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Predictive Value of Leucocytosis in Head Trauma

Lökositozun Kafa Travmasındaki Prediktif Rolü

Doğa GÜRKANLAR[1]
Hatice LAKADAMYALI[2]
Tarkan ERGUN[3]
Cem YILMAZ[4]
Engin YÜCEL[5]
Nur ALTINÖRS[6]

[1,4,5,6] Başkent Üniversity, Neurosurgery Department, Ankara, Turkey
[2,3] Başkent Üniversity, Radiology Department, Ankara, Turkey

ABSTRACT

AIM: Head trauma is associated with an acute phase response which is characterized by leucocytosis due to increased levels of catecholamine and cortisol. Early edema formation following severe head injury may also be associated with microglia activation. Therefore, increased white blood cell (WBC) count after head trauma may be a predictive parameter of the severity of craniocerebral trauma.

MATERIAL and METHODS: We retrospectively studied 59 patients with severe, moderate and minor injury between February 2007 and March 2009. WBC counts of all patients were obtained within the first day of their admission. All patients were divided into separate groups according to their Glasgow Coma Scale (GCS) scores and hospital stay durations. Their CT progressions and Glasgow Outcome Scale (GOS) scores were also assessed. The relationship between these parameters and WBC counts were evaluated by statistical methods.

RESULTS: There was a favorable correlation between WBC counts of the patients and GCS scores (pİ0.01), hospital stay (p=0.006), CT progression (p<0.01) and GOS scores (p<0.01).

CONCLUSION: A WBC count exceeding 17.5 x 106/l has a predictive value for poor GCS score, and long hospital stay. CT progression tends to be seen in patients with moderate and severe head injury.

KEY WORDS: Head trauma, Computerized brain tomography, Leucocytosis, White blood cell count

ÖZ

AMAÇ: Kafa travması, artmış katekolamin ve kortisol düzeylerine bağlı gelişen lökositoz ile karakterize akut faz yanıtı ile birliktedir. Kafa travmasını takiben gelişen erken ödem oluşumu mikroglia aktivasyonuyla da ilişkili olabilmektedir. Bu nedenle, kafa travması sonrasında artış gösteren beyaz küre (BK) sayısı, kronioserebral travmanın ağırlığını öngören bir parametre olabilir.

YÖNTEM ve GEREÇ: Şubat 2007 ile Mart 2009 yılları arasında hafif, orta veya ağır kafa travması geçiren 59 hastayı retrospektif olarak inceledik. Tüm hastaların BK sayıları travmalarının ilk gününde elde edildi. Tüm hastalar GCS skorlarına ve hastanede kalış sürelerine göre üçer ayrı gruba ayrıldı. CT progresyonları ve GOS skorları da ayrıca değerlendirildi. Bu parametreler ile BK sayıları arasındaki ilişki istatistik metotlar ile incelendi.

BULGULAR: Hastaların BK sayıları ile Glasgow Koma Skalası (GCS) skorları (Pİ0,01), hastanede kalış süreleri (P=0,006), CT progresyonu (P<0,01) ve Glasgow Sonuç Skalası (GSS) skorları (P<0,01) arasında istatistik olarak anlamlı ilişkiler bulundu.

SONUÇ: 17.5 x 106 / l değerini aşan BK değerleri kötü GKS skorunu ve uzamış hastanede kalış süresini öngörür. CT progresyonu daha çok orta ve ağır kafa travmalı hastalarda görülme eğilimindedir.

ANAHTAR SOZCÜKLER: Kafa travması, Bilgisayarlı beyin tomografi, Lökositoz, Beyaz küre sayımı

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Correspondence address:
Doğa GÜRKANLAR
E-mail : dgurkanlar2000@yahoo.co.uk

INTRODUCTION

Traumatic brain injury is associated with elevated serum levels of catecholamines (4,12,22). Catecholamines are responsible for the release of neutrophil stores while corticosteroids cause a decrease in the egress of neutrophils from the circulation (2,6). Brain swelling occurring after head trauma is probably an inflammatory response due to intracerebral cytokine production and increased leucocyte adhesion as a result of a direct effect on vascular permeability and leucocyte activation (7,8,9,15,18).

We realized that our patients with elevated levels of white blood cell (WBC) count showed computerized tomography (CT) progression, long hospital stays and low Glasgow Coma Scale (GCS) scores. In our paper we tried to find out whether there is a correlation between a high WBC count and GCS, GOS, hospital stay and CT progression.

