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Decompressive craniectomy after traumatic brain injury: a bioethical discussion

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Abstract

Traumatic brain injury is an important cause of death and disability in various age groups. Elevated intracranial pressure following severe traumatic brain injury can result in cerebral ischemia, which is associated with significant mortality rates and adverse outcomes. Among the strategies to control resistant intracranial pressure is decompressive craniectomy. A systematic review was conducted to compare the outcomes of decompressive craniectomy with conservative treatment for intracranial hypertension after traumatic brain injury. The results indicated a reduction in intracranial pressure and longer survival, but also higher rates of disability in the group that underwent decompressive craniectomy. Bioethical considerations on therapeutic obstinacy and resource allocation were addressed, stressing the need for broader discussions on the subject among physicians and family members, emphasizing the complexity of clinical decision-making.

Keywords: Decompressive craniectomy. Brain injuries, traumatic. Intracranial hypertension. Treatment outcome. Prognosis.

Resumo

Craniectomia descompressiva pós-traumatismo cranioencefálico: discussão bioética

O traumatismo cranioencefálico é uma importante causa de morte e invalidez em diversas faixas etárias. A pressão intracraniana elevada após traumatismo cranioencefálico grave pode resultar em isquemia cerebral, associada a taxas significativas de mortalidade e resultados adversos. Entre as estratégias para controlar a pressão intracraniana resistente, está a craniectomia descompressiva. Uma revisão sistemática foi conduzida visando comparar os desfechos da craniectomia descompressiva com o tratamento conservador para hipertensão intracraniana pós-traumatismo cranioencefálico. Os resultados indicaram redução na pressão intracraniana e maior sobrevida, mas também taxas elevadas de incapacidade no grupo submetido a craniectomia descompressiva. Considerações bioéticas sobre obstinação terapêutica e alocação de recursos foram abordadas, destacando a necessidade de uma discussão mais ampla sobre o tema entre médicos e familiares, ressaltando a complexidade na tomada de decisões clínicas.

Palavras-chave: Craniectomia descompressiva. Traumatismo do encéfalo. Hipertensão intracraniana. Resultado do tratamento. Prognóstico.

Resumen

Craniectomía descompresiva después de un traumatismo craneoencefálico: discusión bioética

El traumatismo craneoencefálico constituye una importante causa de muerte y discapacidad en varios grupos de edad. La presión intracraneal elevada después de un traumatismo craneoencefálico grave puede provocar isquemia cerebral asociada con tasas de mortalidad significativas y resultados adversos. Entre las estrategias para controlar la presión intracraneal resistente se encuentra la craniectomía descompresiva. Se realizó una revisión sistemática para comparar los resultados de la craniectomía descompresiva con el tratamiento conservador para la hipertensión intracraneal después de un traumatismo craneoencefálico. Los resultados revelan una reducción de la presión intracraneal y una mayor supervivencia, además de altas tasas de discapacidad en el grupo sometido a craniectomía descompresiva. Se abordaron consideraciones bioéticas sobre la obstinación terapéutica y la asignación de recursos, al destacar la necesidad de una discusión más amplia sobre el tema entre los médicos y los miembros de la familia, al destacar la complejidad en la toma de decisiones clínicas.

Palabras clave: Craniectomía descompresiva. Lesiones traumáticas del encéfalo. Hipertensión intracraneal. Resultado del tratamiento. Pronóstico.

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Research

Traumatic brain injury (TBI) is one of the most common causes of death and disability among children and young adults worldwide and has become increasingly common in older people [1,2]. The incidence of severe TBI is estimated at 73 cases per 100,000 population, or a total of 5.48 million people per year, making it a public health issue with a major socioeconomic impact [3].

After a severe TBI, as a consequence of hemorrhage, cerebral edema, or hydrocephalus, approximately 80% of patients present a significant increase in intracranial pressure (ICP), which leads to cerebral ischemia due to herniation. It is known that intracranial hypertension is directly related to more than half of deaths and one third of adverse outcomes described. Therefore, the treatment is initially aimed at maintaining ICP ≤20 mmHg [2,4,5].

