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POSTOPERATIVE COMPLICATIONS IN CRANIUM RESTRICTED NEUROSURGERY

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Abstract: Introduction: Neurosurgery restricted to the skull has a high risk of developing systemic or localized post-surgical complications. **Goal:** To highlight the main complications in patients undergoing cranial neurosurgery, as well as estimate and compare the prevalence of complications in elective procedures and emergency procedures. **Methods:** Observational, retrospective, descriptive study, with secondary data collection and a quantitative approach, which included all hospital records of patients over 18 years of age who underwent surgery restricted to the skull from January 2018 to March 2019 in a hospital of high complexity in the south of Santa Catarina, Brazil. **Results:** The data obtained found a higher prevalence of elective surgeries and complications such as headache (24.7%), followed by delirium (19.7%), fever (16.7%), paresis/hemiparesis (11.4%), intraparenchymal hematoma (9.1%), hypokalemia (9.1%) and meningitis (9.1%). In addition, an association was found between emergency surgeries and the occurrence of fever, hypokalemia, increased blood pressure and emesis, with p-values < 0.001, < 0.001, 0.016 and 0.004, respectively. **Conclusion**: The most prevalent complications in neurosurgery restricted to the skull were headache, followed by delirium, fever, paresis/hemiparesis, intraparenchymal hematoma, hypokalemia and meningitis. In addition, fever, hypokalemia, increased blood pressure and emesis had a statistically significant association as the most prevalent complications in emergency surgeries.

Keywords: Neurosurgery, Skull, Intercurrence, Postoperative..

INTRODUCTION

The first reports of neurosurgery in the world took place in 10,000 BC by the widespread discovery of human skulls showing evidence of the practice of trephination.[1] Modern neurosurgery with clinical-topographic resources was initiated in 1876 by Broca[2]. Since then, several advances in technology and neuroimaging have enabled new treatments and new minimally invasive surgical techniques.[3] The great development of minimally invasive surgery came as a way to reduce the surgical trauma associated with craniotomy, which in turn has a relatively high incidence of postoperative complications.[4]. However, these techniques do not prove to be the best surgical option in all cases, since the occurrence of hypertensive intracerebral hemorrhage with a large volume of hematoma has been observed in patients undergoing this type of procedure.[5]

Patients undergoing neurosurgery are at high risk of developing neurological and systemic complications.[6] Those occurring in recovery rooms occur in 30% of general surgery patients and 54.5% of neurosurgical patients, with nausea, vomiting, tremors, respiratory and vascular failure being the most prevalent at this time.[7] P Due to the susceptibility to complications, post-surgical monitoring is of paramount importance, and repeated clinical examination in these patients is mandatory.[8]

The most common postoperative complications in neurosurgery are bleeding, seizures, sodium disorders, and clotting disorders.[9] In addition, patients undergoing the neurointensive care unit are susceptible to a range of infections, both systemic and specific to the nervous system, often facilitated by communication between normally protected spaces and the external environment.[10]

In sum, complications are associated with unplanned hospital readmissions after cranial neurosurgery, contributing to higher healthcare costs.[11]

One study[12] showed that the main causes of hospital readmission within 30 days were due to complications such as fever, infection, altered mental status and new sensory or motor deficits.

In this regard, one of the main goals of current neurosurgery is to minimize complications during the perioperative and intensive care period, as they contribute greatly to the increase in morbidity and mortality in patients after neurosurgical procedures.[13]

The present work was justified due to the high risk that neurosurgical patients have of developing postoperative complications, which may appear in a short or long period, being systemic or localized. Therefore, the objective of this work was to analyze the electronic medical records of patients undergoing elective and emergency neurosurgeries restricted to the skull, in a hospital in the Extremo Sul Catarinense, and to identify their post-surgical complications from January 2018 to March. of 2019.

MATERIALS AND METHODS

ETHICAL ASPECTS

The present study complied with the bioethical principles determined by Resolution 466/12 of the National Health Council, and was approved by the Ethics and Research Committees of the Universidade do Extremo Sul Catarinense (UNESC), under protocol number 4,183,954 and the hospital, with opinion number 4,208,790.

