

Can serum C-Reactive Protein and Procalcitonin levels associate with Carpal Tunnel Syndrome?

Yaşar Altun^{1*}, Ali Zeynal Abidin Tak¹,

Abstract

Objective: The purpose of this study was to examine whether an increase occurs in serum C-reactive protein (CRP) and procalcitonin (PCT) levels in patients with carpal tunnel syndrome (CTS).

Material and Methods: Thirty-six patients who have CTS due to electrophysiological tests and 40 healthy individuals were included the study. Boston Questionnaire (BQ) was used to assess the functional and clinical status of the patients. Also, CRP and PCT levels were investigated. Correlations between such parameters (electrophysiological findings, BQ results, and clinical findings) were evaluated.

Results: CTS and control subjects had similar CRP levels, whereas there was significant elevation in PCT among CTS patients. Serum PCT activity did not correlate with subunits of BQ ($p > 0.05$).

Conclusion: The results of this small study showed significant PCT increases in patients with CTS. Further studies in this regard may help to clarify the diagnostic and or follow-up value of PCT in patients with CTS.

Keywords: Carpal tunnel syndrome, Procalcitonin, C-reactive protein.

Introduction

Carpal tunnel syndrome (CTS) represents the most common type of mononeuropathy and is caused by entrapment of the median nerve at the level of the carpal tunnel. Majority of the cases are idiopathic which occurs more frequently in females and between the ages of 40 and 60 years; 50-60% of the cases are bilateral (1). Idiopathic CTS has been correlated with hypertrophy of the synovial membrane of the flexor tendons caused by degeneration of the connective tissue, accompanied by vascular sclerosis, edema and collagen fragmentation (2). Microtrauma within the canal, narrowing or deformation of the canal volume, or any pathological process resulting in an increase in the content of the canal leads to the development of a variety of symptoms and signs (3). Systemic causes may also facilitate localized nerve compression either through increasing the anatomical deformation at the trap site or through accumulation of pathological material that can reduce the volume of the canal. The typical symptoms include pain and paresthesia occurring mostly in the night time at the area innervated by the median nerve (4). Several previous studies have examined the association between CTS and fasting blood glucose, thyroid function tests, complete blood count, uric acid, or growth hormone levels (5).

The pathophysiologic mechanisms involved in median nerve compression and traction; however, are thought to be complex and as yet are not fully understood. In contrast with studies suggesting very low level of inflammation (6), others reported that it may actually represent a chronic inflammatory condition (7). Therefore, inflammatory factors were thought to play a role in the etiopathogenesis of CTS.

C-reactive protein (CRP) is a marker for active systemic inflammation and oxidative stress. Procalcitonin (PCT) is a newer diagnostic parameter that is dissimilar to the existing inflammatory response markers and is secreted by the liver and thyroid glands. Under normal conditions almost all PCT is broken down, precluding entry into the blood circulation and PCT level is below 0.1 ng/mL in healthy adults (8,9). Since PCT secretion is closely linked with inflammatory mediator concentrations and as suggested before acute phase reactants are released not only during acute events, but also in chronic processes (10), we assumed that PCT may have a possible diagnostic and or follow-up role in CTS.



Due to a potential increase in CRP and PCT resulting from inflammation in CTS, the association between these two parameters and CTS was examined. In this regard, to our knowledge our study represents the first of its kind that examines PCT levels in CTS patients that may serve as an indicator for the inflammation in CTS. Also, it was hypothesized that higher levels of CRP and PCT may be positively associated with the presence and progression of CTS among younger patients.

