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Original Article

Investigation of the predictive factors for mortality in patients undergoing decompressive craniectomy: A retrospective cross-sectional study

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Abstract

Aim: Malignant middle cerebral artery (MCA) infarctions and severe traumatic brain injuries (TBI) can cause increased intracranial pressure (ICP), herniation, and eventually lead to death. Decompressive craniectomy (DC) can be life-saving in these patients. The present study aims to investigate the predictive factors for mortality in patients undergoing DC due to malignant MCA infarction and severe TBI.

Material and Methods: Between January 2015 and January 2020, clinical and imaging findings, demographic characteristics and laboratory results of patients who underwent DC due to severe TBI and malignant MCA infarction were retrospectively analyzed and recorded for statistical analysis. In order to identify the most significant parameter in relation to mortality, a receiver operating characteristic (ROC) analysis was performed, and the area under the ROC curve was calculated.

Results: The study included 30 patients undergoing DC. Out of 12 patients with TBI and 18 with malignant MCA infarction, 6 (50%) and 15 (83.3%), respectively, died. There was no statistically significant difference between survivors and non-survivors in terms of age and gender (p = 0.625 and p = 0.626). Patients who did not survive had significantly lower Glasgow coma scale (GCS) scores than survivors (p = 0.001). Moreover, the degree of midline shift, C-reactive protein-to-albumin ratio (CAR) and red blood cell distribution width (RDW-SD) levels were significantly higher in non-survivors than in survivors (p = 0.017, p = 0.002, and p = 0.009, respectively). The AUC values were as follows: GCS = 0.876 (95% Confidence Interval (CI), 0.733-1), CAR = 0.844 (95% CI, 0.706-0.982), RDW-SD = 0.796 (95% CI, 0.637-0.955), and amount of shift 0.775 (95% CI, 0.602-0.948).

Conclusion: The present study found that patients with low GCS, an increased degree of midline shift, and high CAR and RDW-SD values benefit less from DC. It was considered that high CAR and RDW-SD could be a predictive marker for mortality.

Keywords: C-reactive protein-to-albumin ratio; decompressive craniectomy; glasgow coma scale; Intracranial pressure; malignant middle cerebral artery infarction; traumatic brain injury

INTRODUCTION

Decompressive craniectomy (DC) is the removal of a sufficiently large skull fragment to reduce malignant intracranial pressure (ICP) and prevent neurological impairment (1). The rationale underlying the DC is the Monro-Kellie doctrine, which states that any increase in intracranial volume must be balanced with a concomitant decrease in another intracranial component to lower the ICP (2). The goal of DC is to remove a sufficiently large bone flap (1). Due to the enlargement of the brain parenchyma, removal of a bone flap of at least 12 cm is recommended in order to avoid adverse consequences, such as damage to the vascular structures and brain parenchyma on the edge of the bone (3).

Decompressive hemicraniectomy and bifrontal craniectomy procedures are the most frequently used methods (1).

In neurology and neurosurgery intensive care units, the most common cause of death and disability is the malignant increase in intracranial pressure, resulting in impaired cerebral perfusion or herniation, the two leading causes of which are malignant middle cerebral artery (MCA) infarctions and severe traumatic brain injury (TBI) (4).

Secondary brain injury occurs as a result of increased ICP despite medical therapy, making the medical management of the condition impossible. Therefore, DC may be a life-saving option as the last resort in such patients.

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Review of the literature by the authors revealed that there are only a limited number of studies examining the laboratory parameters affecting survival in patients undergoing DC. Therefore, The objective of the current study is to investigate whether C-reactive protein-to-albumin ratio (CAR) and red blood cell distribution width (RDW) are predictors of mortality in patients with severe TBI and malignant MCA infarction undergoing DC.

MATERIALS and METHODS

Between January 2015 and January 2020, a retrospective study was conducted on patients who underwent DC at Aksaray University Training and Research Hospital. Patients who underwent DC due to severe TBI and malignant MCA infarction were included in the study. The clinical and imaging findings, demographic characteristics, and laboratory results of the patients were analyzed retrospectively and recorded for statistical analysis. Patients with tumoral pathologies and infections, chronic renal failure, chronic liver failure, patients with missing data, and patients for whom the relatives did not provide consent for surgery were excluded.

Medical history of each patient was obtained immediately from their respective relatives on presenting to the emergency department with a pre-diagnosed TBI or stroke. After the neurological examination of patients, those with a GCS score of ≤8 were intubated. In our study, the GCS scores of patients before intubation were recorded for study purposes. Computed tomography (CT) or magnetic resonance imaging (MRI) scans of the brain were acquired to visualize the brain parenchyma. Vascular imaging (CT angiography or MRI angiography of the brain) was performed to evaluate the patients for vascular pathologies. Peripheral venous blood samples were collected from the patients in the hematology laboratory of our hospital. An autoanalyzer (Sysmex XN-1000) was used to process blood samples. For our study, CAR was calculated by dividing the C-reactive protein level by the albumin level.

