JAMP

RESEARCH

# Age Factor Affecting The Success of Decompressive Cranietomy in Traumatic Brain Injury: Single Center Experience

**Densel Arac**[1]

[1] Necmettin Erbakan University Meram School of Medicine, Department of Neurosurgery, Konya, Turkey

ORCID; 0000-0003-0616-8835

**Abstract:** We aim to discuss factors especially age affecting the effectiveness of decompressive craniectomy in traumatic brain injury in the light of current literatüre. 44 patients who experienced decompressive craniectomy were analyzed, according to the Glasgow coma scale (GCS), midline shift, age, and outcome scores retrospectively. There were 44 patients, 26 males and 18 females, with a mean age of 54,72 years (range 20-78 years). Glasgow coma scale (GCS) scores ranged from 5 to 11 preoperatively. The midline shift was 10 mm (range 4-27 mm) on brain computed tomography (CT). Increased age (>55 years), preoperative midline shift >9 mm, low preoperative GCS (<8), preoperative findings of herniation, early clinical deterioration (within the first three days of traumatic brain injury), and delayed surgical intervention were predictors of a poor outcome. Decompressive craniectomy can be life-saving in young patients if it is done in patients and timely, but the effectiveness of surgery on morbidity and mortality is related to several other factors.

## INTRODUCTION

Traumatic brain injury (TBI) is defined as an injury to the head arising from blunt or penetrating trauma or acceleration/deceleration forces associated with a decreased level of consciousness, amnesia, neurologic regression, skull fractures, intracranial contusion and/or hematoma, and edema [1,2].

Decompressive craniectomy (DC) is described as the temporary removal of a part of the cranium to form a place where the brain can expand without being under pressure [3]. Following intracranial pressure (ICP) decrease to normal levels together with an increase in cerebral blood flow, cerebral perfusion pressure (CPP) is maintained again.

In most cases, DC is used as a secondary treatment in resistant intracranial edema and hypertension that do not respond to medical treatment [4,5]. The time to perform DC plays an important role in mortality and morbidity [5]. The surgical practice is a "wait and see" approach, the DC decision is made with neurological regression, increase in ICP, and increase in midline shift in the control CT [6].

In this study, we presented cases experienced with decompression surgery to evaluate the morbidity and mortality rates, and factors affecting the outcome of patients.

## MATERIALS and METHODS

The study included 55 patients diagnosed with traumatic brain injury and followed up in the Neurosurgery Clinics of Necmettin Erbakan University Meram Faculty of Medicine between 2015-2018. A detailed history of patients and neurological examinations were performed. Pathologies were established using the imaging methods of brain computed tomography (CT), diffusion magnetic resonance imaging (MRI), and CT/MRI angiography.

Patients were initially treated with conservative medical management such as anti-edema agents (mannitol, furosemide, steroids), hyperventilation, and surgical treatment decisions that were made based on serial CT reports and neurological deterioration. A large decompressive craniectomy was performed unless the patient had a definite medical contraindication to surgery. Data were collected on age, gender, etiology, whether the dominant hemisphere was affected, preoperative GCS, measurement of midline shift, recovery of midline shift after decompressive craniectomy, and time from trauma to surgery. Modified Rankin Scale (mRS) (Table 1) was used for functional outcomes and evaluation of recovery [7].

*Received : 08/05/2021*
*Received in revised form : 11/15/2021*
*Accepted : 12/10/2021*
*Available online : 01/15/2022*

*Keywords:*

*Age*
*Decompressive craniectomy*
*Factors*
*Traumatic brain injury*

Corresponding Author:
Densel Arac
E-mail; denselarac@hotmail.com
http://dx.doi.org/10.29228/jamp.52250

*Int J Acad Med Pharm,*
2022; 4 (1); 19-23

**Table 1:** Modified rankin score

| Modifed Rankin Score (mRS) | |
|---|---|
| 0 | No symptoms at all |
| 1 | No significant disability, able to carry out usual activities |
| 2 | Slight disability-unable to carry out previous activities, but able to look after themselves |
| 3 | Moderate disability-requires some help but walks unaided |
| 4 | Moderately severe disability-unable to walk or attend to bodily needs without assistance |
| 5 | Severely disabled-bedridden, requires constant care and attention |
| 6 | Dead |

Among the 55 patients treated with a diagnosis of TBI in our hospital, 7 of them were followed up with conservative medical treatment and discharged. 4 patients had only managed medical treatment without surgery because GCS 3 and pupils were dilated bilaterally and died in an average of 1 week. 44 patients who operated with the diagnosis of TBI were included in this study to examine mortality and morbidity rates and factors affecting prognosis.