Material and Methods

The study was conducted in accordance with the Helsinki declaration of human rights, and the study protocol was approved by the Ethics Committee of our Faculty of Medicine. All patients and controls provided written informed consent to participate in the study. A total of 36 patients (72 hands; 36 right/36 left) between 20 and 60 years of age who were referred to our electrophysiology unit with a pre-diagnosis of CTS and who were subsequently diagnosed as having CTS according to American Academy of Neurology criteria (11) were included in this study. Clinical findings, nerve conduction tests were recorded and compared with controls. Electrophysiological studies are considered the most reliable method for the diagnosis of CTS. Wrist ultrasound was performed to include patients with idiopathic CTS. Patients with radiculopathy, mononeuropathy or plexopathy affecting median nerve on the basis of neurological and electrophysiological examination and patients suffering from systemic diseases such as diabetes, hypothyroidism and connective tissue diseases or degenerative joint disorders were excluded from the study. Also infection signs were excluded from the study. Tinel's sign and Phalen's test were noted as positive or negative. Functional and clinical statuses of patients were evaluated by Boston Questionnaire (BQ) (12). The BQ is an assessment tool for symptom severity and functional status in CTS (12-14). This questionnaire consists of two parts, namely the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). In SSS, there are 11 questions; responses may be scored between one (mildest) point and five (most severe) points. The overall result is calculated as the mean of all 11 scores. FSS poses 8 questions assessing the difficulty in performing selected activities. The overall score for functional status is calculated as the mean of all eight (15). Thus, a higher SSS or FSS indicates worse symptoms or dysfunction. Also, serum levels of CRP and PCT were measured in the study population.

A control group consisted of voluntary individuals who were referred to EMG laboratory and who had normal electromyography results. There were 40 healthy individuals (80 hands, 40 right/40 left) under 60 years of age in the control group who had no known risk factors for neuropathy and no neurological abnormality. Age and body mass index (BMI) of the healthy controls were also recorded in addition to CRP and PCT measurements and BQ assessments.

Electrophysiological investigations

A Medelec Synergy (Oxford Instruments Medical, Inc, UK) EMG device was used for all electrophysiological studies. Motor nerve conduction velocity (MNCV) of the median nerve from elbow to wrist and distal motor latency (DML) at a distance of 7 cm were measured with pad recording electrodes on the motor point of the abductor pollicis brevis muscle. Surface recording electrodes and stimulating ring electrodes were used to assess sensory conduction. Sensory nerve conduction velocity (SNCV) of the median nerve was measured from second finger to the wrist (M2). Fourth finger sensory median-ulnar peak latency difference (M4-U4) was registered. The amplitude of sensory nerve action potentials (SNAP) was measured peak to peak and the amplitude of compound muscle action potentials (CMAP) was calculated from the origin of the potentials to the negative peak. Skin temperature of the arm was kept constant above 30°C with an infrared lamp (11).

Surface bar recording and bipolar surface recording electrodes were used in the nerve conduction study (NCS). Standard methods were utilized for median and ulnar sensory NCS. F-wave latencies of the both upper extremities were measured to predict whether the lesion is at proximal or distal part of peripheral nerve. Minimum F-response latency was obtained using 20 stimulations. Delayed responses were obtained with minimum F-response latencies from the median nerve bilaterally. Filter settings were 5 Hz–10 kHz for motor studies and 20 Hz–2 kHz for sensory studies. A sweep speed of 2 ms/division and sensitivity of 20 mV/division were used for the distal sensory nerves. The stimulus was 0.1 ms in pulse duration.

The diagnosis of CTS was based the presence of at least one following: abnormal SNCV in the finger-wrist segment or prolonged DML. The severity of CTS was graded as follows: mild CTS (SNCV slowing [<50 m/s]); moderate CTS (SNCV slowing [<50 m/s] and delayed DML [>4.5 ms]); and severe CTS (no SNAP) (16).