To this end, strategies are used to control ICP and minimize secondary brain injuries after TBI. These include: the patient's head at 30°, hypothermia, sedation, intravenous mannitol, barbiturates, hyperventilation, analgesia, osmotherapy, and drainage of cerebrospinal fluid with external ventricular drainage catheters. These measurements are taken to reduce disability and mortality rates [4,6-8].

In some patients, however, increased ICP is resistant to conservative therapies. In these cases, temporary removal of a large portion of the skull—called decompressive craniectomy (DC)—is one of the treatment options for persistent elevation of ICP resulting from TBI [2,5,7]. DC was first described in modern neurosurgery by Kocher and Cushing in the early 20th century and has since been the subject of much discussion and controversy [8]. Although it has proven to be effective in reducing mortality rates in severe cases, the negative overall results and postoperative disability make the decision to perform this procedure challenging for family members and neurosurgeons [9].

Objectives

This study aims to perform a comprehensive and critical systematic review of the available scientific evidence on the comparative effectiveness of DC in relation to conservative treatment for the correction of intracranial hypertension after TBI. In addition, we seek to explore and analyze the bioethical implications associated with these therapeutic approaches.

Method

This is a systematic review carried out on the PubMed database using the following descriptors: "*decompressive craniectomy*," "*traumatic brain injury*," "*intracranial hypertension*," "*treatment outcome*," and "*prognosis*." The articles were read and selected independently by two authors, and in case of discrepancies, article inclusion or exclusion was discussed and decided jointly according to the established criteria. The period selected was from 2018 to 2022.

In total, 46 articles were found, and 13 were selected. Of the 33 articles excluded, eight were not available, and 25 did not meet the inclusion criteria. The inclusion criteria for the selected articles follow the PICO standard (population: victims of TBI with intracranial hypertension; intervention: DC; control: conservative treatment; outcome: good recovery, disability, or a vegetative state).

Results

Among the articles analyzed, a randomized clinical trial (RCT) reported that patients with post-traumatic intracranial hypertension treated with DC had a significant reduction in mortality rates at 24 months compared to the group of patients that underwent conservative treatment. The same result was seen in another study, which observed lower mortality rates and shorter hospital stays in the surgical group. However, both authors describe a higher proportion of patients who remained in a vegetative state or with severe or moderate disability in the surgical group, with an increase in unfavorable outcomes in patients undergoing DC compared to the standard care group [2,10].

A study that analyzed the outcome of 124 patients undergoing DC after TBI showed that 53 patients died in the hospital where the surgery was performed. Of the 71 patients who survived, 54 were transferred to other hospitals, and only 17 were discharged directly home. At the end of one year, 25 patients were alive, and seven of them had severe disability [6]. Another study that evaluated 94 patients who underwent DC reported that a total of 74 patients died within one month after surgery. Of the patients who survived, more than half had an unfavorable outcome, which included a vegetative state and severe disability. Therefore, according to the study authors, almost 90% of patients had a poor outcome [9].

In a study conducted in Australia with 303 patients who suffered TBI, 66 underwent DC in an attempt to control ICP. Of these patients, 23 died and 43 remained alive. However, although the number of survivors was higher, most of them did not recover well, completely losing their independence and autonomy [3].

Different results were found by an article that analyzed a series of studies. One of them reported an 80% reduction in ICP in patients who underwent DC, which was not observed in the group of patients who underwent medical treatment alone. Another study, however, found very similar results in ICP control between the CD and conservative treatment groups. Regarding survival, the studies showed higher rates in patients who underwent surgery (100% versus 57%, and 100% versus 66%). With respect to disability, some studies observed that the scores were significantly better in patients who underwent DC. Nevertheless, another study reported finding no significant difference in long-term Glasgow Outcome Scale (GOS) scores between the two groups [11].

Among the studies that analyzed pediatric patients, one of the articles observed severe disability in 31% of cases. This study found some predictive factors of unfavorable outcomes after DC in children, such as GOS score, ICP value, combined trauma, pupil status and reactivity, and displacement of median brain structures by more than 5 mm [4].

In a piece of research involving 12 patients up to 17 years of age—all presenting diffuse cerebral edema, subdural hematoma of various sizes, and other intracranial pathologies—it was observed that three patients died and nine survived; of the survivors, three presented severe disability in the postoperative period [12]. Another study, which also analyzed pediatric patients who suffered TBI and underwent DC treatment, demonstrated that of a total of 24 patients, only three died; of the 21 patients who survived, 11 developed complications after surgery and four required new surgeries due to complications [13].

