Migraine is a risk factor for stroke, especially in women who have migraine with aura. The underlying mechanism of coexistence between migraine and cerebrovascular disease is unknown. After a series of experiments, Moskowitz and Cutrer have found results suggesting that migraine pain is a type of sterile inflammation. In migraine models today, presence of neurogenic inflammation is shown and triptans which are effective therapeutic drugs are used to block neurogenic inflammation. During migraine attacks, there might be sterile inflammation in cerebral and extra-cerebral vessels. It is thought that neural activation due to inflammation in particular brain tissues and the release of proinflammatory neuropeptides from perivascular neuron endings are the cause of migraine attacks. In the vascular system, it has been described that inflammatory process plays an important role in ischemic stroke pathogenesis. Recurring episodes of perivascular inflammation during migraine attacks can increase the risk of stroke.

In migraine patients, there are studies showing elevated levels of C-Reactive Protein (CRP) which is an indicator of inflammation. C-Reactive Protein is a marker for active systemic inflammation, oxidative stress and risk of stroke.

From the Department of Infectious Diseases and Clinical Microbiology Department (HT), Neurology Department (BH), Emergency Department (MU), Baskent University Faculty of Medicine, Selçuklu, Konya; Department of Infectious Diseases and Clinical Microbiology (HA), Bahçeşehir, Ankara, Turkey.


Correspondence to: Hale Turan, Baskent University Faculty of Medicine, Department of Infectious Diseases and Clinical Microbiology Department, Hocacihan mahallesi. Saray caddesi No:1, Selçuklu 42080, Konya, Turkey.
Identified in recent years, Procalcitonin (PCT) is a highly sensitive and specific marker that is used in early diagnosis of bacterial infections and follow-up treatments. It was reported that PCT can increase independent of infectious situations such as burns, trauma, surgical attempts and cardiogenic shock. Procalcitonin may be a possible prognostic factor in acute stroke.

Our study will be the first report in the literature that determines PCT levels of migraine patients. Our goal in this study is to determine PCT levels, which are also an indicator of inflammation in migraine patients with and without aura, especially during attack periods.

**Materials and Methods**

Eighty adult patients with migraine who were admitted to the neurology or emergency outpatient clinics in our university hospital between November 2008 and April 2009 participated in our study. Of these patients, 34 were in the migraine attack period, and 46 were in the period in-between attacks. Patients underwent neurological examinations by a neurology specialist; anamnesis and physical examinations findings were recorded.

Migraine with or without aura diagnosis was determined based on The International Headache Society classification. Patients who were under 18 and over 45 years-of-age, with body mass index less than 18 or over 30; had cardiovascular disease, hypertension, history of hypercholesterolemia, smoking, using oral contraceptive medication, and those who were pregnant or lactating were not included in the study. Patients diagnosed with migraine for less than one year and more than six years, cases receiving prophylactic treatment or those who had headaches for more than 15 days each month were excluded from the study. Patients were allowed to use drugs specific or non-specific for migraine.

All patients were informed before participating in the study and all of them signed voluntary consent forms. Blood samples were taken from patients during the in-between attack period at least 72 hours after the last attack. Samples were drawn within 12 hours from patients that were in the attack period. The serum samples from the patients were stored at -40 °C until PCT test was conducted.

Procalcitonin measurement was made using B.R.A.H.M.S sensitive Procalcitonin Kryptor kit in the Kryptor immunoassay.

