



ARAŞTIRMA MAKALESİ

RESEARCH ARTICLE

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## Procalcitonin and C-reactive Protein Measurements in the Early Diagnosis of Surgical Site Infections After Cesarean Section

### Sezaryen Sonrası Cerrahi Alan Enfeksiyonlarının Erken Dönem Tanısında Prokalsitonin ve C-reaktif protein Ölçümlerinin Yeri

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#### Öz

**Giriş ve Amaç:** Sezaryen sonrası ölçülen serum prokalsitonin (PKT) düzeylerinin cerrahi alan enfeksiyonu (CAE)'ların erken tanısında diğer enfeksiyon belirteçlerine göre üstün olup olmadığını belirlemeyi amaçladık.

**Gereç ve Yöntemler:** Bu çalışma, Kasım 2018 ile Nisan 2019 tarihleri arasında Özel Hastane kadın doğum kliniğimizde elektif primer sezaryen ile doğum yapan 249 hasta üzerinde gerçekleştirildi. Postoperatif 6., 12. ve 24. saatlerde serum PKT, C-reaktif protein (CRP) ve beyaz kan hücresi sayılarının ölçümleri yapıldı. Hastalar postoperatif 2., 4. ve 7. günlerde CAE açısından incelendi.

**Bulgular:** Katılımcıların 15'inde (%6) cerrahi alan enfeksiyonu gelişti. PKT, CAE'ların en hassas ve spesifik belirleyicisiydi. PKT için CAE'nın öngörülmesinde eğri altındaki alan 0.912 (% 95 CI: 0,79-1) ve kesme noktası 0,099 ng / ml , % 93,3 duyarlılık ve % 92,3 özgüllük idi (p <0.001). CAE tahmininde CRP eğri altındaki alan (EAA) 0.854 (% 95 CI: 0.782 - 0.926) ve kesme noktası 16.95 mg/dL, %80 hassasiyet ve % 82,4 özgüllük idi. CAE'yi öngörmeye beyaz kan hücresi için eğri altındaki alan (AUC) 0.819 (% 95 CI: 0.708-0.931) ve kesme noktası 18.8x10<sup>9</sup>/L, % 73,3 hassasiyet ve % 83,0 özgüllük idi.

**Sonuç:** Serum PKT düzeyleri, sezaryen sonrası CAE'ların erken tanısında diğer konvansiyonel enfeksiyon belirteçlerinden daha duyarlı ve özgün bir belirteç olarak bulundu.

**Anahtar kelimeler:** Cerrahi alan enfeksiyonu, C-reaktif protein, Prokalsitonin, Sezaryen.

#### Abstract

**Objective:** We aimed to determine whether serum procalcitonin (PCT) levels measured after cesarean section were superior to the levels of other infection markers in the early diagnosis of surgical site infection (SSI).

**Materials and Methods:** The present study was conducted with consecutive 249 patients who underwent elective primary cesarean delivery in our obstetrics clinic of a Private Hospital between November 2018 and April 2019. Measurements of serum PCT, C-reactive protein (CRP) and white blood cell (WBC) counts were performed at the postoperative 6<sup>th</sup>, 12<sup>th</sup> and 24<sup>th</sup> hours. The participating patients were examined for SSI on the postoperative 2<sup>nd</sup>, 4<sup>th</sup> and 7<sup>th</sup> days.

**Results:** Of the participants, 15 (6%) developed surgical site infections, PCT was the most sensitive and specific marker of the SSI. Area under the curve (AUC) for PCT in predicting the SSI was 0.912 (95% CI: 0.79-1) and cutoff point was 0.099 ng/ml with a sensitivity of 93.3%, and specificity of 92.3% (p<0.001). Area under the curve (AUC) for CRP in predicting the SSI was 0.854 (95% CI: 0.782 - 0.926) and cutoff point was 16.95 mg/dL with a sensitivity of 80%, and specificity of 82.4%. Area under the curve (AUC) for WBC in predicting the SSI was 0.819 (95% CI: 0.708-0.931) and cutoff point was 18.8 x 10<sup>9</sup>/L with a sensitivity of 73.3%, and specificity of 83.0%.

**Conclusion:** Serum PCT levels were found to be a more sensitive and specific marker in the early diagnosis of SSI after cesarean section than were the other conventional infection markers.

