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Clinical Pulmonary Infection Score (CPIS) as a Screening Tool in Ventilatory Associated Pneumonia (VAP)

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ABSTRACT:

Clinical pulmonary infection score (CPIS) as a screening tool in ventilatory associated pneumonia (VAP)

Objective: Ventilator-associated pneumonia (VAP) is one of the leading nosocomial infections in intensive care units (ICUs), causing high mortality and increased health care costs. It is known that early diagnosis and treatment reduces mortality and morbidity. In this study, we aimed to assess the efficacy of Clinical Pulmonary Infection Score (CPIS) in early diagnosis in VAP.

Material and Methods: The study was performed on 43 cases. Clinical Pulmonary Infection Score parameters of each patient; body temperature, leukocyte count and morphology, volume and character of tracheal secretions, arterial oxygenation, pulmonary infiltration on chest X-ray, progression of pulmonary infiltration, microbiological culture results were recorded. Clinical Pulmonary Infection Scores were calculated at admission using the first five parameters of CPIS (basal CPIS) and after 48 hours following intubation, using seven parameters with the tracheal aspirate (TA) culture results. The patients were followed with CPIS calculated during the mechanical ventilation and with tracheal aspirate (TA) cultures obtained every three days. The patients were grouped as VAP (+) and VAP (-) in accordance with the obtained data.

Results: Basal CPIS levels were similar between the two groups ($p>0.05$), while significant differences were detected between the 48th hour and 5th day CPIS ($p<0.01$). There was difference between the pre-diagnosed CPIS levels of VAP (+) and VAP (-) cases ($p<0.01$).

Conclusion: Serial CPIS measurements can help the clinician in early diagnosis and treatment of VAP.

Keywords: Intensive care, pneumonia, ventilator-associated

ÖZET:

Ventilatör ilişkili pnömoni tanısında klinik pulmoner enfeksiyon skorunun tarama yöntemi olarak kullanımı

Amaç: Ventilatör ilişkili pnömoni (VİP), yoğun bakım ünitelerinde en sık görülen, yüksek mortalite, artmış sağlık bakım maliyetiyle ilişkili nozokomiyal enfeksiyonlardandır. Ventilatör ilişkili pnömonide erken tanı ve tedavinin mortalite ve morbiditeyi azaltacağı bilinmektedir. Çalışmamızda, VİP'i erken tanılamada tarama yöntemi olarak Klinik Pulmoner Enfeksiyon Skoru (KPES) sisteminin etkinliğini araştırmayı amaçladık.

Gereç ve Yöntemler: Çalışma, 43 olgu üzerinde yapıldı. Her hastanın KPES parametreleri; vücut ısısı, lökosit sayısı ve morfolojisi, trakeal sekresyon miktarı ve karakteri, arteryel oksijenizasyon, akciğer radyografisinde pulmoner infiltrasyon varlığı, pulmoner infiltrasyonda ilerleme, mikrobiyolojik kültür sonuçları kaydedildi. Hastaların yatışında KPES'ın ilk 5 parametresi kullanılarak bazal KPES değeri, entübasyondan 48 saat sonra kültür sonucu ile 7 parametre kullanılarak KPES değeri hesaplandı. Hastalar 3 gün arayla endotrakeal aspirat (ETA) örnekleri alınarak ve mekanik ventilatör desteğinde kaldığı sürece KPES değerleri hesaplanarak takip edildi. Elde edilen verilerle hastalar, VİP gelişmesine gore VİP (+) ve VİP (-) olarak iki gruba ayrılarak değerlendirildi.

Bulgular: Olguların bazal KPES düzeyleri arasında farklılık görülmemekte ($p>0.05$) iken 48. saat ve 5. gün KPES değerleri arasında istatistiksel açıdan anlamlı bir farklılık saptanmıştır ($p<0.01$). VİP (+) ve VIP (-) olguların VİP tanısı almadan önceki KPES düzeyleri arasında farklılık görülmektedir ($p<0.01$).

Sonuç: Tekrarlayan KPES ölçümleri; VİP gelişiminde erken şüpheli durum olduğunda ve erken tedavide klinisyene yardımcı olabilir.

Anahtar kelimeler: Yoğun bakım, pnömoni, ventilatör ilişkili

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INTRODUCTION

Ventilator-associated pneumonia (VAP) is a pneumonia that develops at least 48 hours after invasive mechanical ventilation in patients without clinical findings supporting the development of pneumonia or pneumonia during intubation (1).