Biochemical Assessments

Blood samples were obtained from the antecubital veins of patients and control subjects during the study. The serum samples from the patients were stored at -40°C until CRP and PCT measurements were conducted. CRP levels were measured by rate nephelometry (IMAGE, Backman, USA) method. Serum PCT levels were measured using an automatic immunoturbidimetric assay (Hitachi High-Technologies Corporation, Tokyo, Japan) with a Roche Cobas C501 automatic photometric analyzer (Roche Diagnostics Co, Ltd., Mannheim, Germany). (CRP reference level 0-5 mg/L and PCT reference level 0-0.046 ng/mL)

Statistical Analysis

Statistical analysis was performed with SPSS software (IBM Corporation, SPSS Statistics Version 18). To evaluate the assumption of normality of the data, Kolmogorov–Smirnov test was used. The data were presented as frequency (percent), mean \pm SD, median, and range. Independent Student's t-test and one-way ANOVA were used to compare two and three samples with normal

distribution, respectively. For data without normal distribution, Mann-Whitney U-test was used. The Chi-square test was used for the comparison of the nominal data. Correlation between the measurements was evaluated using Spearman's correlation analysis. A p-value less than 0.05 was considered statistically significant.

Results

The number of consecutive patients who were included in the study with bilateral idiopathic CTS was 36, (26 female, 10 male, aged 44.5±10.5 years). Also there were 40 control subjects (30 females, 10 males aged 39.8±8.9 years) with no evident neurological and neurophysiological abnormalities. CTS patients and controls were comparable with respect to age, gender, and BMI (all $p>0.05$). The clinical and demographic characteristics of CTS and control subjects are shown in Table 1, while Table 2 summarizes electrophysiological findings in these two groups. Electrophysiologically, 38.9% of patients had mild, 40.3% had moderate, and 20.8% had severe CTS.

Patients reported no difficulty in completing the BQ questionnaire and regarded BQ. CTS patients had significantly higher BQ scores than controls (Table 1).

CTS and control subjects had similar CRP levels ($p>0.05$), and there was significant elevation in PCT among CTS patients ($p:0.031$). The severity of CTS did not show significant correlations with CRP, PCT, FSS and BMI (all $p>0.05$) except SSS ($p:0.003$).

Also CTS levels were not significantly correlated with CRP, PCT, FSS and SSS with CTS (mild CTS - Middle CTS, Mild CTS - Severe CTS and Middle CTS - Severe CTS) (all $p>0.05$) (Table 3).

Also among the patients CRP and PCT did not correlate with SSS, FSS, bilateral median DML, DSL, and M4-U4 ($p>0.05$ and $p>0.05$, respectively) (Table 4). FSS scores showed a significant correlation with SSS scores, indicating that patients who had severe symptoms had major functional limitations.

Table 1. The clinical and demographical findings of subjects with CTS and controls

	Patient (n: 36)	Control (n: 40)	<i>p</i>
Age (years)	44.5±10.5	42.5±9.8	0,401
Sex (female/male)	26/10	30/10	0,787
CRP (mg/L)	0.554±0.57	0.403±0.29	0,146
PCT (ng/mL)	0.025±0.014	0.020±0.005	0,031*
SSS	36±7.43	11±0.0	<0.001*
FSS	22.94±6.42	8±0.0	<0.001*
BMI (kg/m ²)	31.81±5.69	29.75±5.69	0,119

* $p\leq 0.05$; Independent Samples Test; CTS: Carpal tunnel syndrome; CRP: C- Reactive protein; PCT: Procalcitonin; SSS: Symptom severity scale; FSS: Functional status scale; BMI: Body mass index.

Table 2. The electrophysiological results of subjects with CTS and controls

	Patient (n: 36)	Control (n: 40)	<i>p</i>
DML (ms) right	4.73±0.89	2.99±0.43	<0.001
DML (ms) left	4.81±0.86	2.86±0.40	<0.001
MNCV (m/s) right	54.86±4.53	59.49±4.38	<0.001
MNCV (m/s) left	55.21±4.55	57.71±4.49	0,019
CMAP (mV) right	8.11±2.89	10.36±3.7	0,002
CMAP (mV) left	7.43±2.64	11.99±5.72	<0.001
DSL (ms) right	3.74±0.63	2.45±0.31	<0.001
DSL (ms) left	3.61±0.72	2.47±0.33	<0.001
SNCV (m/s) right	36.13±6.09	55.64±5.86	<0.001
SNCV (m/s) left	36.73±6.01	54.51±4.45	<0.001
SNAP (µV) right	15.66±7.81	36.88±13.64	<0.001
SNAP (µV) left	16.39±8.68	33.13±14.47	<0.001
M4-U4 (ms) right	1.38±0.94	0.24±0.28	<0.001
M4-U4 (ms) left	1.30±0.97	0.24±0.19	<0.001