EXPERIMENTAL DRAW

This is an observational, retrospective, descriptive study, with secondary data collection and a quantitative approach, using electronic medical records of patients undergoing neurosurgery restricted to the skull, both elective and urgent.

STUDY POPULATION

The population of the present study were patients undergoing intracranial neurosurgery, elective or urgent, in a high complexity hospital, in the city of Criciúma (SC), from January 2018 to March 2019. - if there were any post-surgical complications during the hospital stay.

Information obtained from patients was taken from electronic medical records. Included in this study were patients who underwent intracranial neurosurgery, those over 18 years of age, who had or had not had post-surgical complications during hospitalization, treated at a high-complexity hospital in the extreme south of Santa Catarina, by physicians from the institution. . Those who had medical records with missing or illegible data, and patients who had complications after the length of hospital stay were excluded.

STUDY LOCATION

The data evaluated in this study were obtained directly from the medical records of patients treated at a high-complexity hospital located in the city of Criciúma, Santa Catarina (SC).

STUDY SAMPLE

The calculation of the minimum sample size was performed using the formula proposed by Medronho [14]:

$$n = \frac{z_{\frac{\alpha}{2}}^{2} N P(1-P)}{\varepsilon^{2}(N-1) + z_{\frac{\alpha}{2}}^{2} P(1-P)}$$

Where, z (1.96) refers to the bilateral standardized normal statistics linked to the value of α (0.05); P (0.50) is the value that maximizes the sample size; ε (0.05) is the maximum tolerable sampling error; N (300) is the estimated population to be sampled; and n refers to the minimum sample size, which resulted in a 172 records.

COLLECTION INSTRUMENTS

The variables collected from the medical records were divided into dependent and independent. As a dependent variable, postoperative complications of neurosurgery restricted to the skull were analyzed. Regarding the independent variables, age (in years), sex (male or female), color (or race), type of surgery performed (elective or urgent), length of hospital stay, whether the patient had any previous comorbidity and the condition that predisposed him to surgery.

STATISTICAL ANALYSIS

The collected data were analyzed in IBM Statistical Package for the Social Sciences (SPSS) version 22.0 spreadsheets. Quantitative variables were expressed as mean and standard deviation, if they had a normal distribution, and median and interquartile range if they did not follow this type of distribution. Qualitative variables were expressed as frequency and percentage.

Inferential analyzes were performed with a significance level of $\alpha = 0.05$, that is, a confidence level of 95%. The investigation of normality was carried out by applying the Shapiro-Wilk and Kolmogorov-Smirnov tests. The investigation of the existence of association between qualitative variables was carried out using Fisher's Exact Test.

RESULTS

In the present study, a total of 172 patients were included, of which 58.7% were male. Data from Table 1 show that the mean age of patients was 56.74 years, ranging from 46 to 55 years.

As explained in Table 2, among all neurosurgeries restricted to the skull, elective surgeries were more prevalent (51.2%) when compared to emergency neurosurgeries (35.4%). Both had a mean hospital stay of 10.08 ± 6.09 days. Among the main reasons for neurosurgery, brain tumors (33.7%), traumatic brain injury (11%) and chronic subdural hematoma (11%) stood out.

Furthermore, as shown in Table 3, 59.3% of the patients had some type of previous comorbidity. Of these, systemic arterial hypertension stood out as the main one, observed in 53.9%. Regarding post-surgical complications (76.7%), headache (24.7%) stood out, followed by delirium (19.7%), fever (16.7%), paresis/hemiparesis (11.4%), intraparenchymal hematoma (9.1%), hypokalemia (9.1%) and meningitis (9.1%), as the main ones.

When we link, in Table 4, the appearance of complications in emergency neurosurgeries, significance was noticed in values obtained statistically after analysis of residues with the application of Fisher's Exact Test, such as fever (75%), hypokalemia (91, 70%), increased blood pressure (75%) and emesis (88.9%) with p-values < 0.001, < 0.001, 0.016 and 0.004, respectively. Thus, emergency surgeries were associated with a higher prevalence of the aforementioned complications.