Ventilator-associated pneumonia is a common nosocomial infection in intensive care units (ICUs) and its results can be listed as high mortality, prolonged intensive care stay, and increased health care cost (2). In a 2011 survey study, the average incidence of VAP was found to be 20.6% on 1000 mechanical ventilation days (3). High-risk bacteria causing VAP, previous antibiotic and H2-blocker drug use of the patient, follow-up APACHE II score greater than 20, high creatinine levels, bacteriemia, organ failure and premorbid lifestyle score 2 or higher increase VAP-associated mortality (4). Ventilator-associated pneumonia accounts for more than half of all antibiotic use in the ICU (5). As a result, VAP causes great morbidity and financial consequences (6,7). Because of these reasons, early diagnosis and treatment of VAP is crucial.

Despite its high incidence, diagnosis is very difficult due to the presence of similar clinical findings in many patients in the intensive care unit. In the multiple patient series, there was a weak correlation found between the clinical diagnosis of pneumonia and true pneumonia, and it was stated that 50% of the patients defined as VAP were not really ill, and 1/3 of the VAP patients could not be identified (8).

A simple tool for the diagnosis of VAP was needed, thus, a scoring system was developed in 1991, which included 7 clinical parameters for VAP diagnosis and it was named as Clinical Pulmonary Infection Score (CPIS) (9) (Table-1). In this scoring system, the clinic is evaluated with radiological and endotracheal aspirate (ETA) culture results. The diagnosis of VAP was made using body temperature, leucocyte count and morphology, tracheal secretion amount and character, PaO_2 / FiO_2 ratio, presence of pulmonary infiltration and its progression and microbiological culture results. A score of 6 or more suggests VAP.

In our study, we aimed to investigate the efficacy of the Clinical Pulmonary Infection Scoring System (CPIS) as a screening tool for the early diagnosis of VAP.

MATERIAL AND METHODS

This study was conducted in the ICU of Anesthesia and Reanimation Clinic prospectively after the approval of the Local Ethics Committee with patient consent. It was conducted in accordance with the Helsinki Declaration 2008 principles within a 6-month period, on 43 subjects aged between 18 and 97 years with a median age of 68.42±19.76 years, who met the inclusion criteria for the study. During the study period, 372 patients were followed up in ICU and patients who had mechanical ventilator support for longer than 48 hours were included in the study. Patients with pneumonic infiltration during intubation, patients with sepsis diagnosis, immunocompromised with a viral disease, receiving chemotherapy and/or radiotherapy and patients who were intubated for a period of shorter than 48 hours were excluded from the study. Patients' ages, gender, intensive care entry diagnoses, systemic diseases, and APACHE II scores were recorded. Body temperature, leukocyte counts and morphology, tracheal secretion characteristics and volumes, blood gas results of patients were recorded after intubation, and PA chest graphies were obtained. Endotracheal aspiration (ETA) specimen were taken with closed system, protected from contamination under sterile conditions, using Lukens Specimen Container. The ETA sample was sent to the microbiology laboratory for gram staining and culture under appropriate conditions.

Microbiological processes: The samples were delivered to the microbiology laboratory within 30 minutes after collection. 1 ml of ETA was mixed with 1 ml of physiological saline and mechanically crushed for 1 minute, then cultivated into 100 µl of 5% sheep blood agar, chocolate agar and MacConkey agar. Microscope slides were prepared for Gram staining. Endotracheal aspiration slides were scored as 0, + 1, + 2, + 3 according to the Q

scoring system (10). Chocolate-coated agar plates were incubated at 35°C in 5-10% CO_2 in the sterilizator. 5% sheep blood agar and chocolate-coated agar were incubated for 48 hours before evaluation. Breedings were calculated according to literature knowledge by quantifying (colony number) x (dilution rate)$^{-1}$ X 10 (1,11-13). Endotracheal aspiration was again accepted as a positive reproduction over 105 cfu/ml according to the literature (1,8,14,15). Identification was performed with Mini Api (Biomerineux) system.