Among the complications found in the studies, some types of postoperative infections, hemorrhage, seizures, subdural collections, cerebrospinal fluid fistula, and obstructive hydrocephalus requiring ventriculoperitoneal shunt can be mentioned. Reoperation or secondary surgical procedures have also been reported [6,14].

Despite these mostly negative results, other studies have shown more favorable long-term results in patients who underwent DC. A study that compared outcomes in relation to mild or no disability (GOS score=4-5) and moderate and severe disability (GOS score=2-3) at 12 and 36 months showed that outcomes did not differ significantly between patients treated with and without DC [15]. In another article, the authors found that, after DC, patients were more likely to improve over time compared to the medical care group [10].

Chart 1. Summary of the results obtained from the comparison of the outcomes of patients undergoing decompressive craniectomy and/or conservative treatment

Authorship; year	Number of patients/ type of study	Population	Conservative treatment outcome	Decompressive craniectomy outcome	Study conclusion
Lu G, Zhu L, Wang X, Zhang H, Li Y.; 2020[2]	Systematic review	All	Unfavorable outcome in 23.91% of the patients	Unfavorable outcome in 37.3% of the patients	DC can effectively decrease ICP level, shorten hospital stay and reduce mortality compared with the medical treatment group. However, the DC group patients have a higher chance of survival with severe disability
Gantner D, Bragge P, Finfer S, Gabbe B, Varma D, Webb S and collaborators; 2020[3]	66	>15 years old	–	34.9% died, and 47% were referred to rehabilitation services	Although the number of survivors was higher, most of them did not recover well, completely losing their independence and autonomy
Semenova ZB, Meshcheryakov S, Lukyanov V, Arsenyev S.; 2021[4]	64	Pediatric	–	Good recovery within six months in 45.3% of the cases and severe disability in 31% of the cases; vegetative state and death in 23.4% of the cases	More than half of the patients had a poor outcome
Rankothkumbura J, Gunathilaka H, Wadanamby S.; 2021[6]	89	All	–	By the end of the third year, 73% had died, none were in a vegetative state, 7.8% had severe disability, and 19.1% had made a good recovery.	Favorable functional outcomes after DC for TBI are limited to 20%-25%
Cooper DJ, Rosenfeld JV, Murray L, Arabi YM, Davies AR, Ponsford J and collaborators; 2020[7]	Secondary analysis	All	Unfavorable outcomes in 48% of the patients	Unfavorable outcomes in 59% of the patients.	There were fewer favorable outcomes and more vegetative states among survivors after DC. Similar results in survivors were found six months after injury
Wettervik TS, Lenell S, Nyholm L, Howells T, Lewén A, Enblad P.; 2018[8]	58	>16 years old	Favorable outcomes were observed in 52% of the patients treated with thiopental alone, and 4% died	Favorable outcome was observed in 40%, and 17% of the patients died	The proportion of favorable outcomes was 29% among patients treated with DC as the first treatment
Tang Z, Yang R, Zhang J, Huang Q, Zhou X, Wei W, Jiang Q.; 2021[9]	94	All	–	78.7% died within 30 days after DC. Of the survivors, 20% made a good recovery, 20% made a moderate recovery, 10% had severe disability, and 50% remained in a vegetative state	89.4% of the patients had a poor outcome

continues...