DISCUSSION

When evaluating the prevalence of neurosurgery restricted to the skull, it was observed that of the total sample of 172 patients, 51.2% underwent elective surgery. Concordant data were found in studies from Universidade Paulista6, where 89.9% of patients undergoing neurosurgery were part of the elective group. This fact can be explained by the global increase in neurosurgery, due to the aging of the population and a significant increase in the proportion of elderly people who required elective or urgent procedures in recent years.[15], factor also influenced by brain tumor resection surgeries, which are the first line of treatment for brain neoplasms and are performed electively [16]. In sum, studies have found an increase in the incidence and mortality of central nervous system tumors in

	Average ± SD, n (%) n = 172
Age (years)	56,74 ± 16,02
Age groups (years)	
18 to 25	9 (5,2)
26 to 35	11 (6,4)
36 to 45	13 (7,6)
46 to 55	45 (26,2)
56 to 65	40 (23,3)
66 to 75	34 (19,8)
76 to 85	18 (10,5)
Mais than 85	2 (1,2)
Gender	
Male	101 (58,7)
Female	71 (41,3)
Color and/or race	
White	158 (91,9)
Brown	8 (4,7)
Black	6 (3,5)

SD: Standard deviation.

Table 1. Distribution of patients undergoing cranial neurosurgery in a hospital in the extreme south of Santa Catarina between January 2018 and March 2019.

Source: Survey data, 2021.

	n (%) n = 172
Hospital stay (days)	10,08 ± 6,09
Deaths	13 (7,6)
Type of surgery	
Elective	88 (51,2)
Urgency	61 (35,4)
Unespecified	23 (13,4)
Reason for surgery	
Brain tumor	58 (33,7)
Chronic traumatic brain injury	19 (11,0)
Chronic subdural hematoma	19 (11,0)
Hemorrhagic stroke	15 (8,7)
Cerebral aneurysm	10 (5,8)
Ventricle-peritoneal shunt reconstruction	9 (5,2)
Acute subdural hematoma	9 (5,2)
Hydrocephalus	8 (4,7)
Subarachnoid haemorrhage	5 (2,9)
Ischemic stroke	4 (2,3)
Epidural hematoma	3 (1,7)
Brain abscess	2 (1,2)
Subarachnoid hemorrhage	1 (0,6)
Cerebellar hematoma	1 (0,6)
Placement of external ventricular shunt	1 (0,6)
Cerebrospinal fluid fistula	1 (0,6)
Cerebral arteriovenous fistula	1 (0,6)
Subdural empyema	1 (0,6)
Other surgeries	5 (2,9)

Table 2. Prevalence between the reason for surgery and the type of surgery.

Source: Survey data, 2021.

	n (%) n = 172
Prior comorbidity	
Presence	102 (59,3)
Absence	70 (40,7)
Kind of comorbidity	
Systemic arterial hypertension	55 (53,9)
Neoplasm	21 (20,6)
Diabetes mellitus	19 (18,6)
Previous neurological event	18 (17,6)
Heart disease	11 (10,8)
Hypothyroidism	7 (6,9)
Pulmonary pathology	5 (4,9)
Other comorbidities	31 (30,4)
Post-surgical complications	
Presence	132 (76,7)
Absence	40 (23,3)
Kind of póst-surgical complications	
Headache	32 (24,7)
Delirium	26 (19,7)
Fever	22 (16,7)
Paresis and/or hemiparesis	15 (11,4)
Intraparenchymal hematoma	12 (9,1)
Hypokalemia	12 (9,1)
Meningitis	12 (9,1)
Increase in blood pressure	11 (8,3)
Emesis	11 (8,3)
Convulsive crisis	11 (8,3)
Hyponatremia	10 (7,6)
Hypernatremia	10 (7,6)
Polyuria	9 (6,8)
Hypomagnesemia	6 (4,5)
Bleeding	6 (4,5)
Diabetes insipidus	5 (3,8)
Crebellar edema	5 (3,8)
Sepsis	2 (1,5)
Other post-surgical complications	64 (48,5)

Table 3. Prevalence of comorbidities and postoperative complications in patients undergoing neurosurgery restricted to the skull in a hospital in the extreme south of Santa Catarina.