**Keywords:** Cesarean section, C-reactive protein, Procalcitonin, Surgical site infection.

## 1. Introduction

One of the most common surgical procedures in the world is cesarean [1,2]. Surgical site infections (SSI) are one of the most common complications after cesarean section and its prevalence varies between 3% and 15% from one country to another [3,4]. According to the Center for Disease Control and Prevention (CDC), SSI is a condition where there is at least one criterion from purulent drainage, redness and / or swelling of the incision, and wound separation. Long-term stays in the hospital lead to both mother-baby separation, leading to emotional trauma, and economic losses [5]. Therefore, the leading target in SSI should be early diagnosis and treatment [4].

Although biochemical markers such as C reactive protein (CRP) and white blood cell (WBC) which have been used for a long time are preferred to detect postoperative surgical site infections, they are not always sufficient to distinguish between the infection and inflammation of the surgical site. Therefore, physicians have been using other possible markers in the last 10 years. The most popular of these markers is procalcitonin (PCT).

Procalcitonin (PCT) is the pro-peptide of calcitonin, which is normally secreted by the thyroid C cells. PCT is a 116-amino acid, and biochemically similar to its predecessor calcitonin (CT) [6]. However, it lacks hormonal activity. Its half-life in healthy individuals ranges from 25 to 30 hours. In normal physiological conditions, the blood PCT level is between 0.01 ng/mL and 0.04 ng/mL [7,8]. In many studies, the upper value of PCT is accepted as 0.05 ng/ml [9]. That procalcitonin is the response of the human body to a bacterial infection was first discovered by Dandona et al. in 1990 [10]. A high level of PCT in the blood indicates not only severe bacterial infection and sepsis [11,12,13,14], but also postoperative complications [15,16,17,18].

To date, there are very few studies on the role of PCT in early detection of surgical site infections after cesarean section [19]. Thus, we aimed to determine whether PCT levels measured at after cesarean were superior to other infection markers such as CRP and WBC in the early detection of postoperative surgical site infections, and to detect the biochemical changes in the blood of patients with and without postoperative surgical site infections.

## 2. Materials and Methods

The study was approved by the ethical committee of Medipol University noninvasive clinical research (Reference number: 108400098-604.01.01-E.47627 Date:2018/10/30). Institution permission was obtained before the study started. Informed consent form was taken from all participants. All the procedures were performed in accordance with rules regarding studies involving human participants by taking into account the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Nine hundred pregnant women presented to the obstetrics outpatient clinics of a Private Nisa Hospital between November 2018 and April 2019. Of them, 420

presented to have an elective cesarean delivery. 249 consecutive primipar pregnant women in accordance with the inclusion criteria were included in the study.

The inclusion criteria were being between the ages of 20-40, having a singleton pregnancy, first pregnancy and having given birth with elective cesarean surgery. The exclusion criteria were history of chorioamnionitis and early membrane rupture, start of labor pains, presence of preoperative infection, elevated pre-operative WBC and CRP values, diseases with an immune deficiency syndrome predisposing to infection, deep infections, Infectious conditions, such as endometritis, urinary tract infections, endometritis other than SSI.

All the patients were administered adequate general and spinal anesthesia and then they were catheterized with Foley's catheter under aseptic conditions. After catheterization, all the vaginal walls and fornices of the participants in patients were cleaned with sterile square gauze impregnated with three units of povidone iodine solution respectively. The cleaning agents were applied to 360 degrees of the vaginal walls and fornices by the surgical doctor for 30 sec. Skin cleansing of all the patients was performed with an abdominal scrub. All patients were given 2 g of cefazolin sodium for prophylaxis after removal of the placenta. All patients had the same standard preoperative preparation and were operated by the same surgical team. Postoperative routine care was applied to all patients.

All patients were examined in terms of maternal age, weight, height, socio-demographic characteristics, operation duration time, length of hospital stay, postoperative 24th hour fever, surgical site pain VAS score, preoperative hemoglobin and WBC count. Blood samples were taken from all participants at the 6th, 12th and 24th hours to evaluate PCT, CRP and WBC levels. The patients were monitored for infection in the postoperative period using clinical. Blood, urine, and sputum cultures were taken from clinically suspected patients. An occlusive dressing placed on the surgical site postoperatively was removed on the 2<sup>nd</sup>, 4<sup>th</sup> and 7<sup>th</sup> days to inspect the wound in all patients.

