Care Med. 2011;12(3):286-296.
7. Rello J, Ollendorf DA, Oster G, et al. VAP Outcomes Scientific Advisory Group. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. Chest. 2002;122(6):2115-2121.
8. Kollef MH, Burnham CD. Ventilator-associated pneumonia: the role of emerging diagnostic technologies. Semin Respir Crit Care Med. 2017;38(3):253-263.
9. Houck PM, Bratzler DW, Nsa W, Ma A, Barlett JG. Timing of antibiotic administration and outcomes for Medicare patients hospitalized with community-acquired pneumonia. Arch Intern Med. 2004;164(6): 637-644.
10. Prinzi A, Parker SK, Thurm C, Birkholz M, Sick-Samuels A. Association of Endotracheal Aspirate Culture Variability and Antibiotic Use in Mechanically Ventilated Pediatric Patients. JAMA Netw Open. 2021;4(12):e2140378.
11. Wallis C, Paton JY, Beaton S, Jardine E. Children on longterm ventilatory support: 10 years of progress. Arch Dis Child. 2011;96(11):998-1002.
12. Mehel DM, Çelebi M, Özdemir D, Akgül G, Yavuz E. Evaluation of home health service care children with tracheotomy and mechanical ventilator. Türk Aile Hek Derg. 2020;24(1):3-11.
13. Gowans M, Keenan HT, Bratton SL. The population prevalence of children receiving invasive home ventilation in Utah. Pediatr Pulmonol. 2007;42(3):231-236.
14. Ertuğrul A, Baykacı B, Ertuğrul I, Kesici S, Yalçın EG. Clinical Evaluation of Invasive Home Mechanical Ventilation Dependent Pediatric Patients. Iran J Pediatr. 2017;27(4):9531.
15. Can FK, Anıl AB, Anıl M, et al. The outcomes of children with tracheostomy in a tertiary care pediatric intensive care unit in Turkey. Turk Pediatri Ars. 2018;53 (3):177-184.
16. Palfrey JS, Sofis LA, Davidson EJ, Liu J, Freeman L, Ganz ML. The pediatric alliance for coordinated care: evaluation of a medical home model. Pediatrics. 2004;113(5 Suppl):1507-1515.
17. Baker CD, Martin S, Thrasher J, et al. A Standardized Discharge Process Decreases Length of Stay for Ventilator-Dependent Children. Pediatrics. 2016;137(4): 20150637.
18. Erdoğan H, Baykam N, Erdoğan A, Balaban E. Ventilatörle ilişkili pnömoni. Hastane İnfeksiyon Derg. 2003;7(1):45-50.
19. Akalın H. Ventilatörle ilişkili pnömoni ve önlenmesi. Hastane İnfeksiyon Derg. 2004;8(2):112-115.
20. Ağca H. Yoğun bakımda antibiyotik duyarlılıkları. Journal of Clinical and Analytical Medicine. 2013;4(1):27-29.
21. Chawla R. Epidemiology, etiology, and diagnosis of hospital-acquired pneumonia and ventilator-associated pneumonia in Asian countries, J Infect Control. 2008;36(4 Suppl):93-100.
22. Kollef MH, Shorr A, Tabak YP, Liu LZ, Johannes RS. Epidemiology and Outcomes of Health-care– Associated Pneumonia results from a large US database of culture-positive pneumonia. Chest. 2005;128(6): 3854-3862.
23. Küme G, Demirci M. Yoğun bakım ünitelerindeki hastaların alt solunum yolu örneklerinden izole edilen non-fermentatif Gramnegatif bakterilerin antimikrobiyal duyarlılıkları ve alt solunum yolu infeksiyonu ile ilişkili risk faktörleri. Dokuz Eylül Üniv Tıp Fak Derg. 2012;26(1):37-44.
24. Sağmak-Tartar A, Özer AB, Ulu R, Akbulut A. Microbiological Evaluation of the Pathogens Isolated From

the Endotracheal Aspirate Samples of the Patients Followed in the Intensive Care Units: A One-Year Retrospective Analysis. Klimik Dergisi. 2018;31(1):56-60.
25. Dede B, Kadanalı A, Karagöz G, Çomoğlu Ş, Bektaşoğlu MF, İrvem A. Yoğun bakım ünitemizden gönderilen derin trakeal aspirat kültürleninin değerlendirilmesi. Haydarpaşa Numune Eğitim ve Araştırma Hastanesi Tıp Dergisi. 2014;54(1):15-20.
26. Demirdağ K, Cihangiroğlu M, Yüce P, Özden M, KalkanA. Mekanik ventilasyon desteği alan hastaların trakeal aspirat örneklerinden izole edilen bakteriler ve antibiyotik duyarlılıkları. Klimik Derg. 2003;16(2): 68-72.
27. Yenişehirli G, Yenişehirli A, Bulut Y, Bulut N. Metisilin dirençli Staphylococcus aureus izolatlarının vankomisin, teikoplanin, linezolid, kinupristin-dalfopristin ve daptomisine in vitro duyarlılıkları. Ankem Derg. 2015;29(1):21-25.