All patients who met the inclusion criteria were taken to the intensive care unit.

All patients diagnosed with severe TBI were treated according to the brain trauma foundation guidelines (5), and those diagnosed with malignant MCA infarction and symptomatic intracerebral hemorrhage (sICH) were treated as per the latest stroke guidelines (6).

This study was approved by the Aksaray University Ethics Committee (2020 / 13-84) and was conducted in accordance with the Declaration of Helsinki.

Surgical Technique

In our study, bifrontal craniectomy was performed in only two cases, and frontotemporoparietal hemicraniectomy was performed in all other cases.

In frontotemporoparietal hemicraniectomy, the ipsilateral shoulder of the patient was raised, and the patient was placed in supine position with the head facing the opposite side of the craniectomy. The incision was initiated 1 cm anterior to the the ipsilateral tragus in the zygomatic arch and then continued as an inverted question mark extending posterosuperiorly over the pinna towards the external occipital protrusion. It then turned cranially towards the apex and ended just next to the midline and parallel to it at the anterior hairline.

In bifrontal craniectomy, the head was raised 20-30 degrees in a neutral position. The incision was initiated anterior to the tragus on both sides, and joined behind the coronal suture. While lifting the bone flap, care was taken to avoid damage to the saggital sinus in the midline, which was not observed in any patient. After removing a sufficiently large bone flap, the dura was cut open in the form of an asterisk in all cases and left that way.

Statistical Analysis

Results of the analysis were presented as median (min-max). Because the sample sizes of the study were under 30, non- parametric Mann Whitney U test was used for the comparison of the parameters between the groups. The gender distribution of the groups was compared using chi-square test. To determine the parameter most significantly associated with mortality in patients with decompressive craniectomy, receiving operator characteristics curve (ROC) analysis was performed and the area under curve (AUC) values were provided. Statistical analysis was performed using SPSS software v23.0 (SPSS Inc., Chicago, IL). Statistical significance was considered as $p < 0.05$.

RESULTS

Thirty patients undergone decompressive craniectomy were eligible for the study. The group survivors consisted of 9 patients [6 males and 3 females, median age: 63 (15-84)], and the group non-survivors consisted of 21 patients [12 males and 9 females, median age: 61 (16-87)]. The groups were age ($p = 0.625$) and gender- matched ($p = 0.626$, $X2 = 0.23$).

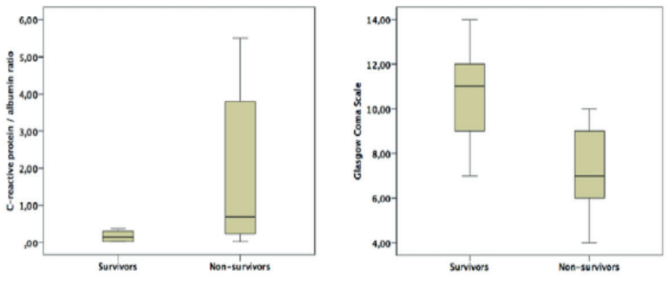

Figure 1. Box-line plots of Glasgow coma scale and C-reactive protein / albumin ratio

Table 1 presents the comparisons of the parameters between the groups. Mann Whitney U test revealed that the median Glasgow coma scale (GCS) was significantly lower ($p = 0.001$), and the median amount of shift, CAR and RDW-SD values were significantly higher in patients non-survivors, compared to the patients survivors ($p = 0.017$, $p = 0.002$ and $p = 0.009$, respectively) (Figure 1).

Table 1. Comparison of the parameters between the groups

	Survivors (n=9)	Non-survivors(n=21)	P Value
Age (year)	63 (15-84)	61 (16-87)	0.625
Duration till the operation (min)	120 (30-360)	240 (30-960)	0.244
Duration of the operation (min)	90 (60-80)	120 (40-245)	0.094
Glasgow Coma Scale	11 (7-14)	7 (4-10)	**0.001**
Amount of the shift (mm)	10 (0-13)	13 (5-15)	**0.017**
WBC (10^9/L)	11.37 (7.5-20)	13 (7-30)	0.625
NLR	3.9 (0.8-11.25)	7.6 (0.75-22)	0.164
CAR	0.15 (0.02-0.37)	0.7 (0.03-5.51)	**0.002**
Platelet (109/L)	275 (228-400)	235 (110-367)	0.086
RDW_CV (%)	13 (12-15)	13 (12-24)	0.178
RDW_SD (fL)	41 (33-43)	43 (37-66)	**0.009**
Urea (mg/dL)	38 (17-64)	39 (14-117)	0.326
Creatinine (mg/dL)	0.7 (0.5-1)	1 (0.3-4)	0.104
ALT (U/L)	15 (10-33)	23 (8-110)	0.137
AST (U/L)	30 (17-66)	37 (13-180)	0.086
Sodium (mmol/L)	139 (132-142)	138 (132-160)	0.722
Potassium (mmol/L)	3.9 (3.5-4.6)	4 (3.5-7)	0.178