### *Surgical Procedure*

All patients underwent large unilateral fronto-temporoparietal craniectomy and duraplasty as a surgical procedure within 24 hours. The dura was opened in a cruciate or inverted U shape. ICP wire was inserted into the brain parenchyma for ICP monitoring. Wide duraplasty was made with synthetic dura to prevent the brain from under pressure. Redivac drain (passive) was inserted before closure. Both the ICP wire and drain were well anchored to avoid slippage of the devices, which could lead to inaccurate ICP readings and drainage, respectively.

### *Statistical Analysis*

Data obtained in the study were statistically analyzed using SPSS 23.0 software (SPSS Inc., Chicago, IL, USA). The data were expressed as mean ± standard deviation (SD). Mann-Whitney U non-parametric tests, Kruskal-Wallis tests, One Way ANOVA tests, and Independent samples t test were used in the analysis of statistical evidence. The value of $p<0.05$ was regarded as statistically significant.

## RESULTS

Decompressive surgery was applied to 44 patients with a mean age of 54.72 years (range 20 -78 years), comprising 26 males with a mean age of 54,88 years and 18 females with a mean age of 54,5 years. The mean midline shift on CT was approximately 10 mm (range 4-27 mm) and the mean time to have surgery was 11.2 hours in patients aged ≤55 years and 12,5 hours in patients aged >55 years.

Subdural hygroma and infections in 5 cases (3 M / 2F) (M: male, F: female), hydrocephalus in 6 cases (2M / 4F), and acute subdural hematoma in 2 cases (2M) were seen as complications. 17 (38.63%) patients discharged with mRS of 0-3 and 12 (27,2%) patients were discharged as severely disabled and bedridden with mRS 4-5. The mortality rate was (34,09%), 15 patients died the mean 52nd day postoperatively. Patients discharged in good condition with mRS 0-3 had preoperative mean GCS 10 (range 9-13), mean age 45 years (range 20-66 years), and mean midline shift 8,9± 3,16 mm (range, 5-17 mm). The patients discharged as disabled and/or bedridden had preoperative mean GCS 9 (range 5-12), mean age 55 (range 26-78), and mean midline shift 11,10±4,5 (range 5-22) (Fig.1-4).

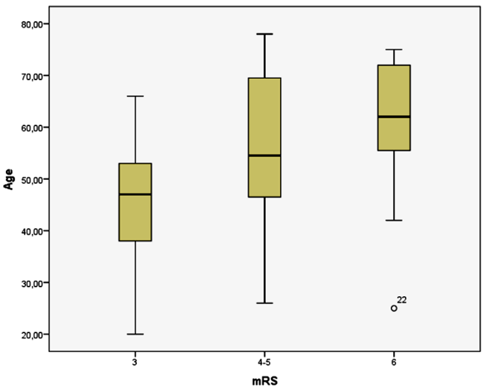


**Fig. 1.** Patients's ages and mRS
There is a statistically significant difference between patients outcomes (mRS) depending on age especially in mRS 0-3 and mRS 6 (p <0.05).