PATIENTS and METHODS

We retrospectively studied the WBC counts of 59 patients (45 male and 14 female) with severe, moderate or minor craniocerebral injury, who were admitted to our emergency department between February 2007 and March 2009. The age range was 4 to 72 years and the mean age was 35.8.

Patients with brain death, penetrating injury, infection and possible diseases that may alter the WBC count (myocardial infarction, cerebrovascular accident, surgical procedures etc.) were excluded.

The WBC counts of the patients were obtained within the first day and the patients were divided into three separate groups according to their Glasgow Coma Scale (GCS) scores (25). There were 7 patients in Group I (severe) with GCS scores ranging from 3 to 8, 11 patients in Group II (moderate) with GCS scores ranging from 9 to 13 and 41 patients in Group III (minor) with GCS scores ranging from 14 to 15 (Table I).

The patients were also divided into three groups according to their hospital stay. There were 30 patients in Group I with a hospital stay of 1 day, 14 patients in Group II with a hospital stay of 2-4 days and 15 patients in Group III with a hospital stay of 5 days and more (Table II).

The patients were either taken to surgery (due to a hematoma (mass lesion) or cerebral edema) or to the intensive care unit according to their neurological examinations and radiological evaluation with CT and skull radiographs.

The cranial CT images of our patients were evaluated by two separate radiologists who lacked any information on the WBC levels of the patients. Cranial CT parameters, such as traumatic subarachnoid haemorrhage, intraventricular blood, compression of basal cisterns, midline shift, contusions and mass lesions were recorded. The lesions that appeared in the first cranial CT were accepted as primary lesions and follow up cranial CTs of the patients were performed on the first, third and fifth day of their admission. The presence of any additional CT parameter was accepted as CT progression.

The outcomes of all patients were assessed at least six months after the injury according to the Glasgow outcome scale (GOS) (14).

STATISTICAL METHODS

A completely randomized design (One-way Anova) was used to compare the groups with WBC counts, and the Tukey (post-hoc) test was used as a procedure for testing all pairwise comparisons.

RESULTS

WBC count versus GCS

GCS scores were highly correlated with WBC counts. The mean WBC count values were 23.74 x 10^6/l for Group I, 16.41 x 10^6/l for Group II and 11.26 x10^6/l for Group III. There were statistically significant differences between the mean WBC count values of Group I and Group II, Group I and III and Group II and Group III ($p<0.01$) (Table I).

WBC count versus hospital stay

There was also a statistically significant correlation between the time of hospital stay and WBC count ($p=0.006$). WBC levels of the patients in Group I were significantly different than patients in Group III (Table II).

WBC count versus GOS

The mean WBC count was 21.1 x 10^6/l when GOS was 1 and 12.28 x 10^6/l when GOS was 5. The GOS value therefore increased as the WBC count decreased (Table III). This relationship was statistically significant ($p<0.01$).

WBC count versus CT progression

The correlation between the CT progression and WBC count was also meaningful ($p<0.01$). The mean

value of WBC count was 18.23 x 106/l when there was CT progression (Table IV).

The cranial CT of 20 patients showed progression (Figure 1). Of the 20 patients with CT progression, 6 underwent surgical intervention. The mean WBC count of these six patients was 17.95 x 10^6/l.

Table I. Mean WBC counts of patients according to their GCS score groups.

GCS	N	Mean	SE Mean	St Dev
3-8	7	23.74	3.97	10.50
9-13	11	16.41	1.17	3.88
14-15	41	11.26	0.52	3.34

N: Number of patients, **SE Mean:** Standard error of the mean, **St Dev:** Standard deviation.

Table II. Mean WBC counts of patients according to their hospital stay.

Hospital stay (day)	N	Mean	SE Mean	St Dev
1	30	11.58	0.98	5.35
2-4	14	14.11	0.72	2.70
5 and more	15	17.54	2.19	8.47

N: Number of patients, **SE Mean:** Standard error of the mean, **St Dev:** Standard deviation.

Table III. Mean WBC counts of patients according to their GCS score groups.

GOS	N	Mean	SE Mean	St Dev
1	4	21.1	3.64	7.29
5	52	12.28	1.56	4.02

N: Number of patients, **SE Mean:** Standard error of the mean, **St Dev:** Standard deviation.

Table IV. Mean WBC counts of patients according to their CT progression.

CT progression	N	Mean	SE Mean	St Dev
1	30	11.58	0.98	5.35
2-4	14	14.11	0.72	2.70
5 and more	15	17.54	2.19	8.47

N: Number of patients, **SE Mean:** Standard error of the mean, **St Dev:** Standard deviation.