* $p\leq 0.05$; Independent Samples Test; CTS: Carpal tunnel syndrome; DML: Distal motor latency; MNCV: Motor nerve conduction velocity; CMAP: Compound muscle action potentials; DSL: Distal sensory latency; SNCV: Sensory conduction velocity; SNAP: The amplitude of sensory nerve action potentials; M4-U4 (ms): The antidromic sensory median-ulnar latency difference to digit IV

Table 3. Relationship between CRP, PCT concentrations, SSS and FSS in subjects with CTS group.

	Mild CTS (n:28)	Middle CTS (n:29)	Severe CTS (n:15)	p
CRP	0.46±0.55	0.57±0.64	0.68±0.45	0,459
PCT	0.03±0.02	0.02±0.01	0.02±0.00	0,264
SSS	35.00±7.37	34.07±6.52	41.60±6.51	0.003*
FSS	22.29±7.37	22.38±4.54	25.27±7.27	0,288

*p<0.05; Oneway Anova; CTS: Carpal tunnel syndrome; CRP: C- Reactive protein; PCT: Procalcitonin; SSS: Symptom severity scale; FSS: Functional status scale.

Table 4. Correlations between CRP and PCT concentrations with SSS, FSS, right/left DML, DSL, M4-U4 in subjects with CTS

	SSS	FSS	DML	DSL	M4-U4
CRP					
r:	+0.139	+0.089	0,046	0,119	0,07
p:	0,245	0,455	0,704	0,32	0,557
PCT					
r:	-0,149	-0,121	-0,141	-0,183	-0,061
p:	0,31	0,311	0,237	0,125	0,175

r: Pearson correlations coefficient; CTS: Carpal tunnel syndrome; CRP: C- Reactive protein; PCT: Procalcitonin; SSS: Symptom severity scale; FSS: Functional status scale; DML (ms): Distal motor latency; DSL (ms): Distal sensory latency; M4-U4 (ms): The antidromic sensory median-ulnar latency difference to digit IV

Discussion

Carpal tunnel syndrome represents an important clinical condition and to our knowledge no previous studies examined the association of CTS with inflammatory markers CRP and PCT. Carpal tunnel syndrome is a multifactorial disease where increased intra-carpal canal pressure plays a key role in its development (17). Although factors associated with increased carpal tunnel pressure have not been completely elucidated, clinical experience suggests that compression and/or inflammation represent potential mechanisms associated with elevated pressure. As mentioned above acute phase reactants are released not only during acute events, but also in chronic processes (10). Recently it has been suggested that CTS could represent an inflammatory condition, although data supporting this is scarce (7). Although studies about this issue have emphasized that CTS is an inflammatory condition; the possible mechanism has not been addressed yet (7,10,18). In patients with CTS, the caliber of the median nerve has been found to be decreased at the site of the compression, and proximal to the trap-site, edema was found. It has been proposed that these alterations could be related to fibrosis resulting from axoplasm accumulation, edema, or chronic inflammatory changes (18).

Reported uses of PCT include the early diagnosis of bacterial infection in patients with heart failure (19), reduction of antibiotic use through facilitating the diagnosis of bacterial lower respiratory tract infections (20), and diagnosis and follow-up of the clinical course of septic shock (21); also, it has been reported to be a better marker than CRP in the early diagnosis of septic complications in patients with multiple-trauma (22).