Clinical Pulmonary Infection Score (CPIS) parameters for each patient; body temperature, leucocyte count and morphology, tracheal secretion volume and character, PaO_2/FiO_2 values, presence of pulmonary infiltration, pulmonary infiltration progression, and microbiological culture results were recorded. Ventilator-associated pneumonia (VAP) was diagnosed according to the results of ETA culture, taking clinical findings and chest X-ray into account and was confirmed by the "Infectious Diseases Committee" which was formed by experts on the subject. Clinical Pulmonary Infection Score (CPIS) values were calculated at patient admission using the first 5 parameters of CPIS (body temperature, leukocyte count and morphology, tracheal secretion volume and character, PaO_2/FiO_2 values, presence of pulmonary infiltration) until the gram staining and culture results were obtained. This value was accepted as basal CPIS. Clinical Pulmonary Infection Score (CPIS) values were calculated 48h after intubation using 7 parameters (body temperature, leukocyte count and morphology, tracheal secretion volume and character, PaO_2/FiO_2 values, presence of pulmonary infiltration, pulmonary infiltration progression, microbiological culture results). Then, ETA samples were taken with 3 days of intervals. Culture results were obtained 2 days after the samples. The diagnosis of VAP was made according to these results. The CPIS values of patients who were not diagnosed as VAP and continued to be monitored were also calculated according to these culture results. Patients were followed up with 3 days of intervals (48th hour, 5th day, 8th day, 11th day, 14th day) with CPIS values calculated. Patients were divided into two groups as VAP (+) and VAP (-).

Number Cruncher Statistical System (NCSS) 2007 & PASS (Power Analysis and Sample Size) 2008 Statistical Software (Utah, USA) program was used for statistical analyses. During the evaluation of the study data, descriptive statistical values were given as mean and standard deviation when parametric tests were applied, as median, minimum and maximum values when non-parametric tests were applied, and as frequency and ratio for categorical data. Student's t-test and paired t-test were used to compare variables. The Mann-Whitney U test was used to compare percent changes between measurements. Significance was assessed at $p<0.05$ level.

Table-1: Clinical Pulmonary Infection Score (CPIS)

Body temperature ≥ 36.5 or ≤ 38.4 = 0 point ≥ 38.5 or ≤ 38.9 = 1 point ≥ 39 or < 36.5 = 2 point	**Pulmonary infiltration in chest X-ray** No infiltration = 0 point Diffuse infiltration = 1 point Localized infiltration = 1 points
Leukocyte count, microscopy ≥ 4000 or ≤ 11.000 = 0 point < 4000 or > 11.000 = 1 point Rod form ≥ % 50 = Add 1 point	**Progression in pulmonary infiltration** Radiographic progression (-) = 0 point Radyografic progression (+) (After the exclusion of HF and ARDS) = 2 points
Tracheal secretion Tracheal secretion (-) = 0 point Tracheal secretion with less purulence = 1 point Abundant purulent secretion = 2 points	**Pathogenic bacteria in tracheal aspirate culture** No or few pathogenic bacteria = 0 point Moderate or high levels of pathogenic bacteria = 1 point Pathogenic bacteria to be seen in Gram staining, add 1 point
Oxygenization PaO_2/FiO_2, mmHg > 240 or ARDS (ARDS: PaO_2/FiO_2 < 200, PaO_2/FiO_2 < 200, PAWP ≤ 18 mmHg and bilateral acute infiltration) = 0 point PaO_2/FiO_2, mmHg ≤ 240 or ARDS = 2 points	Total (>6 is accepted as pneumonia) ARDS: acute respiratory distress syndrome; HF: heart failure; PAWP: pulmonary artery wedge pressure