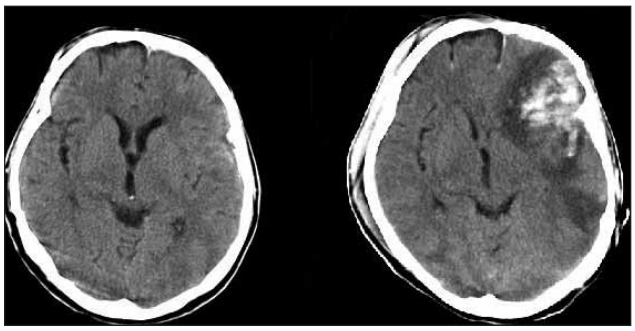

Figure 1: *Cranial CTs of a patient with a WBC count of 22.5 x 10^6/l showing CT progression.*

DISCUSSION

Although the mechanism is still controversial, many authors have demonstrated a correlation between head trauma and WBC count (5,17,21).

The role of catecholamines and corticosteroids has been reported in the literature (2,6), but the inflammatory events triggered by activated microglia and lymphocytes following head trauma are also of great importance (5).

Catecholamines increase the leucocyte count by release of the marginated cells into the circulating pool. Corticosteroids increase the neutrophil count by releasing the cells from the storage pool in the bone marrow into the blood and by preventing egress from the circulation into these tissues (2,6).

The blood brain barrier (BBB) opens at the time of the trauma and approaches closure at about 60 minutes post injury (1). After the trauma, the cell body of the microglia becomes hypertrophic with long, branched and crennellated processes during the first 60 minutes post injury. Microglia cells express class I and class II MHC antigens and these antigens could be presented to lymphocytes in the regional lymph nodes and trigger the activation of circulating lymphocytes in the central nervous system (3,16,20,21). These findings suggest microglia cells play a predominant role in the induction and maintenance of the immune response following head trauma (5).

Another mechanism by which leucocytes can be associated with cerebral damage is the traumatic rupture of microvessels followed by physical occlusion. The leucocytes are less deformable than the erythrocytes, and a greater pressure gradient is therefore required to force them through the capillaries with small diameter. Under conditions of

reduced perfusion pressure, the capillaries may behave like a sieve and trap the leucocytes to increase the WBC count. After the entrapment, the leucocytes form a common area of contact with the endothelium and may not be dislodged even after the perfusion pressure returns to normal (10,13,24,26). The mechanical occlusion of the capillaries may become more evident as a result of the release of a number of cytotoxic chemicals that leads to increased leucocyte-endothelial interactions (11).

In our study, blood WBC levels correlated with GCS and GOS in accordance with the literature (2,17). High WBC counts were associated with greater neurological severity (23,74 x 10^6/l) and long hospital stay (17.52x10^6/l), whereas patients with low WBC count had a favourable outcome.

Patients with a mean WBC value of 23.74 x 10^6/l were associated with poor clinical grade, whereas patients with a mean WBC value of 11.3 x 106/l were associated with good clinical grade.

We also demonstrated that high WBC counts (18.23x10^6/l) were associated with CT progression regardless of the primary lesion type contrary to other authors (2,17,19). CT progression was observed especially in GCS groups II and III. We also found out that six of our patients with CT progression underwent surgery. Their mean WBC count was 17.95x10^6/l, which could probably be a cut-off value.

CONCLUSION

A WBC count exceeding 17.5x10^6/l has a predictive value for poor GCS score and long hospital stay. CT progression tends to be seen in patients with moderate and severe head injury. A WBC count exceeding 17,95x10^6/l should alert the neurosurgeon to the possibility of surgical intervention while a mean WBC value of 23,74x10^6/l is associated with poor clinical grade.