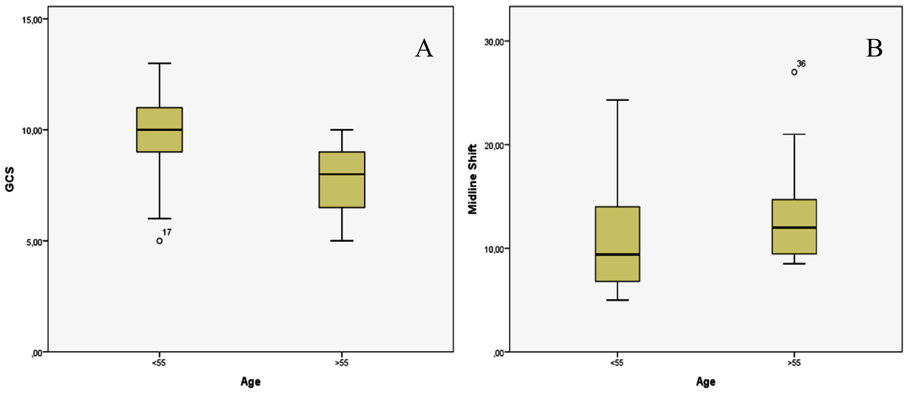


**Fig. 2.** Relationship of patients's ages and GCS (A), midline shift (B)
A; Statistically significant difference was found between age and GCS, B; Statistically significant difference was not found between age and Midline Shift

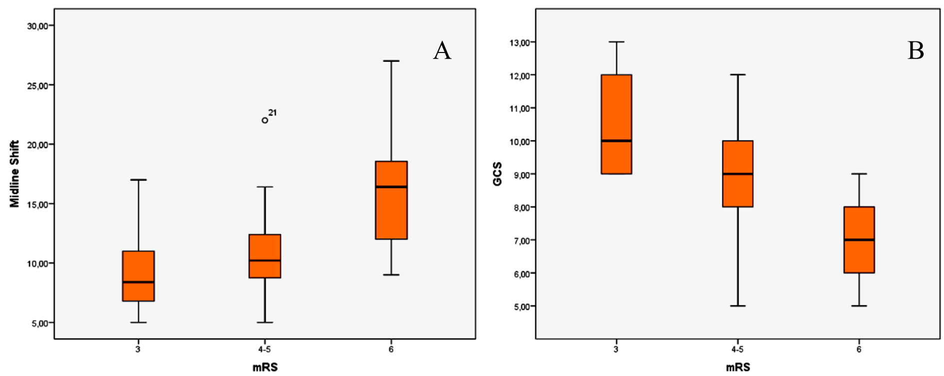


**Fig. 3.** Midline shift and mRS (A), GCS and mRS (B)
A;There is no significant difference between mRS 0-3 and mRS 4-5 in terms of midline shift degree; There is a significant difference between mRS 6 and 0-3, 4-5 (p <0.05)., B; GCS value was examined between the mRS groups, it was shown that there was a significant difference (p <0.05).

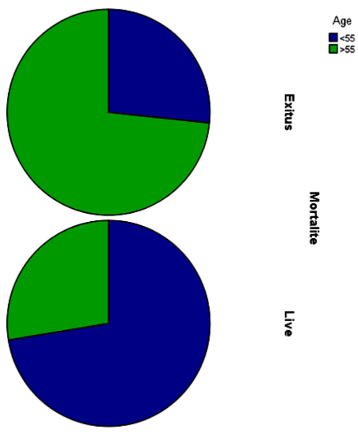


**Fig. 4.** Relationship between patients's age and mortality
Mortality rates of patients older than 55 years old and younger, and a statistically significant difference was found (p <0.05).

In the patients with mortality, (mRS 6), the preoperative mean GCS was 7 (range 5- 9), mean age was 60 years (range 25-75 years), and mean midline shift was 15.94±5,35 mm (range 9-27 mm).

**DISCUSSION**

The best time to decompressive craniectomy is still controversial [8] but early DC (within 24 h after injury) is recommended for severely head-injured patients without brain stem dysfunction requiring neurosurgery for removing intracranial collections [9]. This may be delayed for older patients showing symptoms as they are better accommodated to intracranial hypertension due to cerebral atrophy [10].

Previous studies have shown that the surgical technique is effective in patients' outcomes. In our study, we applied fronto-temporoparietal decompressive craniectomy and duraplasty to our patients, which are the most preferred techniques. Large fronto-temporoparietal decompressive craniectomy significantly improved the outcome in severe TBI patients with refractory intracranial hypertension and had a better effect in terms of decreasing ICP, compared with routine temporopatiyetal craniectomy [11]. Duraplasty had better outcomes and lower incidences of secondary surgical complications such as hydrocephalus, subdural effusion, epilepsy, infection, and adhesion of the brain to adjacent structures compared with those who only underwent surgical decompression, leaving the dura open [12],[13]. Besides, insufficient size of decompression without duraplasty leads to infarctions and brain leakage, especially due to the compression of the cortex and superficial brain veins [14].