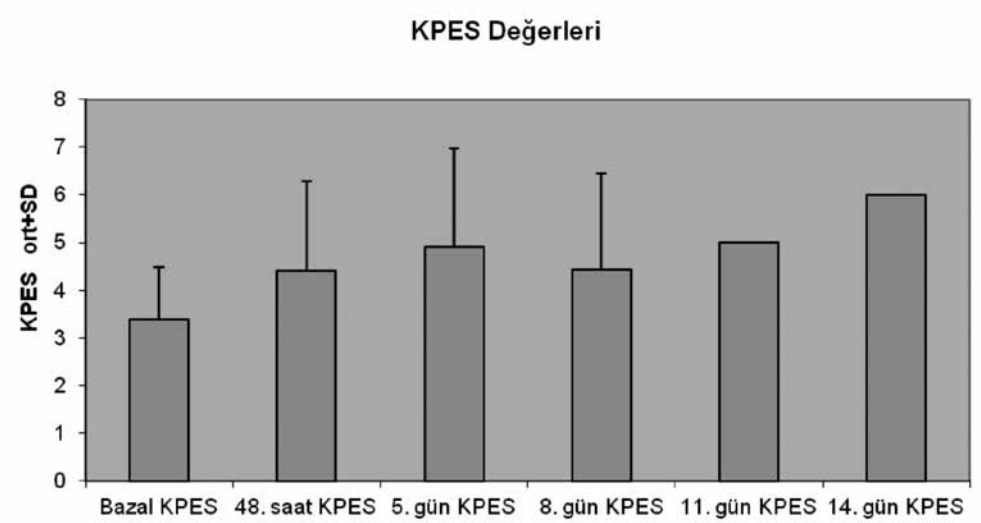

Figure-1: Distribution of CPIS Values
CPIS: Clinical Pulmonary Infection Score

Table-2: Distribution of CPIS Values

	n	CPIS		VAP	Dead	Discharged
		Min/Max	Mean±SD			
Basal CPIS	43	0 - 5	3.38±1.10	0	-	-
48th hour CPIS	43	1 - 10	4.40±1.89	10	-	4
5th day CPI S	29	1 - 11	4.90±2.06	8	5	7
8th day CPIS	9	2 - 9	4.44±2.01	1	4	3
11th day CPIS	1	5 - 5	5.00±0	-	-	-
14th day CPIS	1	6 - 6	6.00±0	1	-	-

CPIS: Clinical Pulmonary Infection Score, VAP: Ventilator-associated pneumonia

RESULTS

The study was conducted within 6 months on 43 subjects aged between 18 and 97 with a mean age of 68.42±19.76 years. Of the 372 patients followed in the ICU during the study period, 329 were excluded from the study due to sepsis, malignancy, diagnosis of pneumonia at admission and/or mechanical ventilator support for less than 48 hours. 46.5% of the cases (n=20) were women and 53.5% (n=23) were male subjects. Of the cases, brain malignancy was found in 2.3%, gastrointestinal bleeding in 4.7%, hemorrhagic stroke in 4.7%, hepatorenal syndrome in 2.3%, ischemic stroke in 20.9%, post-CPR in 16.3%, pulmonary edema in 9.3%, respiratory failure in 25.6%, status epilepticus in 2.3% and multiple organ trauma in 9.3%. The distribution of cases according to CPIS values is shown in Table-2.

Baseline CPIS values were between 0 and 5, with a mean value of 3.38±1.10. The 48th hour CPIS values of the cases were between 1 and 10, with a mean value of 4.40±1.89. According to the 48th hour culture results, 10 of the cases received VAP diagnosis. After 48 hours, 4 of the cases were discharged and 29 cases were continued to be monitored. The 5th day CPIS value was evaluated in 29 cases. The CPIS values of 29 patients were between 1 and 11, with a mean value of 4.90±2.06. According to culture results on day 5, 8 of the cases received VAP diagnosis. After the 5th day, 7 of 29 cases were discharged, 5 cases died, 9 cases were continued to be followed. On day 8, CPIS was assessed in 9 cases. The CPIS values were found to range from 2 to 9 with a mean value of 4.44±2.01. According to culture results on day 8, 1 of the cases received VAP diagnosis. After the 8th

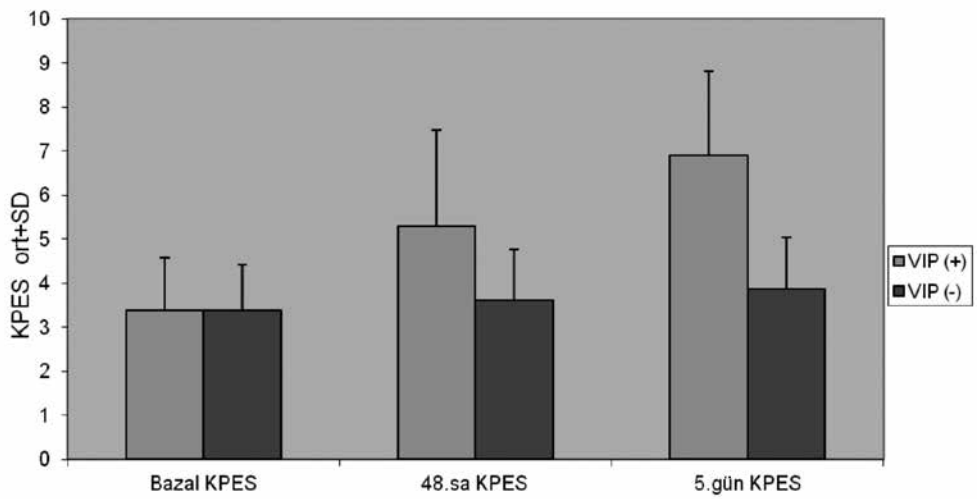

Figure-2: VAP development according to CPIS results
CPIS: Clinical Pulmonary Infection Score, VAP: Ventilator-associated pneumonia