More recently Liu et al. (2015) reported that serum levels of PCT and high sensitivity CRP are associated with long-term mortality in acute ischemic stroke (23). This finding may support the notion that PCT contributes to the inflammatory process. Although the physiological role of PCT remains obscure long after its consideration as an inflammatory marker, it has proven a useful tool in clinical practice. Despite intensive research, a number of uncertainties still exist concerning the metabolism of this “inflammatory” PCT and its physiological role. In a recent study, PCT has been proposed to act as a non-steroidal analgesic in inflammation (24). CRP has anti-inflammatory and pro-inflammatory effects (25), similar to the effect of PCT. PCT synthesis occurs via the cytokines such as tumor necrosis factor alpha (TNF- α), interleukin-6 (IL-6) and interleukin-1 (IL-1) produced by immune cells in response to bacterial infections or endotoxins released after bacterial degradation during infection (26-28). Also increased interferon gamma production during viral infections suppresses PCT production (28). In a study by Ozgenel et al. (2010) an increased co-occurrence of CTS with intensive physical stress on hands, hypertension, diabetes mellitus, obesity, and trigger finger, although they failed to investigate an association with bacterial infections (29). On the other hand, Oh et al. (2013) showed through two-dimensional electrophoresis patterns of serum obtained from six CTS patients and six normal controls that 10 proteins were significantly altered in the serum of CTS patients, among which four were upregulated and six were downregulated (30).

The authors concluded that the information obtained from their proteomic analysis will be very useful in understanding the pathophysiology of CTS and in finding suitable proteins that can serve as new diagnostic biomarkers of CTS. Similar to study of Oh, Takasu et al. (1994) in their study with CTS patients undergoing chronic hemodialysis, a significant increase in IL-1, TNF- α and beta levels was found in CTS patients than in controls (31). Also IL-6 levels were significantly increased as compared to controls. Curatola et al. (1990) demonstrated that some inflammatory markers (alfa1-antitrypsin, alfa2-macroglobulin, CRP) are higher in 9 hemodialysis patients with CTS than 9 hemodialysis patients without CTS (32). Freeland et al. (2002) examined the tenosynovial homogenates removed after CTS surgery and did not find a significantly higher IL-1; on the other hand, IL-6 was significantly higher than in controls (33). In our study there was significant elevation in PCT among CTS patients. Significant increase in PCT levels in CTS patients as compared to controls in our study is probably associated with the increase in IL-1 and TNF- α , which causes PCT production. The significant increase in PCT may be explained by increased IL-6, which induces PCT production (7,10,30). This finding supports the hypothesis that PCT plays important role on chronic inflammation in CTS. In a retrospective study by Tutoglu et al. (2014) involving geriatric CTS patients over 65 years of age, although CTS patients had significantly higher CRP ($p=0.023$), the CRP values in the overall population of patient and control subjects were below the normal range (0-0.5 mg/dl). Higher CRP levels in geriatric CTS patients might have been due to several factors including diabetes, hypertension, or obesity that could increase CRP and that were not considered in that study (34). In our study CRP values showed not significant increases in patients with CTS when compared with controls.

Furthermore, the severity of CTS did not show significant correlations with CRP, PCT, FSS and BMI except SSS. Additionally, CTS levels were not significantly correlated with CRP, PCT, FSS and SSS with CTS (mild CTS - Middle CTS, Mild CTS - Severe CTS and Middle CTS - Severe CTS) (all $p>0.05$). Also among the patients CRP and PCT did not correlate with SSS, FSS, bilateral median DML, DSL, and M4-U4. FSS scores showed a significant correlation with SSS scores. In the light of these data, we believe that PCT measurements in CTS patients may provide significant diagnostic yield. Particularly points out to the fact that PCT may be a valuable bio-marker in CTS diagnosis.