Surgical site infection is defined as erythema or wound edge separation with purulent discharge containing cesarean incision site. Clinical findings were evaluated together with inflammatory laboratory findings, culture taken from the wound. Empirical antibiotic therapy (second generation cephalosporin) was started when SSI was suspected. According to the Centers for Disease Control and Prevention (CDC), patients who developed SSI were hospitalized.

Serum PCT levels were measured with an immunoluminometric PCT kit (Germany) and recorded in ng / ml. Serum CRP levels were measured using a C501 module (Switzerland) and recorded in mg / dL. Visual Analog Scale (VAS): It was developed by Bond and Pilowsky in 1966 for the first time [20]. VAS is a 10 cm scale, defined as "painless" on one end and "worst pain" on the other. VAS assessment is defined as no pain: 0 cm, Slight pain: 0.5 cm-3.0 cm, Moderate pain: 3.5 cm - 6.5 cm and Severe pain: 7.0 cm - 10.0 cm

The primary outcome of the study was determine whether PCT levels measured at after cesarean were superior to other infection markers such as CRP and WBC in the early detection of postoperative surgical site infections

### 2.1. Statistical Analysis

The data were analyzed using the IBM SPSS V23. Whether the data were normally distributed was tested with Kolmogorov Smirnov and Shapiro Wilk tests. For the comparison of the non-normally distributed data for surgical site infections, Mann Whitney U test was used. All the categorical data were compared with the chi-square test. ROC analysis was used to determine whether PCT and CRP values are good predictors of wound formation. P-values of < 0.05 were considered statistically significant. The results of the multivariate analysis were calculated as odds ratio and 95 % confidence interval. Receiver operating characteristic (ROC) curves and there spective areas under the curve

(AUC) were calculated to evaluate the predictive value of each marker and to determine the cutoff level for SSI prediction of each marker.

### 3. Results and Discussion

The study sample included 260 patients. Of them, 11 were identified to have infections other than surgical site infections in the postoperative period and were excluded from the study. Of them, 5 had urinary tract infections, 4 had lower respiratory tract infections and 2 had upper respiratory tract infections. Of the participants, 15 (6%) developed surgical site infections, 10 (4%) developed superficial surgical site infections and were successfully treated with oral and intravenous antibiotics. Five (2%) of the participants had deep wound infection, and 2 of them received long-term intravenous antibiotic therapy following tissue debridement.

**Table 1.** Relationship between the participants' demographic characteristics and development of surgical site infection

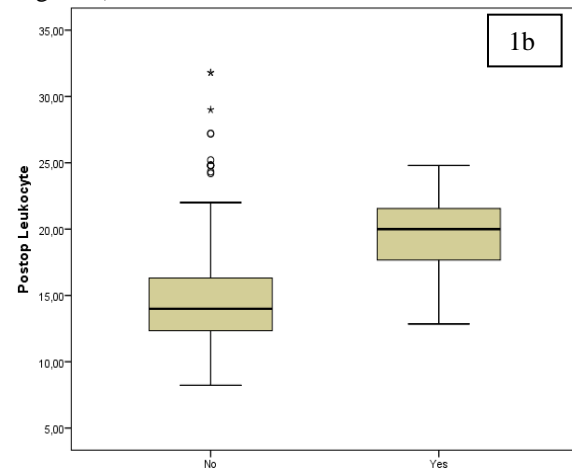
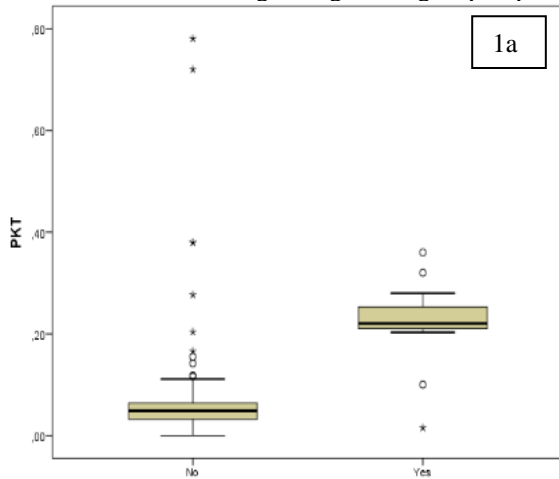
	Surgical site infection *			p
	Yes	No	Total	
	(n=15) n %	(n=234) n %	(n=249) n %	
<b>Marital status</b>				
Married	15 (6)	234 (94)	249 (100)	---
<b>Length of marriage</b>				
1-5 years	8 (7)	106 (93)	114 (45.8)	0.736
6-10 years	7 (5.4)	123 (94.6)	130 (52.2)	
≥11 years	0 (0)	5 (100)	5 (2)	
<b>Educational attainment</b>				
Illiterate	0 (0)	4 (100)	4 (1.6)	0.859
Primary school graduate	6 (7.7)	72 (92.3)	78 (31.3)	
High school graduate	7 (5.4)	123 (94.6)	130 (52.2)	
University graduate	2 (5.4)	35 (94.6)	37 (14.9)	
<b>Income-generating jobs</b>				
Yes	5 (5.2)	92 (94.8)	97 (39)	0.645
No	10 (6.6)	142 (93.4)	152 (61)	
<b>Income status</b>				
Income less than expenses	2 (5.4)	35 (94.6)	37 (14.9)	0.775
Income equal to expenses	13 (6.3)	192 (93.7)	205 (82.3)	
Income more than expenses	0 (0)	7 (100)	7 (2.8)	
<b>Social security</b>				
Yes	15 (6.1)	231 (93.9)	246 (98.8)	0.659
No	0 (0)	3 (100)	3 (1.2)	
<b>Family type</b>				
Nuclear	15 (6.4)	219 (93.6)	234 (94)	0.312
Extended	0 (0)	15 (100)	15 (6)	