The result of the current study confirmed age is a crucial factor for mortality and functional outcome as 15/44 patients (34,09%) died despite having undergone surgery with 4 of those patients (16%) aged ≤ 55 years and 11 aged > 55 years (57,8%). Therefore, age may be the most important factor in deciding which patients should undergo craniectomy. Tagliaferri et al. reported that age was the most important prognostic factor by stating that only 7% of patients over 65 years of age were well outcome [15]. But some studies, such as Bonis et al., reported that there is no relationship between age and prognosis [16].

In examining outcome scores in our study; Patients younger than 55 years old have higher rates of mRS 0-3 and mRS 4-5, and there was a significant difference in statistical comparison with patients older than 55 years (p<0.05) (Table 2) and the statistical difference between mRS 0-3 and mRS 6 (exitus) groups was evident in the outcome score comparison (Fig. 1). While the GCS score of the patients younger than 55 years old is higher than the patients older than 55 years old, and there was a statistically significant difference (p <0.05), there was no relationship between midline shift and age (p>0,05) (Fig. 2).

**Table 2.** Descriptive analysis of age and mRS

| | Age | | | | |
|---|---|---|---|---|---|
| mRS | N | Mean | Std. Deviation | Minimum | Maximum |
| 0-3 | 17 | 45,2353 | 12,83808 | 20,00 | 66,00 |
| 4-5 | 12 | 55,0833 | 15,81977 | 26,00 | 78,00 |
| 6 | 15 | 59,9333 | 14,22004 | 25,00 | 75,00 |
| Total | 44 | 52,9318 | 15,26418 | 20,00 | 78,00 |

When we look at the relationship between the outcomes of the patients and the midline shift value, there was no significant difference in mRS 0-3 and mRS 4-5 patients (p> 0.05); Midline shift value was higher in mRS 6 patients compared to other mRS groups, and there was a statistically significant difference (p <0.05) (Fig. 3). In the literature, it has been shown that preoperative midline shift over 10 mm in patients with traumatic brain injury is a marker of poor prognosis [17,18,19]. When the GCS value was studied in the patient outcome groups, it was observed that there was a significant difference between the groups (p <0.05), and the GCS value in mRS 6 patients was lower than in the other groups (Fig. 3). Reddy et al. reported that mortality of 22% among their patients who had a preoperative GCS ≥ 8, and mortality of 73% among those with GCS <8 [17,20]. Pupil size shows a statistically significant difference in mRS groups and mRS 4-5 and 6 are higher in anisocoria and miosis patients (Fig. 6). Anisocoria and miosis rate is higher in patients >55 years old and there is a statistically significant difference between age groups (Fig. 7).

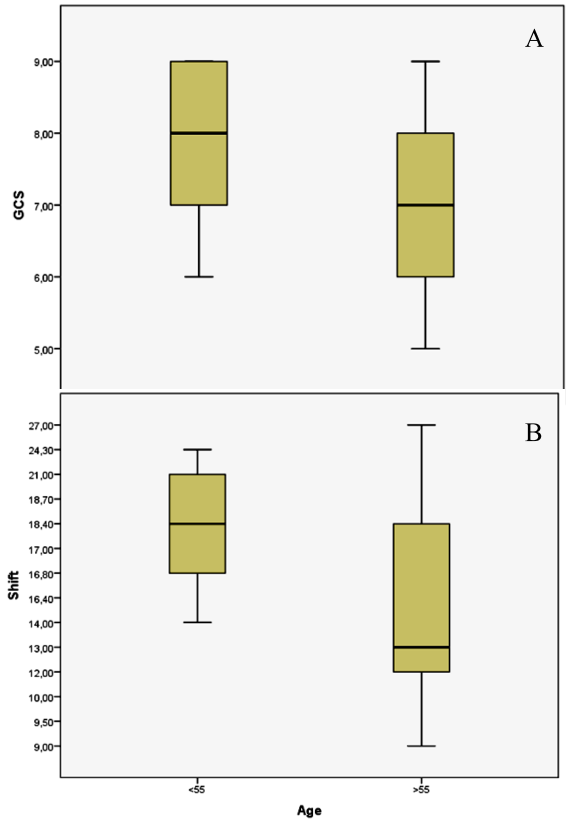


**Fig. 5**. Relationship between age and GCS (A), and midline shift (B) in the mortality group
A; There is no significant difference between age and GCS in the mortality group, B; There is no significant difference between age and midline shift in the mortality group.