REFERENCES

1. Bednar MM, Gross CE, Howard DB, Lynn M: Neutrophil activation in acute human central nervous system injury. Neurol Res 19:588-592, 1997
2. Boggs DR: The kinetics of neutrophilic leukocytes in health and in disease. Semins Hemat 4:359-386, 1967
3. Capps JA: A study of the blood in general paralysis. Am J Med Sci 3:650-682, 1896 (cited in 1)
4. Clifton GL, Ziegler MG, Grossman RG: Circulating catecholamines and sympathetic activity after head injury. Neurosurgery 8:10-14,1981
5. Czigner A, Mihaly A, Farkas O, Büki A, Krisztin-Peva B, Dobo E, Barzo P: Kinetics of the cellular immune response following closed head injury. Acta Neurochir (Wien) 149:281-289, 2007
6. Dale DC: Leukocytosis, leukopenia, and eosinophilia. In: Harrison's, ed. Principles of Internal Medicine. New York: McGraw-Hill, Inc., 1991:359-362
7. Dietrich WD, Chatzipanteli K, Vitarbo E, Wada K, Kinoshita K: The role of inflammatory processes in the pathophysiology and treatment of brain and spinal cord trauma. Acta Neurochir Suppl 89: 69-74, 2004
8. Fee D, Crumbaugh A, Jacques T, Herdrich B, Sewell D, Auerbach D, Piaskowski S, Hart MN, Sandor M, Fabry Z: Activated/effector CD4+ T cells exacerbate acute damage in the central nervous system following traumatic injury. J Neuroimmunol 136: 54-66, 2003
9. Gourin CG, Shackford SR.: Production of tumor necrosis factor-alpha and interleukin-l beta by human cerebral microvascular endothelium after percussive trauma. J Trauma 42:1101-1107,1997
10. Hallznbeck J, Dutka A, Tanishima T, Kochanek P, Kumaroo K, Thompson C, Obrenovitch T, Contrzras T: Polymorphonuclear leucocyte accumulation in brain regions with low blood flow during the early post-ischemic period. Stroke 17: 246-253, 1986
11. Harlan JM: Leucocyte endothelial interactions. Blood 65: 513-525,1985
12. Hortangl H, Hammerle AF, Hackl JM, Brucke T, Rumpl E, Hortangl H: The activity of the sympathetic nervous system following severe head injury. Intensive Care Med 6:169-177, 1980
13. Janoff A, Schaeffer S, Scherer J. Bean MA: Mediators in inflammation in leucocyte lysosomes. Mechanism of action of lysosomal cationic protein upon vascular permeability in the rat. J Exp Med 132: 841-851, 1965
14. Jennett B, Bond M: Assessment of outcome after severe brain damage. A practical scale. Lancet 1: 480-484, 1975
15. Juurlink BH: Introduction: The role of inflammation in mediating damage following stroke and neurotrauma. Brain Pathol 10: 93-94, 2000
16. Kakarieka A: Review on traumatic subarachnoid hemorrhage. Neurol Res 19:230-232, 1997
17. Keskil S, Baykaner MK, Ceviker N, Aykol Ş. Head Trauma and Leucocytosis. Acta Neurochir (Wien) 131:211-214, 1994
18. Lenzlinger PM, Hans VH, Joller-Jemelka HI, Trentz O, Morganti¬Kossmann MC, Kossmann T: Markers for cell-mediated immune response are elevated in cerebrospinal fluid and serum after severe traumatic brain injury in humans. J Neurotrauma 18: 479--489 30, 2001
19. Maas AIR, Hukkelhoven CWPM, Marshall LF, Steyerberg EW: Prediction of outcome in traumatic brain injury with computed tomographic characteristics: A comparison between the computed tomographic classification and combinations of computed tomographic predictors. Neurosurgery 57(6): 1173-1182, 2005
20. Neil-Dwyer G, Cruickshank J: The blood leukocyte count and its prognostic significance in subarachnoid hemorrhage. Brain 97:79-86, 1974
21. Rovlias A, Kotsou S: The Blood Leucocyte count and its prognostic significance in severe head injury. Surg Neurol 55:190-196, 2001
22. Rosner MJ, Newsome HH, Becker DP: Mechanical brain injury: The sympathoadrenal response. J Neurosurg 61:76-86, 1984

23. Sitri ZC, Homnick AT, Vaynman A, Lavery R, Liao W, Mohr A, Hauser CJ, Manniker A, Livington D: A prospective evaluation of the value of repeat cranial computed tomography in patiens with minimal head injury and an intracranial bled. J Trauma 61(4):862-867, 2006

24. Suval WD, Duran WN, Boric VIP, Hobson RV. Berendson PB. Ritter AB: Microvascular transport and endothelial cell alterations preceding skeletal muscle damage in ischernia and reperfusion injury. Am J Surg 154: 211-215, 1987

25. Teasdale G, Jennett B: Assessment of coma and impaired consciousness. A practical scale. Lancet 2:81-84, 1974

26. Yamakawa T, Yamaguchi S, Niimi H. Sugiyama I: WBC plugging and blood flow maldistribution, in the capillary network of cat cerebral cortex in acute hemorrhagic hypotension: An intra-vital microscopic study. Circ Shock 22: 323-332, 1987