χ<sup>2</sup>: Pearson Chi-square test

Investigation of the relationship between the participants demographic characteristics and development of surgical site infection revealed there were no statistically significant relationship between development of surgical site infections and demographic characteristics such as the length of marriage, educational status, working at an income-generating jobs, having social security, and family type (Table 1).

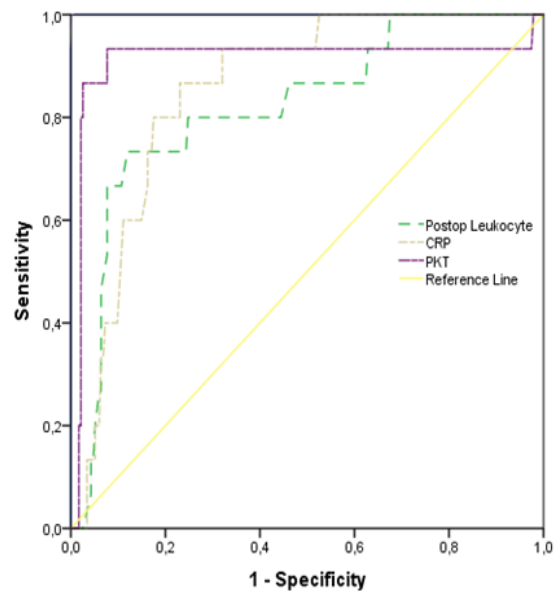
There was no statistically significant correlation between the median values for age, height, weight, preoperative

hemoglobin level (Hb), preoperative leukocyte level (WBC) postoperative hemoglobin level (Hb) and the presence of surgical site infections. However, the median values for the postoperative pain of surgical site VAS scores, fever, length of hospital stay, duration of surgery, ( $p < 0.001$ ) the postoperative 6th hour WBC, CRP and PCT levels and the postoperative 12th and 24th hour CRP and PCT levels differed statistically significantly in terms of the presence of a surgical site infection (Table 2, Figure 1)



**Figure 1a,1b.** Baseline postoperative PCT, CRP concentrations, postoperative WBC count in the study groups

To calculate the cutoff points for each parameter in predicting SSI, the area under the curve (AUC) and Youden's index were used. According to the comparison of the postoperative 6th hour PCT, CRP and WBC values revealed that when the cutoff point for PCT was 0.099ng/mL, the area under the curve (AUC) was calculated as 0.912. At this stability, the sensitivity was 93.3%, specificity was 92.3% and accuracy was 92.4%. When the cutoff point was 16.95mg/dL for the postoperative 6th hour CRP, the area under the curve (AUC) was calculated as 0.854. At this stability, the sensitivity was 80%, specificity was 82.5% and accuracy was 82.3% (Table 3 and Figure 2). When the cutoff point was  $18.8 \times 10^9/L$  for the postoperative 6th hour WBC count, the area under the curve (AUC) was calculated as 0.819. At this stability, the sensitivity was 73.33%, specificity was 88.03% and accuracy was 87.15% (Table 3 and Figure 2).