Mortality rates of patients >55 years old are higher than younger patients, and a statistically significant difference was found (p <0.05) (Fig. 4). In mortality analysis, there was no statistically significant difference between Age - GCS and Age - Midline shift (p> 0.05) (Fig. 5). The GCS value and midline shift value in patients ≤55 years of age in the mortality group are higher than those of > 55 years old patients. As a numerical value, the mean GCS value is 8 and the midline shift value is 18 mm in patients ≤55 years old, while the GCS value is 7 and the midline shift value is 13 mm in patients > 55 years old. Our analysis results showed that there is no linear relationship between midline shift values and GCS. The effect of pupil size on mortality is explained by an increased mortality rate, especially in patients with anisocoria and miosis. Although there was no statistically significant difference in the mortality group when compared to age and pupil size, the rate of miosis and anisocoria was higher in patients older than 55 years.

A prominent result of our study: It is stated that the age factor has an important effect on outcomes and mortality in patients who underwent decompressive craniectomy and duraplasty in the first 24 hours (Table 3). Although the effects of GCS, midline shift, and pupil size values on patients' outcome scores and mortality in patients with traumatic brain injury are known; our study shows that the controversial age factor is too important to be ignored.

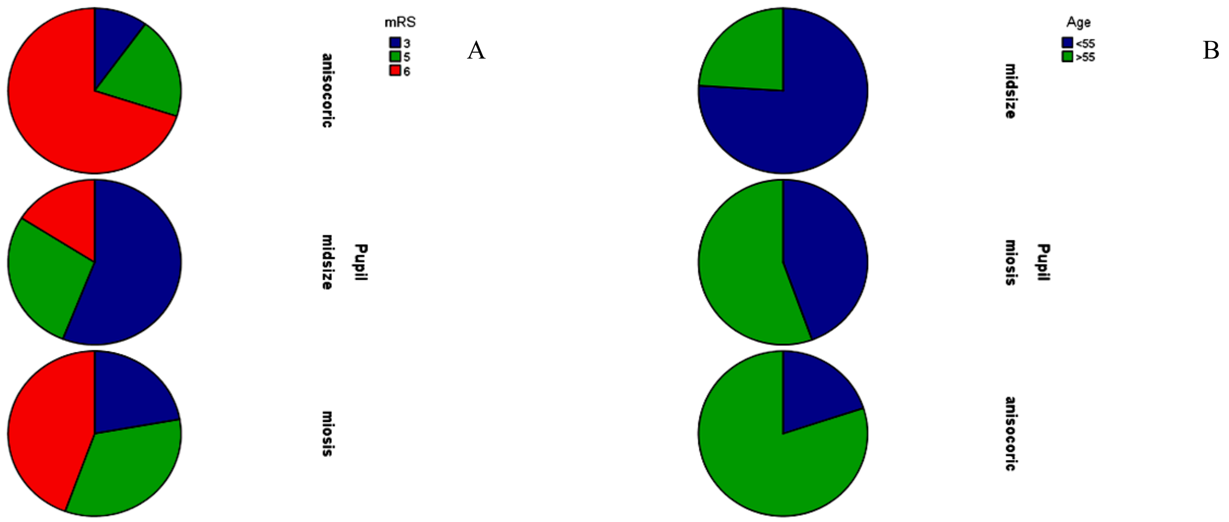


**Fig. 6.** Relationships of pupil size and Mrs (A), and age (B)

A; Pupil size in mRS groups show statistically significant difference (p <0.05), B;Pupil size according to age was found to be statistically significant (p<0.05)