Chart 1. Continuation

Authorship; year	Number of patients/ type of study	Population	Conservative treatment outcome	Decompressive craniectomy outcome	Study conclusion
Kolias AG, Adams H, Timofeev IS, Corteen EA, Hossain I, Czosnyka M and collaborators; 2022 [10]	Secondary analysis	All	Higher mortality rate and reduced likelihood of improvement over time	For every 100 patients treated with surgery, four were in a vegetative state, two had severe lower disability, seven had severe upper disability, and eight had moderate disability	Patients in the surgical group had a lower mortality rate, a higher disability rate, and a greater likelihood of improvement over time
Ardissino M, Tang A, Muttoni E, Tsang K.; 2019 [11]	Systematic review	Pediatric	The mortality rate in some articles ranged from 42.8% to 44%, and 50% had favorable outcomes	The mortality rate in some articles was zero. Most patients received a favorable GOS score	DC reduces ICP and mortality, and patients have possible long-term rehabilitative improvement
Goker B, Guclu DG, Dolas I, Ozgen U, Altunrende ME, Akinci AT and collaborators; 2020 [12]	12	Pediatric	–	25% died and 25% survived with severe disability	Half of patients had unfavorable outcomes
Korhonen TK, Suo-Palosaari M, Serlo W, Lahtinen MJ, Tetri S, Salokorpi N.; 2022 [13]	24	< 18 years old	–	12.5% died and 63% of the patients recovered well. No survivors were in a vegetative state	Almost two-thirds of the surviving patients recovered well, and 90% returned to school with or without support
Tian R, Dong J, Liu W, Zhang J, Han F, Zhang B and collaborators; 2021 [14]	44	All	–	Survival over the next 12 months was 25%. The favorable outcomes at discharge, after six months, and after 12 months was 9.1%, 13.6% and 20.5%, respectively	The overall survival rate was low, but patients improved over time after disability
Hubertus V, Finger T, Drust R, Al Hakim S, Schaumann A, Schulz M and collaborators; 2022 [15]	48	≤ 16 years old	In-hospital mortality of 11%; lower disability rate (GOS 5)	Mortality of 27%; higher disability rate (GOS 4)	Outcome did not differ significantly between patients treated with or without DC

DC: decompressive craniectomy; ICP: intracranial pressure; GOS: Glasgow Outcome Scale

Discussion

Several studies have been conducted recently in an attempt to provide clarifying answers regarding the techniques and outcomes of DC treatment for intracranial hypertension after TBI. The two main RCTs are the Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension (RESCUEicp) and Decompressive Craniectomy in Patients with Severe Traumatic Brain Injury (DECRA) [5,10]. DECRA was restricted to the DC effects in patients in the early stages of resistant intracranial hypertension, while RESCUEicp focused on patients with more established resistance. Therefore, the time between injury and surgery was shorter in DECRA than in RESCUEicp, and the analysis time for RESCUEicp was longer than for DECRA [5].

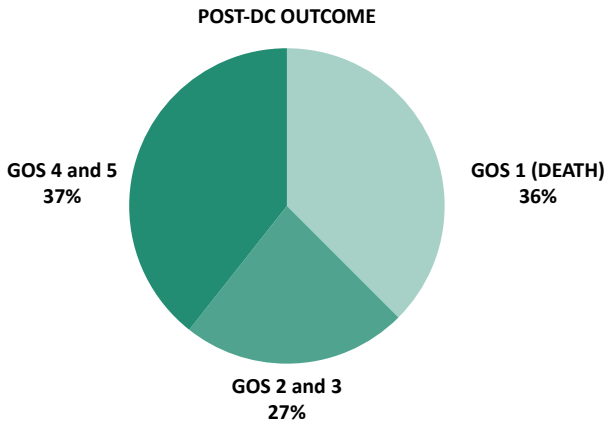
In 2013, DECRA researchers compared the outcomes of patients who underwent DC and those who received standard care. They found similar mortality rates and a higher rate of unfavorable

outcomes in the surgical group patients at six months. In 2016, the RESCUEicp results were published, which showed significant differences in outcomes at six and 12 months. The DC group patients presented a lower mortality rate but higher GOS scores for vegetative state and severe disability compared with those who received medical treatment alone [7,10].

Both studies were therefore consistent in demonstrating that DC reduces ICP and the duration of intensive care, as well as mortality. However, both also reported an increased rate of poor prognostic outcomes after surgery [5,10].

Two decades after its description, GOS remains the most widely used method for analyzing outcomes in series of patients with severe TBI. Among the articles analyzed, some authors used GOS as a way to qualify patient's outcomes and classify them according to their disability (Figure 1). This scale has a score from 1 to 5, where: 1=death; 2=vegetative state; 3=severe disability (able to follow commands, unable to live independently); 4=moderate disability (able to live independently, unable to return to work or school), and 5=mild disability/good recovery (able to return to work or school) [16,17].