Table-3: Evaluation of CPIS results at other measurement times according to VAP status and start time

VAP	Basal CPIS (Mean±SD)	48th hour CPIS (Mean±SD)	5th day CPIS (Mean±SD)	Significance (++p)		
				Basal-48th hour	Basal-5th day	48th hour-5th day
Presenr	3.38±1.20	5.30±2.18	6.90±1.91	0.004**	0.003**	0.010*
Absent	3.39±1.03	3.61±1.16	3.87±1.17	0.312	0.214	0.359
+p	0.962	0.004**	0.001**			

+Student t test, ++Paired t test, *p<0.05, **p<0.01, CPIS: Clinical Pulmonary Infection Score, VAP: Ventilator-associated pneumonia

Table-4: Comparison of percentage change values of CPIS measurements in VAP gropus

VAP	Basal-48th hour % Change Median (min:max)	Basal-5th day % Change Median (min:max)	48th hour-5th day % Change Median (min:max)
Present	0.40 (0:1.00)	0.80 (0.25:1.83)	0.67 (0.33:1.46)
Absent	0 (-0.25:0.33)	0.13 (-0.19:0.31)	0 (-0.15:0.25)
p	0.043*	0.007**	0.005**

Mann Whitney U test, *p<0.05, **p<0.01

day, 3 of 9 patients were discharged, 4 died, 1 patient was continued to be followed up. The CPIS score on the 11th day of this case was found to be 5. The 14th day of CPIS value of this case under on-going follow-up was 6. On the 14th day, the patient was diagnosed with VAP according to the culture result (Figure-1, Table-2).

Intensive care entry basal CPIS levels were found to be 3.38±1.20 in cases with VAP and 3.39±1.03 in cases with no VAP, with no significant difference between them (p=0.962). There was a statistically significant difference between the 48th hour CIPS and 5th day CPIS values of VAP (+) and VAP (-) cases (p=0.004, p=0.001). In VAP (+) cases, a mean increase of 1.86 units was found at 48th hour CPIS values over basal CPIS levels, and it was found to be statistically significant at advanced level (p=0.004). Compared to the baseline CPIS, the rise of 3.33 units in CPIS values at 5th day was statistically significant (p=0.003). The rise of 3.33 units in the CPIS values

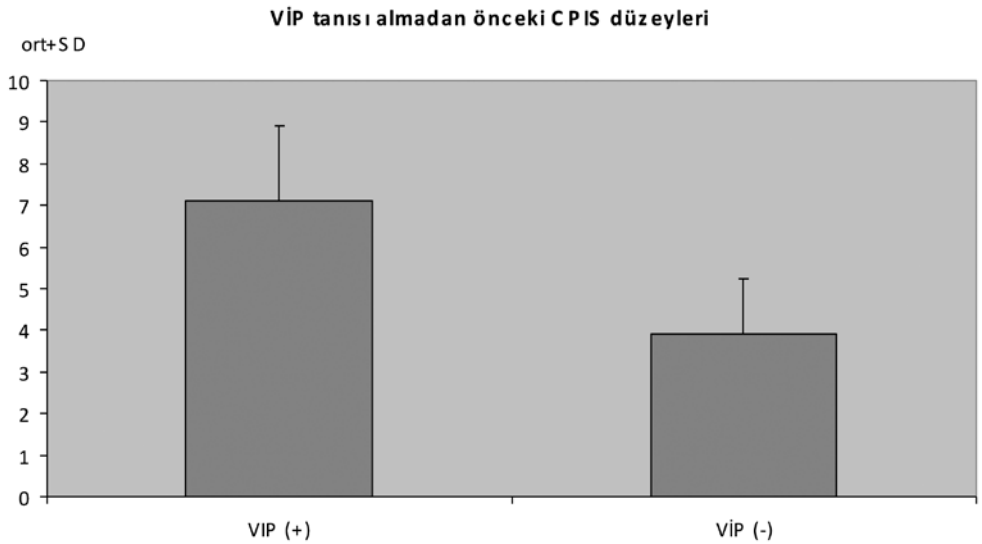

Figure-3: Distribution of CPIS Results Before VAP Diagnosis

Table-5: Assessment of CPIS Results Before VAP Diagnosis

	CPIS levels before VAP diagnosis		†p
	Min-Max	Mean±SD	
VAP (+)	4-11	7.10±1.82	0.001**
VAP (-)	1-6	3.92±1.32	