**Figure 2.** ROC analysis for PCT, CRP levels and Leukocyte (WBC) count at the postoperative 6<sup>th</sup> hour

**Table 2.** Comparison of parameters in terms of the presence of surgical site infection

	Presence of Surgical Site Infections*			P
	Yes (n=15) Median (min-max)	No (n=234) Median (min-max)	Total (n=249) Median (min-max)	
Age (year)	30 (21 - 34)	29 (21 - 40)	29 (21 - 40)	0.534
Height (cm)	160 (150 - 170)	160 (150 - 174)	160 (150 - 174)	0.455
Weight (kg)	65 (50 - 80)	68 (48 - 109)	68 (48 - 109)	0.243
Postoperative 24 <sup>th</sup> fever °C	37.2 (36.2 - 38)	36.3 (35.5 - 37.8)	36.4 (35.5 - 38)	<b>&lt;0.001</b>
Postoperative 24 <sup>th</sup> surgical site pain VAS score	7 (6 - 9)	4 (2 - 7)	4 (2 - 9)	<b>&lt;0.001</b>
Length of hospital stay (hour)	50 (32 - 60)	35 (30 - 48)	36 (30 - 60)	<b>&lt;0.001</b>
Duration of surgery (minute)	30 (25 - 45)	30 (23 - 40)	30 (23 - 45)	<b>&lt;0.001</b>
Preoperative Hb g/dL	12.3 (10.2 - 14.7)	12.3 (8.4 - 14.5)	12.3 (8.4 - 14.7)	0.646
Preoperative WBC(x 10 <sup>9</sup> /L)	11.7 (9 - 20)	10.7 (4 - 18)	10.7 (4 - 20)	<b>0.034</b>
Postoperative 6 <sup>th</sup> hour Hb g/dL	11.4 (8.9 - 12.7)	11.2 (7.4 - 14.3)	11.2 (7.4 - 14.3)	0.439
Postoperative 6 <sup>th</sup> hour WBC(x 10 <sup>9</sup> /L)	20 (12.9 - 24.8)	14 (8.2 - 31.8)	14 (8.2 - 31.8)	<b>&lt;0.001</b>
Postoperative 6 <sup>th</sup> hour CRP mg/dL	25 (7.9 - 49)	8.3 (0.9 - 85.6)	9.3 (0.9 - 85.6)	<b>&lt;0.001</b>
Postoperative 6 <sup>th</sup> hour PCT ng/mL	0.2 (0 - 0.4)	0 (0 - 0.8)	0.1 (0 - 0.8)	<b>&lt;0.001</b>
Postoperative 12 <sup>th</sup> hour CRP mg/dL	50 (21 - 110)	23.3 (3.5 - 106)	24.5 (3.5 - 110)	<b>&lt;0.001</b>
Postoperative 12 <sup>th</sup> hour PCT ng/mL	0.28 (0.12 - 0.4)	0.07 (0.01 - 20.8)	0.07 (0.01 - 20.8)	<b>&lt;0.001</b>
Postoperative 24 <sup>th</sup> hour CRP mg/dL	88 (50 - 130)	59.1 (3.5 - 185)	60.7 (3.5 - 185)	<b>&lt;0.001</b>
Postoperative 24 <sup>th</sup> hour PCT ng/mL	0.32 (0.12 - 0.45)	0.07 (0.02 - 4.66)	0.08 (0.02 - 4.66)	<b>&lt;0.001</b>

U: Mann Whitney U test , median (min-max)CRP:C-reactive protein, Hb: hemoglobin, PCT:Procalcitonin, WBC:white blood cell, VAS: visual analogue score

**Table 3.** Results of ROC analysis for postoperative PCT, CRP and WBC levels at the postoperative 6<sup>th</sup> hour

	PCT	CRP	WBC
Cutoff point	0.099 ng/mL	16.95 mg/Dl	18.8 x 10 <sup>9</sup> /L
AUC (%95CI)	0.912 (0.79 - 1)	0.854 (0.782 - 0.926)	0.819 (0.708-0.931)
Sensitivity	93.33 (68.04-99.83)	80 (51.91-95.67)	73.33 (44.90-92.21)
Specificity	92.31 (88.12-95.38)	82.48 (76.99-87.12)	88.03 (83.17-91.90)
Positive Predictive Value	43.75 (32.84-55.30)	22.64 (16.73-29.89)	28.21 (19.83-38.42)
Negative Predictive Value	99.54 (97.02-99.93)	98.47 (95.89-99.44)	98.10 (95.69-99.17)
Accuracy	92.37 (88.34-95.34)	82.33 (77.01-86.86)	87.15 (82.34-91.04)