WBC, white blood cell; NLR, neutrophil/lymphocyte ratio; CAR, C- reactive protein/albumin ratio; RDW, red blood cell distribution width; ALT, alanine aminotransferase; AST, aspartate aminotransferase

Figure 2 shows the ROC curve presenting the predictive value of the parameters for mortality. The areas under curve were as follows: Glasgow coma score = 0.876 (95% CI, 0.733-1), CAR = 0.844 (95% CI, 0.706-0.982), RDW-SD = 0.796 (95% CI, 0.637-0.955) and amount of shift = 0.775 (95 % CI, 0.602-0.948).

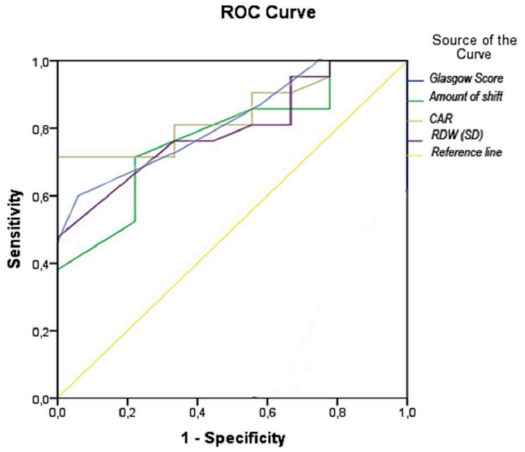

Figure 2. The ROC curve presenting the predictive value of the parameters for mortality

DISCUSSION

The important findings of this study are that GCS, the presence of midline shift, CAR and RDW-SD levels are predictive factors for mortality in patients with malignant MCA infarction and severe TBI who underwent decompressive craniectomy. To our knowledge, our study was the first of its kind to demonstrate that CAR and RDW-SD are prognostic markers for in-hospital mortality in DC.

It is known that the GCS score is associated with prognosis in patients undergoing DC (7). Similar to other studies in literature, the present study found that low GCS score is a predictive factor for mortality (8,9). In addition, all patients with a GCS score ≤6 died in our study. Therefore, the surgeon should be aware that patients with a GCS score ≤6 before undergoing DC have a very high risk of mortality and that the associated risks should be clearly explained to the patients' relatives.

Midline shift occurs due to increased ICP on the side of the cerebral pathology leading to the shift of that hemisphere toward the opposite side. (10). Literature shows that the amount of midline shift is a prognostic factor in patients undergoing DC (11).

Similar to other studies in literature, we found that the amount of shift is a prognostic marker for mortality in our study. In addition, among the patients included in this study, patients with a midline shift ≥15 mm did not survive. These findings suggest that it is important for the surgeon to evaluate the patient for DC quickly before the amount of shift increases.

Depending on the severity of the pathology, secondary events such as impaired perfusion and ischemia can develop in pathologies resulting from TBI (12) and malignant MCA infarction (13). An inflammatory response occurs following secondary tissue damage (14). With an increase in inflammatory mediators, a series of pathophysiological events occur, resulting in vascular endothelial damage, disruption of the blood-brain barrier, and development of brain edema (15). In recent years, it has been emphasized that CAR is a parameter reflecting systemic inflammation (16).

One study showed that CAR is an independent marker for in-hospital mortality in patients with spontaneous intracerebral hemorrhage (17) In this study, we found that high CAR is a poor prognostic marker for in-hospital mortality in patients undergoing DC due to malignant MCA infarction and severe TBI. Therefore, we believe that high CAR can be used as a prognostic marker in such patients.

Another study suggested that there may be a relationship between hematoma size and RDW in patients with intracerebral hemorrhage (18). However, to the best of our knowledge, RDW has never been studied in patients undergoing DC. In our study, we determined that RDW is a predictive parameter for in-hospital mortality in patients undergoing DC. Further studies are needed to establish the nature of the relationship between RDW and prognosis in patients undergoing DC.

LIMITATIONS

Due to its retrospective design, the study presented here relies on a limited number of cases. However, the authors believe that this study provides new insights that may contribute to the literature.

CONCLUSION

The present study found that patients with low GCS score, midline shift, and high CAR and RDW-SD benefit less from DC. The present study also found that high CAR and RDW-SD could be a predictive marker for mortality. However, further studies are needed to establish the value of these biomarkers in predicting prognosis in patients undergoing DC due to malignant MCA infarction and severe TBI.

Competing Interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical Approval: This study was approved by the Aksaray University Ethics Committee (2020 / 13-84) and was conducted in accordance with the Declaration of Helsinki.

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