†Student t test, **p<0.01, CPIS: Clinical Pulmonary Infection Score, VAP: Ventilator-associated pneumonia

at 5th day compared to the 48th hour CPIS values was also statistically significant (p=0.010). In VAP (-) cases; the CPIS values of 3.39±1.03 at baseline, 3.61±1.16 at 48 hours and 3.87±1.17 at 5th day were not significantly different (p=0.312, p=0.214) (Figure-2, Table-3).

Percentage change in 48th hour CPIS measurement compared with baseline CPIS value was 0.40 in VAP (+) cases, 0 in VAP (-) cases; percentage change was found to be significantly higher in VAP (+) cases (p=0.043). Percentage changes of the 5th day CPIS measurement compared to the baseline CPIS value were calculated as 0.80 in VAP (+) cases and 0.13 in VAP (-) cases; the change was found to be significantly higher in VAP (+) cases (p=0.007). Percentage change of the 5th day CPIS measurement compared to the 48th hour CPIS value was calculated as 0.67 in VAP (+) cases; the change was found to be significantly higher (p=0.005) (Table-4).

In the VAP (+) cases, CPIS levels before culture outcomes were calculated as 7.10±1.82, which was significantly higher than VAP (-) cases (p=0.001) (Figure-3, Table-5).

CONCLUSION

The primary obstacle in VAP diagnosis is the absence of an exact same gold stardard (8). It is usually diagnosed according to clinical, radiological and microbiological criteria (14). Concerns about inaccuracies with clinical approaches in VAP has led researchers to specify invasive diagnostic methods (quantitative culture of bronchoscopically acquired lower respiratory tract secretions) (16). However, these procedures require strict adherence to bronchoscopic and microbiological techniques and their place in routine practice is controversial (4-7,17). The best method for the diagnosis of VAP is to find the earliest and most accurate technique, with the subject still being controversial. In 1991,

Pugin et al. attempted to establish a candidate marker of VAP and they defined the CPIS. This is followed by some studies, not enough in number, about the efficiency of CPIS (9).

In a retrospective study involving 58 patients with severe brain injury, Pelosi et al. found that CPIS increased from entry to ICU to VAP onset and that CPIS had 97% sensitivity, 100% specificity in VAP diagnosis (18).

In the study of Luna et al., it was observed that the CPIS values increased significantly in the patients until the day of VAP diagnosis. The CPIS value remained high in those who did not survive while VAP showed a significant decrease in the treatment phase in who survived. This observation suggests that CPIS correlates with final mortality (19). In our study, a statistically significant increase was observed in the CPIS values of patients until the VAP diagnosis. In patients with suspected VAP, the CPIS levels before diagnosis confirmed by culture results were found to be significantly higher and the mean value was found to be 7,10. In VAP (-) cases, no increase in CPIS values was observed. The question of whether the requirement for high CPIS calculated before the culture results to alert the clinician to be a preliminary indicator for the use of empiric antibiotics is controversial.

In the multicentre randomized VAP diagnostic strategy study performed by Luyt et al., the sensitivity of CPIS>6 for diagnosing VAP patients with bronchoscopic results was 89% and the specificity was only 47%. In this study where the incidence of VAP was 44%, the positive predictive value of the calculated CPIS value to be over 6 was 57% and the negative predictive value was 84%. Considering microbiological culture results on the 3rd day in this study, it was observed that patients with VAP had higher CPIS values than those without VAP and CPIS> 6 could identify more patients with lung infection. Based on high sensitivity (89%) and negative predictive value (84%), this clinical scoring has been achieved as a valid alternative strategy for minimizing unnecessary antibiotic use in patients with suspected VAP (16).