AUC: Area under curve, CRP:C-reactive protein, PCT:Procalcitonin, WBC:white blood cell,

*Efficacy of PCT and CRP values measured at the postoperative 6<sup>th</sup>, 12<sup>th</sup> and 24<sup>th</sup> hours in predicting SSI:*

When the cutoff point was 18.8 ng/mL for the postoperative 6<sup>th</sup> hour PCT, the area under the curve (AUC) was calculated as 0.912. At this stability, the sensitivity was 93.3%, specificity was 92.3% and accuracy was 92.4%.

When the cutoff point was 0.1495 ng/mL for the postoperative 12<sup>th</sup> hour PCT, the area under the curve (AUC) was calculated as 0.964. At this stability, the sensitivity was 93.3%, specificity was 91.5% and accuracy was 91.6%.

When the cutoff point was 0.2025 ng/mL for the postoperative 24<sup>th</sup> hour PCT, the area under the curve

(AUC) was calculated as 0.971. At this stability, the sensitivity was 93.3%, specificity was 97% and accuracy was 96.8% (Table 4, Figure 3)

When the cutoff point was 16.95 for the postoperative 6<sup>th</sup> hour CRP, the area under the curve (AUC) was calculated as 0.854. At this stability, the sensitivity was 80%, specificity was 82.5% and accuracy was 82.3%

When the cutoff point was 34.95 mg/dL for the postoperative 12<sup>th</sup> hour CRP, the area under the curve (AUC) was calculated as 0.866. At this stability, the sensitivity was 86.7%, specificity was 81.2% and accuracy was 81.5%.

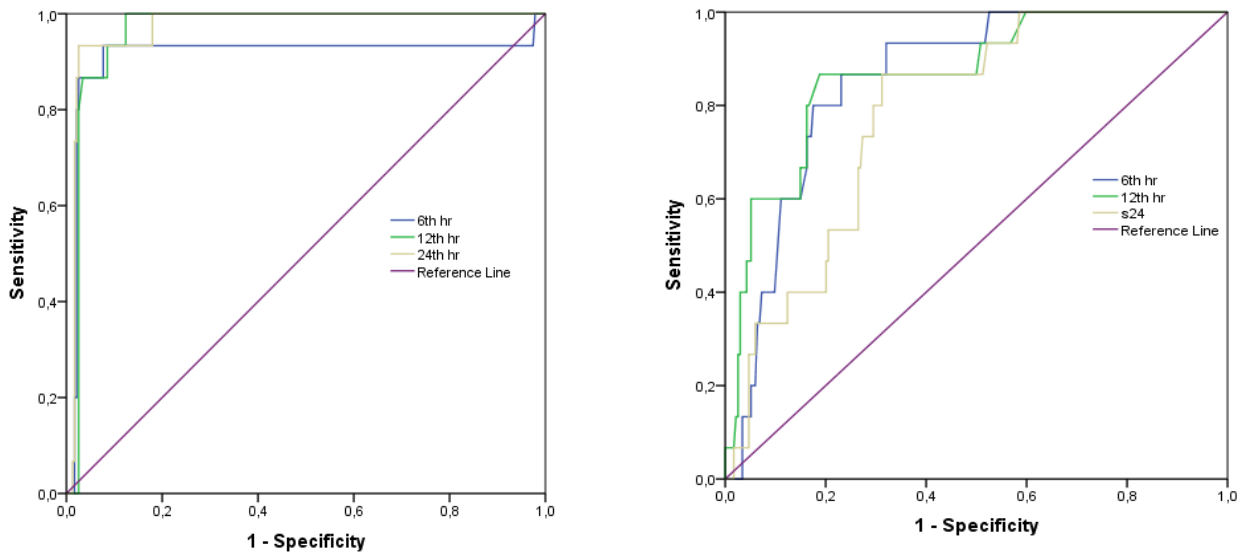
**Table 4.** Results of ROC analysis for PCT levels at the postoperative 6<sup>th</sup>, 12<sup>th</sup> and 24<sup>th</sup>hours