Several limitations of the present study should be mentioned. The number of patients in the study group was relatively small. However, this was a preliminary study on inflammation in CTS utilizing serum PCT levels as a potential marker. A cross-sectional design may also not be the best way to clarify the relationship of PCT with the occurrence and severity of CTS, potentially leading to false positive as well as negative results. More comprehensive further clinical studies are warranted to clarify the pathophysiological role of increased serum PCT levels in CTS.

Conclusion

This small study revealed that increased PCT levels may be important for evaluating CTS patients. We think that PCT levels may be useful for diagnosis and or follow-up of these patients. Further studies in this regard may help to clarify the diagnostic and or follow-up value of PCT in patients with CTS.

Acknowledgement: We thank the patients who participated in the study.

Conflict of Interest: The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author's Contributions: YA, AZAT: Research concept and design; data collecting, analysis and interpretation of data. **YA, AZAT:** Preparation of article, and Revisions. All authors approved the final version of the manuscript.

Ethical issues: All Authors declare, Originality and ethical approval of research. Responsibilities of research, responsibilities against local ethics commission are under the Authors responsibilities.

References

1. Michelsen H, Posner MA. Medical history of carpal tunnel syndrome. *Hand Clin.* 2002; 18: 257 - 268.
2. Schuind F, Ventura M, Pasteels JL. Idiopathic carpal tunnel syndrome: histologic study of flexor tendon synovium. *J Hand Surg Am.* 1990; 15: 497 - 503.
3. Rosenbaum R. Carpal Tunnel Syndrome. In: Johnson RT, Griffin WJ: *Current therapy in neurologic disease.* 5th ed USA: Mosby-Year book Inc.; 1997. pp.374 - 377.
4. Aygül R, Deniz O, Ulvi H. Association of different electrophysiological parameters with age in Carpal Tunnel Syndrome. *MJAU* 2004; 36: 77 - 82.
5. van Dijk MA, Reitsma JB, Fischer JC, Sanders GT. Indications for requesting laboratory tests for concurrent diseases in patients with carpal tunnel syndrome: a systematic review. *Clin Chem* 2003; 49: 1437 - 1444.
6. Hirata H, Nagakura T, Tsujii M, et al. The relationship of VEGF and PGE2 expression to extracellular matrix remodelling of the tenosynovium in the carpal tunnel syndrome. *J Pathol.* 2004; 204: 605 - 612.
7. Joshi P, Lele V. Lighting the tunnel: FDG PET/CT findings leading to incidental diagnosis of carpal tunnel syndrome. *Clin Nucl Med* 2014; 39: 78 - 79.
8. Oczenski W, Fitzgerald RD, Schwarz S. Procalcitonin: a new parameter for the diagnosis of bacterial infection in the perioperative period. *Eur J Anaesthesiol* 1998; 15: 202 - 209.
9. Carrol ED, Thomson AP, Hart CA. Procalcitonin as a marker of sepsis. *Int J Antimicrob Agents* 2002; 20: 1 - 9.
10. Saez-Lorens X, Lagrutta F. The acute phase reaction during bacterial infection and its clinical impact in children. *Pediatr Infect Dis J.* 1993; 12: 83 - 87.
11. American Academy of Neurology Practice parameter for carpal tunnel syndrome (summary statement): report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 1993; 43: 2406 - 2409.