It has been suggested in many studies that the efficacy of CPIS in diagnosing VAP is low; for this reason, the efficacy of CPIS has been investigated in specific patient groups. In the study of Croce et al. with 158 trauma patients followed by CPIS, no difference was found in terms of bacterial index among patients with CPIS≤6 and CPIS>6. Only 44% of patients with CPIS>6 had VAP on bronchoalveolar lavage (BAL), 39% of patients with CPIS≤6 were diagnosed with VAP. In the diagnosis of VAP, the sensitivity of CPIS>6 was 61% and the specificity was 43%. Positive and negative predictive values were 44% and 62%, respectively. The use of CPIS as a screening tool in trauma patients is not considered to be helpful for the definitive diagnostic procedure due to VAP presence in 40% of patients with CPIS≤6 (20). The results of this study is controversial because of CPIS>6 being a threshold value for VAP diagnosis and the inflammatory response in trauma patients. 9.3% of our study group consisted of trauma patients and all of these patients developed VAP. Pham et al. had similar results in the burn patient group. They found that CPIS had poor discriminability and patients with positive and negative culture results had similar CPIS (mean CPIS of 5,7 and 5,5, respectively) (21). Based on the poor sensitivity and specificity of the studies, Zilberberg et al. found that CPIS has a limited role both clinically and as a research tool (8).

Leukocyte count and body temperature changes, which are of the CPIS criteria, are observed in many diseases. Aspiration pneumonia (chemical), pulmonary haemorrhage, lung contusion and drug reaction should be considered in the differential diagnosis of VAP. Systemic inflammatory response syndrome (SIRS) is observed in many patients in the ICU, and in many disease groups (ARDS, sepsis, trauma and burns, etc.). Systemic findings are fever, tachycardia, leukocytosis and non-specific findings due to increased cytokines. Trauma, fever and leukocytosis seen in the postoperative patient group and sepsis, complicate the clinician's job. It is clear that the exclusion of patients with sepsis in our study increased the efficacy of CPIS in the diagnosis of VAP. We believe that CPIS value to be 6 or more is not diagnostic alone, in the light of our study. However, we believe that follow-up of patients with CPIS leads to early suspicion of VAP development

and leads to early admission to the necessary diagnostic approach, thus providing a high clinical benefit. Fever and leucocytosis observed in the first 72 hours postoperatively can be observed in also pulmonary edema, pulmonary infarction, devascular tissue and atelectasis. It has been shown that the CPIS efficacy is weak in these patient groups (21,22). 9.3% of our study group is composed of postoperative patients. 25% of these developed VAP, and 75% did not.

The largest prospective study conducted today is the study by the Canadian Intensive Care Working Group to measure the differential power of CPIS in VAP. In this multicentre study involving 739 patients, they investigated the utility of modified CPIS as a pre-test for the identification of VAP diagnosis. Of the 739 patients, they defined 107 (14.5%) as low, 293 (39.6%) as moderate, and 339 (45.9%) as highly probable VAP. Of these patients, 625 (84.6%) were defined as VAP. However, 341 (45.99%) patients were found to have proliferation in ETA and BAL samples. Therefore, it is understood that CPIS is a preliminary test for VAP diagnosis but it is not a definite diagnostic tool alone. In addition, it is evaluated as a parallel screening tool to the antimicrobial treatment (21). In a study conducted by Sachder et al. in a pediatric ICU, modified CPIS was used in the follow-up of the patients and they found that it helped to initiate the diagnostic procedure in the diagnosis of VAP (23).

The importance of early diagnosis of VAP in ICUs is crucial. Clinical Pulmonary Infection Score (CPIS) provides close follow-up of intensive care patients and early suspicion of developing pneumonia. It is a method warning the clinician and providing an application to the necessary diagnostic methods. In this regard, we believe that it will be a useful screening method in the follow-up of ICU patients.

Current studies suggest that serial CPIS measurements in patients under mechanical ventilation may be used to identify developing pneumonia that has not yet been clinically defined. Patients who receive improper treatment or delayed treatment with appropriate antibiotics differ in their mortality from those receiving adequate therapy. Authorities believe that early initiation of appropriate treatment with guidance of CPIS or another clinical score guideline leads to improvement in the outcomes of VAP patients (19).

The rise of CPIS should be warning for clinicians. In our study, ETA cultures showed positive results on the day of CPIS increase. For this reason, it is possible to start early antibiotic therapy against the potential agent without waiting for the culture result thanks to repeated CPIS measurements. Differences in the morbidity and mortality of patients can be recorded with early treatment.

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