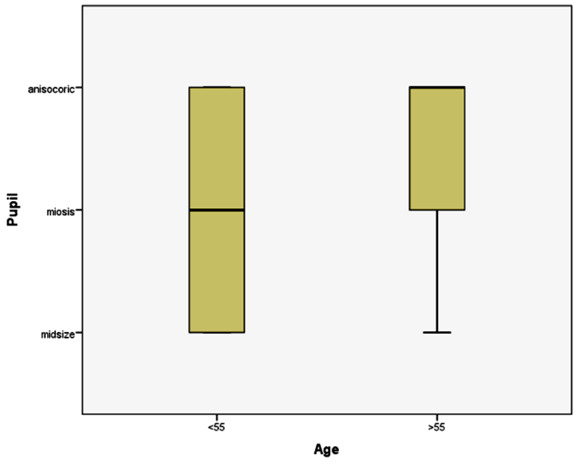


**Fig. 7.** Relationship between age and pupil size in mortality group
There are no significant difference between age groups according to pupil size in mortality group p>0.05

**Table 3.** Patients's outcome scores and mortality

| mRS | Mean age | Patients no | GCS | Midline shift (mm) |
|---|---|---|---|---|
| 0-3 | 45 (20-66) | 17 | 10 (9-13) | 8,9 +/-3,16 (5-17) |
| 4-5 | 55 (26-78) | 12 | 9 (5-12) | 11,10 +/- 4,5 (5-22) |
| 6 (dead) | 60 (25-75) | 15 | 7 (5-9) | 15,94 +/- 5,35 (9-27) |

There were some limitations to this study. Although the data on decompressive surgery is significant, it was a non-randomized, retrospective study, and the results need confirmation from larger randomized trials. Although there is no consensus for the surgical treatment of traumatic brain injury, decompressive craniectomy can be recommended for:

1) Patients ≤ 55 years old;
2) Patients with cerebral edema in CT scans and with GCS ³ 8;
3) Before signs of brain herniation, if possible (within 24 hours).

### *Conclusion*

DC is undoubtedly a lifesaving intervention for patients with brain edema following traumatic brain injury. More extensive studies are clearly required. Nevertheless, age, time for surgery, whether the affected hemisphere is dominant or not, preoperative and postoperative midline shift, and especially preoperative GCS are factors known to influence mortality and morbidity.

In the results obtained from our study, we recommend that decompressive craniectomy be performed in the first 24 hours before GCS goes below 8 in young patients with brain trauma.


### *Conflict of interest*

The authors declare that there are no conflict of interests.

### *Financial disclosure*

The authors declared that this study has received no financial support.


### *Acknowledgments*

**GCS:** Glasgow coma scale, **CT:** Computed tomography, **TBI:** Traumatic brain injury, **DC:** Decompressive craniectomy, **ICP:** Intracranial pressure, **CCP:** Cerebral perfusion pressure, **MRI:** Magnetic resonance imaging, **mRS:** Modified Rankin Scale, **SD:** Standard deviation, **M:** Male, **F:** Female

## REFERENCES


1. Coronado VG, McGuire LC, Sarmiento K, Bell J, Lionbarger MR, Jones CD et al. Trends in Traumatic Brain Injury in the U.S. and the public health response: 1995-2009. *J Safety Res* 2012;43(4):299-307, doi: 10.1016/j.jsr.2012.08.011
2. Blennow K, Brody DL, Kochanek PM, Levin H, Mckee A, Ribbers GM et al. Traumatic brain injuries. *Nat Rev Dis Primers* 2, 2016;16084 DOI: 10.1038/nrdp.2016.84
3. Timofeev I, Hutchinson PJ. Outcome after surgical decompression of severe traumatic brain injury. *Injury*. 2006;37:1125-1132, doi: 10.1016/j.injury.2006.07.031
4. Gong J, Wen L, Zhan R, Zhou HJ, Wang F, Liu G et al. Early decompressing craniectomy in patients with traumatic brain injury and cerebral edema. *Asian Biomed*. 2014;8:53–9, doi: 10.5372/1905-7415.0801.261
5. Hartings JA, Vidgeon S, Strong AJ, Zacko C, Vagal A, Andaluz N et al. Surgical management of traumatic brain injury: A comparative-effectiveness study of 2 centers. *J Neurosurg*. 2014;120:434–46, doi: 10.3171/2013.9.JNS13581
6. Heuts SG, Bruce SS, Zacharia BE, Hickman ZL, Kellner CP, Sussman ES et al. Decompressive hemicraniectomy without clot evacuation in dominant-sided intracerebral hemorrhage with ICP crisis. *Neurosurg Focus*. 2013;34:E4, doi: 10.3171/2013.2.FOCUS1326.
7. Rankin J. Cerebral vascular accidents in patients over the age of 60: II. Prognosis. *Scott Med J*. 1957;2:200-215, doi: 10.1177/003693305700200504.