	6 <sup>th</sup> hour PCT	12 <sup>th</sup> hour PCT	24 <sup>th</sup> hour PCT
Cutoff point ng/mL	0.099	0.1495	0.2025
AUC (%95CI)	0.912 (0.790-1.000)	0.964 (0.938-0.989)	0.971 (0.945-0.998)
Sensitivity	0.933 (0.681-0.998)	0.933 (0.681-0.998)	0.933 (0.681-0.998)
Specificity	0.923 (0.881-0.954)	0.915 (0.871-0.947)	0.970 (0.939-0.988)
PPV	0.438 (0.328-0.553)	0.412 (0.311-0.521)	0.667 (0.488-0.808)
NPV	0.995 (0.970-0.999)	0.995 (0.967-0.993)	0.996 (0.972-0.999)
Accuracy	0.924 (0.883-0.953)	0.916 (0.874-0.947)	0.968 (0.938-0.986)

AUC: Area under curve, PCT:Procalcitonin, NPV: negative predictive value PPV:positive predictive value

When the cutoff point was 79.65 mg/dL for the postoperative 24<sup>th</sup> hour CRP, the area under the curve (AUC) was calculated as 0.783. At this stability, the

sensitivity was 73.3%, specificity was 72.7% and accuracy was 72.7 % (Table 5, Figure 3).



**Figure 3.** Receiver operating characteristic (ROC) curve of PCT and CRP for the prediction of SSI

**Table 5.** ROC analysis results for CRP levels at the postoperative 6<sup>th</sup>, 12<sup>th</sup> and 24<sup>th</sup> hours

	6 <sup>th</sup> hour CRP	12 <sup>th</sup> hour CRP	24 <sup>th</sup> hour CRP
Cutoff point mg/dL	16.95	34.95	79.65
AUC (%95CI)	0.854 (0.782-0.926)	0.866 (0.775-0.956)	0.783 (0.692-0.874)
Sensitivity	0.800 (0.519-0.957)	0.867 (0.595-0.983)	0.733 (0.449-0.922)
Specificity	0.825 (0.770-0.871)	0.812 (0.756-0.860)	0.727 (0.665-0.783)
PPV	0.226 (0.167-0.298)	0.228 (0.175-0.292)	0.147 (0.106-0.199)
NPV	0.985 (0.959-0.994)	0.989 (0.963-0.997)	0.977 (0.948-0.990)
Accuracy	0.823 (0.770-0.869)	0.815 (0.761-0.862)	0.727 (0.667-0.781)

AUC: Area under curve, CRP:C-reactive protein, NPV: negative predictive value PPV:positive predictive value

### 3.1. Discussion

Of the participants, 15 (6%) developed SSI, 10 (4%) developed SSIs. 5 (2%) of the participants had deep wound infection, and 2 of them received long-term intravenous antibiotic therapy following tissue debridement. The median values for the postoperative pain VAS scores, fever, length of hospital stay, duration of surgery, the postoperative 6th hour WBC count, CRP, and PCT levels and the postoperative 12th and 24th hour CRP and PCT levels were statistically significantly higher in the participants with a surgical site infection ( $p < 0.001$ ). In their retrospective study conducted with patients having undergone posterior lumbar surgery in 3 centers between 2006 and 2016, Wang t et al. determined that Postoperative WBC count, CRP, PCT levels, duration of the surgery, blood loss and operation level, instrumentation surgery and incision length were statistically significantly higher in the patients who had surgical site infections [21].

In their study conducted with 98 intensive care patients with intracerebral hemorrhage, Kara et al. determined that the median (interquartile range) PCT levels were 4 ng/ml (0.9-11) and 0.1 ng/ml (0.1-0.4) in patients who had infectious fever and central fever respectively, and there was a statistically significant difference between the groups ( $p < 0.001$ ). The areas under the curve (ROC) for predicting infectious or central fever PCT and CRP were calculated as 0.958 ng/mL ( $p < 0.001$ ) and 0.816 mg/dL ( $p < 0.001$ ) respectively. There was a positive correlation between PCT and CRP levels in patients with infectious fever ( $\rho = 0.461$ ;  $p = 0.003$ ), but this was not significant in patients with central fever [22]. High WBC count, a nonspecific inflammatory marker, is one of the SIRS criteria [23]. Although the WBC count and CRP level are more commonly used in screening of surgical site infection after cesarean section, PCT is a more sensitive and specific marker [18]. In the present study, according to the comparison of the postoperative 6th hour PCT, CRP and WBC values revealed that when