### Table 1: Characteristics of study participants

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (n:34)</th>
<th>Group 2 (n:46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), years</td>
<td>38.5±7.6</td>
<td>33.8±7.0</td>
</tr>
<tr>
<td>Gender (female/male)</td>
<td>25/9</td>
<td>37/9</td>
</tr>
<tr>
<td>Body Mass Index, mean (SD), kg/m²</td>
<td>22.7±2.8</td>
<td>21.9±3.0</td>
</tr>
<tr>
<td>Blood pressure, mean (SD), mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>119 (7)</td>
<td>117 (5)</td>
</tr>
<tr>
<td>Diastolic</td>
<td>62 (3)</td>
<td>66 (3)</td>
</tr>
<tr>
<td>Cholesterol, mean (SD), mg/dL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>158±16</td>
<td>161±17</td>
</tr>
<tr>
<td>High-density lipoprotein</td>
<td>51±6</td>
<td>49±8</td>
</tr>
<tr>
<td>Low-density lipoprotein</td>
<td>76±15</td>
<td>86±19</td>
</tr>
<tr>
<td>Triglycerides, mean (SD), mg/dL</td>
<td>99±22</td>
<td>101±27</td>
</tr>
</tbody>
</table>

**Table 2: Procalcitonin levels in groups and subgroups**

<table>
<thead>
<tr>
<th>Procalcitonin ng/mL</th>
<th>Group 1 (Patients during attack period)</th>
<th>Group 2 (Patients during interictal period)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n: 34</td>
<td>n: 46</td>
</tr>
<tr>
<td></td>
<td>0.0485±0.035*</td>
<td>0.0298±0.014*</td>
</tr>
<tr>
<td></td>
<td>Group 1a†</td>
<td>Group 1b</td>
</tr>
<tr>
<td></td>
<td>n:27</td>
<td>n:7</td>
</tr>
<tr>
<td></td>
<td>0.0493±0.03</td>
<td>0.0457±0.02</td>
</tr>
<tr>
<td></td>
<td>Group 2a†</td>
<td>Group 2b</td>
</tr>
<tr>
<td></td>
<td>n:40</td>
<td>n:6</td>
</tr>
<tr>
<td></td>
<td>0.0285±0.01</td>
<td>0.0383±0.01</td>
</tr>
</tbody>
</table>

*Group 1 compared to Group 2: p<0.01; † Group 1a compared to Group 2a: p<0.01; Group 1a and 2a: Patients without aura
machine which uses immunofluorescence TRACE (Time Resolved Amplified Cryptate Emission) technology. (Brahms-Diagnostica, Henningsdorf, Germany).

Data were analyzed using the Statistical Package for the Social Sciences, version 13.0 (SPSS, Chicago, Illionis, USA). Student’s t-test, one way analysis of variance test and linear regression analysis were used for statistical analyses. Values p<0.01 was taken as the criterion of statistical significance.

RESULTS

None of the patients had signs of active infection. As the anti-migraine treatment, 50 of the patients (62.5%) received analgesic treatment, 10 (12.5%) received triptan therapy and 20 (23%) did not receive any treatment.

The patients were divided into two groups. Those who had migraines during attack period (34 patients) were assigned to Group 1, and those who had migraines during the period in-between attacks (interictal) (46 patients) were in Group 2. Clinical characteristics of the study participants are shown in Table 1.

The average PCT level of patients during the attack period (0.0485±0.035) was found to be higher than the average PCT levels of patients during the period in-between attacks (0.0298±0.04). The high levels were found to be statistically significant (p<0.01) (Table 2).

Patient grouping was made based on the aura status; the groups were further divided into two sub-groups:

- Group 1a. Migraine without aura, attack period, n=27 (average age=37.6±8; 22 females, 5 males).
- Group 1b. Migraine with aura, attack period, n=7 (average age=41.7±4; 3 females, 4 males).
- Group 2a. Migraine without aura, interictal period, n= 40 (average age=33.3±7; 33 females, 7 males).
- Group 2b. Migraine with aura, interictal period, n= 6 (average age=37.5±3, 4 females, 2 males).

Average PCT levels from the subgroups of migraine patients are shown in Table 2. When migraine subgroup distinction was made, serum PCT levels of patients during attack period were significantly higher than those of migraine patients without aura during interictal period (p<0.01). There were no significant difference in serum PCT levels between other groups (p>0.01). (Figure)

DISCUSSION

As a result of a series of experiments, Moskowitz and colleagues have obtained results that suggested migraine pain is a type of sterile inflammation3. Waeber and colleagues have stressed that ions, free radicals, complement system, kinines and cytokines are important in the inflammatory process6. C-
Reactive Protein is a marker for active systemic inflammation, oxidative stress and stroke risk. There are studies showing elevated levels of CRP in patients with migraine. In the first one of these studies, CRP levels in-between attack period was studied, in the second one CRP levels of migraine patients during attack period was studied. In our study, we evaluated PCT values from cases in both periods.