8. Li LM, Timofeev I, Czosnyka M, Hutchinson PJA. Review article: the surgical approach to the management of increased intracranial pressure after traumatic brain injury. *Anesth Analg* 2010;111(3):736-48, doi: 10.1213/ANE.0b013e3181e75cd1.
9. Albanèse J, Leone M, Alliez JR, Kaya JM, Antonini F, Alliez B et al. Decompressive craniectomy for severe traumatic brain injury: Evaluation of the effects at one year. *Crit Care Med* 2003;31(10):2535-8, doi: 10.1097/01.CCM.0000089927.67396.F3.
10. Alvis-Miranda H, Castellar-Leones SM, Moscote-Salazar LR. Decompressive Craniectomy and Traumatic Brain Injury: A ReviewBull Emerg Trauma 2013;1(2):60-68), *PMCID*: PMC4771225
11. Jiang JY, Xu W, Li WP, Xu WH, Zhang J, Bao YH et al. Efficacy of standard trauma craniectomy for refractory intracranial hypertension with severe traumatic brain injury: a multicenter, prospective, randomized controlled study. *J Neurotrauma*. 2005;22:623-628, doi: 10.1089/ neu.2005.22.623.
12. Yang XJ, Hong GL, Su SB, Yang SY. Complications induced by decompressive craniectomies after traumatic brain injury. *Chin J Traumatol*. 2003;6:99-103, PMID: 12659705
13. Mumert ML, Altay T, Couldwell WT. Technique for decompressive craniectomy using Seprafilm as a dural substitute and antiadhesion barrier. *J Clin Neurosci* 2012;19(3):455-7, doi: 10.1016/ j.jocn.2011.09.004.
14. Lubillo S, Blanco J, López P, Molina I, Domínguez J, Carreira L et al. Role of decompressive craniectomy in brain injury patient. *Med Intensiva* 2009;33(2):74-83. 60, doi: 10.1016/s0210-5691(09)70685-0.
15. Tagliaferri F, Zani G, Iaccarino C, Ferro S, Ridolfi L, Basaglia N et al. Decompressive craniectomies, facts and fiction: a retrospective analysis of 526 cases. *Acta Neurochir* (Wien) 2012;154(5):919-26, doi: 10.1007/ s00701-012-1318-0
16. De Bonis P, Pompucci A, Mangiola A, D'Alessandris QG, Rigante L, Anile C. Decompressive craniectomy for the treatment of traumatic brain injury: does an age limit exist? *J Neurosurg* 2010;112(5):1150-3, doi: 10.3171/2009.7.JNS09505.
17. Bagheri SR, Alimohammadi E, Saeidi H, Fatahian R, Soleimani P, Sepehri P et al. Decompressive Craniectomy in Traumatic Brain Injury: Factors Influencing Prognosis and Outcome. *Iran J Neurosurg*. 2017;3 (1):21-26, Doi: 10.29252/irjns.3.1.21
18. Schreckinger M, Marion DW. Contemporary management of trau- matic intracranial hypertension: is there a role for therapeutic hypothermia? *Neurocrit Care* 2009;11(3):427–36 DOI: 10.1007/s12028-009-9256-2
19. Nalbach SV, Ropper AE, Dunn IF, Gormley WB. Craniectomy associated progressive extra-axial collections with treated hydrocephalus (CAPECTH): redefining a common complication of decompressive craniectomy. *J ClinNeurosci* 2012;19(9):1222–7 doi: 10.1016/ j.jocn.2012.01.016.
20. Bor-Seng-Shu E, Figueiredo EG, Amorim RL, Teixeira MJ, Valbuza JS, de Oliveira MM et al. Decompressive craniectomy: a meta-analysis of influences on intracranial pressure and cerebral perfusion pressure in the treatment of traumatic brain injury.*J Neurosurg*. 2012 Sep;117(3):589-96 doi: 10.3171/2012.6.JNS101400.