12. Kurt S, Çevik B, Kaplan Y, et al. The relationship between Boston Questionnaire and electrophysiological findings in Carpal Tunnel Syndrome. *Archives of Neuropsychiatry* 2010; 47: 237 - 240.
13. Cevik MU, Altun Y, Uzar E, et al. Diagnostic value of F-wave inversion in patients with early carpal tunnel syndrome *Neurosci Lett.* 2012; 508: 110 - 113.
14. Yildirim A, Bulut HT, Ekmekci B, et al. Use of diffusion tensor imaging for nonsurgical treatments of carpal tunnel syndrome. *Muscle Nerve.* 2014 Dec; 50(6): 950 - 955.
15. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Surg (Am)* 1993; 75: 1585 - 1592.
16. Stevens JC. AAEM minimonograph #26: the electrodiagnosis of carpal tunnel syndrome. *American Association of Electrodiagnostic Medicine. Muscle Nerve* 1997; 20: 1477 - 1486.
17. Bland JD. Carpal tunnel syndrome. *Curr Opin Neurol* 2005; 18: 581 - 585.
18. Werner RA, Andary M. Carpal tunnel syndrome: pathophysiology and clinical neurophysiology. *Clin Neurophysiol* 2002; 113: 1373 - 1381.
19. Sandek A, Springer J, Habedank D, et al. Procalcitonin-guided antibiotic treatment in heart failure. *Lancet* 2004; 363(9420): 1555; author reply 1555 - 1556.
20. Christ-Crain M, Jaccard-Stolz D, Bingisser R, et al. Effect of procalcitonin guided treatment on antibiotic use and outcome in lower respiratory tract infections: cluster-randomised, single-blinded intervention trial. *Lancet.* 2004; 363(9409): 600 - 607.
21. Schröder J, Staubach KH, Zabel P, et al. Procalcitonin as a marker of severity in septic shock. *Langenbecks Arch Surg.* 1999; 384: 33 - 38.
22. Balci C, Sivaci R, Akbulut G, Karabekir HS. Procalcitonin levels as an early marker in patients with multiple trauma under intensive care. *J Int Med Res.* 2009; 37: 1709 - 1717.
23. Li YM, Liu XY. Serum levels of procalcitonin and high sensitivity C-reactive protein are associated with long-term mortality in acute ischemic stroke. *J Neurol Sci.* 2015; 352: 68 - 73.
24. Maruna P, Nedelniklova K, Gürlich R. Physiology and genetics of procalcitonin *Physiol Res.* 2000; 49 Supply 1: S57 - 61.
25. Vanderschueren S, Deeren D, Knockaert DC, et al. Extremely elevated C-reactive protein. *Eur J Intern Med* 2006; 17: 430 - 433.
26. Nijsten MW, Olinga P, The TH, et al. Procalcitonin behaves as a fast responding acute phase protein *in vivo* and *in vitro*. *Crit Care Med* 2000; 28: 458 - 461.
27. Dandona P, Nix D, Wilson MF, et al. Procalcitonin increase after endotoxin injection in normal subjects. *J Clin Endocrinol Metab* 1994; 79: 1605 - 1608.
28. Schuetz P, Albrich W, Mueller B. Procalcitonin for diagnosis of infection and guide to antibiotic decisions: past, present and future. *BMC Medicine* 2011; 9:107.
29. Ozgenel GY, Bayraktar A, Ozbek S, et al. Carpal Tunnel Syndrome: Retrospective Analysis of 92 Cases. *Uludağ Medical Journal* 2010; 36: 95 - 98.
30. Oh YM, Ma TZ, Kwak YG, Eun JP. Proteomic evaluation to identify biomarkers for carpal tunnel syndrome: a comparative serum analysis. *Connect Tissue Res* 2013; 54: 76 - 81.
31. Takasu S, Takatsu S, Kunitomo Y. Serum hyaluronic acid and interleukin-6 as possible markers of carpal tunnel syndrome in chronic hemodialysis patients. *Artificial organs* 1994; 18: 420 - 424.
32. Curatola G, Malara E, Sisca S, et al. Biological markers of inflammation and carpal tunnel syndrome in dialysis patients. *Nephron.* 1990; 56: 453 - 454.
33. Freeland AE, Tucci MA, Barbieri RA, et al. Biochemical evaluation of serum and flexor tenosynovium in carpal tunnel syndrome. *Microsurgery* 2002; 22: 378- 385.
34. Tutoglu A, Boyacı A, Kocatürk Ö, et al. The relationship of carpal tunnel syndrome and mean platelet volume in geriatric patients. *Gaziantep Med J.* 2014; 20: 182 - 185.