Graph 1. Deaths, survivors and disability after decompressive craniectomy



Source: prepared based on Tang and collaborators [9]; Goker and collaborators [12]; Semenova and collaborators [4]; Lu and collaborators [2]; Wettervik and collaborators [8]

DC: decompressive craniectomy; GOS: Glasgow Outcome Scale

Based on the graph information analysis, it is possible to reinforce that DC, in spite of increasing the patient survival rate, still results in a high number of people with motor and cognitive sequelae that prevent them from returning to their normal lives or having some quality of life. In view of these results, evidenced by RCTs, systematic reviews and cohort studies, it is necessary to raise a bioethical question regarding the medical motivation and the consequences of this therapeutic decision, which affect the patient, their family, and public health.

Historically, death has been viewed in different ways by different cultures. For many centuries, throughout the European Middle Ages, death was understood as natural, being part of society's daily life. For the modern Western culture, with the technical and scientific development of medicine from the 19th century onwards, death became synonymous with failure, impotence, and shame [18].

Interventions are then made to try to avoid death at any cost, which is also known as therapeutic obstinacy or dysthanasia. This concept, first proposed by Morcache in 1904, means a difficult or painful death and is used to delay death through treatments that extend the patient's biological life, but without considering quality of life or dignity. The main objective of dysthanasia is focusing on the amount of time of this life—to provide all possible resources to prolong it as much as possible, with no regard to the patient's physical and psychological suffering [18-20].

Nonetheless, this practice is not perceived as harmful by most physicians, whose training is conditioned to always intervene and combat death and not to deal with the sick person or the person who is dying. The healthcare team's knowledge, focused exclusively on technical solutions, requires an attitude of denial of death, in an attempt to alleviate the feeling of helplessness. In this sense, investment in technological resources becomes an alternative to prolong the patient's life to avoid not only contact with death but also communication with the family and the patient's deepest feelings [18]. Thus, biotechnology makes the human desire to overcome death achievable, creating a feeling of power in the physician [20].

Reflecting on the dying process is necessary—after all, it is inherent to medical practice—so that professionals can behave appropriately when faced with cases such as patients who have suffered TBI with persistent intracranial hypertension and talk about the subject with the family [20].

Another point that must be taken into consideration in these cases is the allocation of healthcare resources. This concept cannot be seen as a purely technical decision, carried out based solely on medical, economic, and administrative management or political issues. "To allocate" means to best place something where it belongs. Consequently, it can be said that "to allocate" has an ethical dimension that expresses the best alternative among several possibilities, evaluated based on well-established criteria [21].

The end-of-life bioethics and the allocation of public resources converge, therefore, at the point where the use of dysthanasia measures to prolong the dying process of a patient with no prospect of improvement and increased quality of life prevents other patients from having access to that resource. For that reason, it is worth reflecting on the irresponsibility of making already-scarce resources available for the maintenance of those patients, subjecting them to a distressing, unnecessary, and expensive dying process. In this sense, resources, which are finite, must be applied in the best way possible, so that, for example, actions that are traditionally paramount in public health, such as vaccination, are contemplated [20].

It is a fact that the choice of treatment for sustained intracranial hypertension after TBI involves several aspects of the patient, of the physician, and of the context of the service in which they are inserted. Religious, cultural, scientific, and financial aspects must be taken into account, and the results already known and proven in the literature must be discussed within the neurosurgery community, as well as with the patients' families.

Final considerations

This study reveals a complex dichotomy between the benefits and challenges associated with the intracranial hypertension treatment after TBI. The results demonstrate a significant reduction in short-term mortality rates with DC. However, a long-term analysis stimulates critical consideration, given that, in most cases, the improvement in immediate survival is offset by high rates of unfavorable outcomes, such as a vegetative state or severe disability. This paradox highlights the complexity of clinical decision-making and stresses the importance of ethical considerations regarding the concepts of therapeutic obstinacy and resource allocation, as well as the need for greater discussion on the topic among physicians and family members.

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Participation of the authors
Adriano Torres Antonucci participated as an advisor, helping with the selection of articles and with corrections during the process. Thaís Yumi Kobayashi Batista collaborated in the selection of articles, in the methodology design, and in the writing of the article.

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Research