Serum PCT levels may be very high in patients with inhalational injury, burn injury, mechanical trauma, extensive surgery or heatstroke. Although bacterial infection may be absent in these conditions, the PCT levels attained may not differ very much from many of the levels seen in sepsis.

In case of infection, many indicators develop in the body in response to the infection. Among these, CRP is quite a sensitive indicator of inflammation. However, it cannot distinguish between bacterial and non-bacterial infections since CRP levels also increase significantly due to surgery, trauma, malignancies, autoimmune diseases, and chronic inflammatory diseases. C-Reactive Protein elevation is a predefined marker for risk of stroke in patients with atherosclerotic cerebrovascular disease. In addition, increased serum CRP levels are associated with the presence and progression of white matter lesions in patients with cerebral small-vessel disease. Reasonably established in patients as the basis for migraine aura, spreading cortical depression in experimental models causes oxidative stress, leukocyte activation, and inflammatory dilation of extra-parenchymal vessels mediated by trigeminal peptide release. Migraine without aura may have the same inflammatory basis. C-Reactive Protein is associated with oxidative stress and inflammatory mechanisms in blood vessels, and in itself may contribute to atherogenesis and a procoagulant state. In previous studies, CRP levels in migraine without aura patients were determined to be significantly higher than normal levels. In both studies, high CRP levels in migraine without aura patients could not be explained. In a recent study, Godmundsdsson and colleagues have reported that women with migraineurs without aura had higher CRP values than normal women. Intrinsic brain activity triggers trigeminal meningeal afferents in a migraine model. In the attack period, we found significantly high levels of PCT in patients with migraine without aura during attack periods. This finding supports studies showing elevated CRP values in patients with migraine without aura.

Serum CRP is an established inflammatory risk marker for ischaemic stroke and coronary heart disease. There are also studies related to the role of PCT in coronary artery disease and acute stroke. Some authors report increased levels of PCT in acute coronary syndrome patients. As a result of their study with 30 stroke patients, Miyakis and colleagues have reported that serum PCT cannot be a candidate marker for prognosis of stroke.

Calcitonin gene-related peptide (CGRP)-containing nerves are closely associated with cranial blood vessels. Calcitonin gene-related peptide is the potent vasodilator known in isolated cerebral blood vessels. Calcitonin gene-related peptide can induce migraine attacks, and two selective CGRP receptor antagonists are effective in the treatment of migraine attacks. Intravenous administration of CGRP causes headache and migraine in migraineurs, suggesting that the increase in CGRP observed during spontaneous migraine attacks may play a causative role. Procalcitonin is the precursor of the hormone calcitonin. Production is governed by the Calc-1 gene, located on chromosome 11. Calc-1 codes for preprocalcitonin which undergoes proteolytic cleavage of its signal sequence to produce PCT. Alternative splicing of the mRNA from Calc-1 leads to the generation of CGRP, a powerful vasodilator mainly found in the central nervous system. Similar to PCT, CGRP synthesis is also increased in sepsis, although to lower concentration.

In our study, we found significantly high levels of PCT in patients with migraine during the attack period. As a result, we can state that there might be an increase in PCT levels in addition to CGRP increase, in migraine patients similar to sepsis patients.

**Conclusions**

Based on our results, we can state that PCT is a more distinguishing marker for migraine attacks. These high PCT levels are parallel to Moskowitz and Cutrer's findings which suggest that migraine pain is a type of sterile inflammation. Our results support that inflammation plays a role in acute migraine attacks. Although no prognostic effect was shown in patients with stroke, further studies are necessary to find an answer to the question of whether PCT is a marker for risk of stroke in migraine patients.

**References**