the cutoff point for PCT was 0.099 ng/mL, the area under the curve (AUC) was calculated as 0.912. At this stability, the sensitivity was 93.3%, specificity was 92.3% and accuracy was 92.4%. When the cutoff point was 16.95 mg/dL for the CRP, the area under the curve (AUC) was calculated as 0.854. At this stability, the sensitivity was 80%, specificity was 82.5% and accuracy was 82.3%. When the cutoff point was 18.8 x 10<sup>9</sup>/L for the WBC, the area under the curve (AUC) was calculated as 0.819. At this stability, the sensitivity was 73.33%, specificity was 88.03% and accuracy was 87.15%.

In the literature, a large number of publications in different surgical branches investigated the importance of PCT in detecting postsurgical site infections and emphasized its superiority over other infection markers. In their study conducted in 2018, Al-Jabiet al. found that PCT was a more sensitive and specific marker than CRP, WBC or ESR (Erythrocyte Sedimentation Rate) in predicting surgical site infections after spinal surgery [24]. In their study, the sensitivity and specificity values were 100% and 95.2% for PCT, 100% and 91.7% for CRP, 35.8% and 100% for WBC, and 100% and 52.4% for ESR respectively. In the present study, when the cutoff point was 0.1495 ng/ml for PCT at the postoperative 12th hour, the sensitivity was 93.3% whereas the specificity was 91.5%. When the cutoff point was 34.95mg/dl for the postoperative 12th hour CRP, the sensitivity and specificity were 86.7% and 81.2% respectively.

In a study conducted by Takakura et al. in 2013 with 114 patients, on the postoperative 1st and 3rd days, serum PCT levels and on the postoperative 3rd day serum CRP levels were statistically significantly higher in patients having undergone colorectal surgery. At the postoperative 24th hour, cut off point for PCT was 0.77 ng/mL and the sensitivity was 83.3% and the specificity was 63.5% [25]. In the present study, when the cutoff point was 0.2025 ng/ml for PCT at the postoperative 24th hour, the sensitivity and specificity were 93.3% and 97% respectively. When the cutoff point was 79.65 mg/dL for the postoperative 24th hour CRP, the sensitivity and specificity were 73.3% and 72.7% respectively.

In the literature, the number of studies conducted on the role of postoperative procalcitonin level after cesarean section for the early detection of SSI is very limited, and these studies included small-size samples. In their study, Aslan Çetin et al. compared PCT and CRP levels in patients with post-cesarean surgical site infections, and consistent with the present study, they found that the PCT level was statistically significantly higher in patients with surgical site infections requiring secondary suture (0.21 vs. 0.05 ng/ml,  $p < 0.001$ ). There was positive correlation between the serum PCT levels and the length of hospitalization ( $p < 0.001$ ). For the prediction of secondary suture need for PCT (AUC: 0.85) (95% CI: 0.772-0.922) and the cut-off point was 0.142 ng / ml with 75% precision and 97.8% specificity ( $p < 0.001$ ) [19].

If we compare the infection markers from an economic aspect, the cost of WBC, CRP and PCT tests in our hospital was \$ 2, \$ 8 and \$ 20 respectively. The present

study indicated that PCT was superior to the other evaluated inflammatory markers in terms of sensitivity and specificity. Although procalcitonin is a more expensive marker, it contributes to the early diagnosis and treatment, reduces the length of hospital stay of the mother and her baby and thus can effectively reduce health care costs.

Increasing evidence suggests that PCT is an important marker in the diagnosis of postoperative infections and complications; therefore, further studies should be performed to compare the predictive value of PCT and other inflammatory parameters in the diagnosis of SSI.

The strength of our study is that in the literature, studies conducted on the role of PCT in the early detection of surgical site infections after cesarean section are very few. The limitation of our study is that we included primiparous women who underwent first cesarean section, our specific group may limit generalization.

#### 4. Conclusion

In conclusion, in the present study, serum PCT levels measured at the postoperative 6th, 12th and 24th hours were determined to be a more sensitive and specific marker in the early diagnosis of SSI after cesarean section than were the other conventional infection markers such as CRP and WBC. Therefore, we recommend that after cesarean section, serum PCT levels should be routinely measured. We also recommend that to confirm and generalize our findings, future studies to be conducted on the issue should include larger samples.

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The authors have no conflicts of interest to declare.

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