Source: Survey data, 2021.

	n	Surgery reason, n (%)		Value-p
		Elective	Urgence	
Complications				
Headache	28	19 (67,9)	9 (32,1)	0,394
Delirium	21	14 (66,7)	7 (33,3)	0,484
Fever	20	5 (25,0)	15 (75,0)[b]	<0,001
Paresis and/or Hemiparesis	12	9 (75,0)	3 (25,0)	0,361
Intraparenchymal hematoma	11	6 (54,50)	5 (45,50)	0,760
Hypokalemia	12	1 (8,30)	11 (91,70)[b]	<0,001
Meningitis	11	6 (54,5)	5 (45,5)	0,760
Increase in blood pressure	12	3 (25,0)	9 (75,0)[b]	0,016
Convulsive crisis	10	3 (30,0)	7 (70,0)	0,109
Hypernatremia	10	4 (40,0)	6 (60,0)	0,318
Emesis	9	1 (11,1)	8 (88,9)[b]	0,004
Hyponatremia	9	7 (77,8)	2 (22,2)	0,310
Polyuria	9	8 (88,9)	1 (11,1)	0,083
Hypomagnesemia	7	2 (28,6)	5 (71,4)	0,123
Bleeding	6	2 (33,3)	4 (66,7)	0,227
Diabetes insipidus	5	3 (60,0)	2 (40,0)	0,999
Cerebellar edema	5	4 (80,0)	1 (20,0)	0,649
Sepsis	2	1 (50,0)	1 (50,0)	0,999

[†]Values obtained after application of Fisher's exact test. bStatistically significant values obtained after residual analysis.

Table 4. Association between the type of post neurosurgery complication and its association with elective or urgent surgeries.

Source: Survey Data, 2021.

most developed countries, especially in older age groups.[17]

With regard to age, the average found in the present study was 56.74 years. Concordant data were found in the international literature [18] with larger samples of neurosurgical patients, where an average age of 54.3 years was obtained. The age profile of patients can be explained taking into account the higher prevalence of some comorbidities at older ages, which may be predisposing factors for neurosurgery, among which the association of arterial hypertension and subarachnoid hemorrhage stands out. [19].

Regarding the profile of the analyzed patients, there was a higher prevalence of males (58.7%). In common agreement, data from the literature18 also show a higher prevalence of neurosurgery in patients of this gender. There is evidence [20] that chronic subdural hematoma, one of the main causes seen in the present study as a reason for neurosurgery, has a high prevalence in male patients, a fact motivated by the greater occurrence of cranial asymmetry in men, as well as the high exposure of males to injuries.

In the current study, the mean hospital stay of patients was 10.08 ± 6.09 days, which is consistent with post-neurosurgery studies for brain tumors, where a mean hospital stay of 7.8 days was found. ± 8.7 days[21], by mutual agreement with 12.5 days [18]. Factors such as age and postoperative complications, such as infections, are responsible for increasing the length of stay of these patients. [22].

Among the neurosurgeries, the most prevalent in the present study were brain tumor resection surgeries, occurring in 33.7% of the patients (n = 58). Data confirmed by Siqueira et. al.[6] where 51.9% of patients undergoing elective neurosurgery had a diagnosis of brain tumors. It also shows agreement with another study [23], in which 49.8% of individuals admitted for neurosurgery also had tumors as a prevalent condition. The high prevalence is due to the fact that surgery remains the first and most important modality for the treatment of most solid brain tumors.[16].

Traumatic brain injury (TBI) was the second reason for admissions to neurosurgery in the study in question, with a prevalence of 11% (n = 19). This data contrasts with the world literature, where some authors6 report that TBI is the most frequent diagnosis in emergency neurosurgeries, affecting 38.7% of patients. Others[24] show that 19% of patients undergoing decompressive craniectomy were caused by TBI. What may explain this discrepancy in percentages is the variability of TBI causes, given that in Western countries [25] it is more common to occur due to falls, whereas in oriental people26, due to transport accidents.

Chronic subdural hematoma (CHS) is one of the most common causes of neurosurgical diagnoses in adults. [27], being the cause of neurosurgery in 11% of patients (n = 19) in the study in question. It develops over a course of three weeks or more. [28], being associated with a history of trauma, alcohol abuse, seizures, coagulopathies, or anticoagulation [29]. In a sample [30] with 1133 subjects with chronic subdural hematoma, 85% of patients had surgery as a treatment. This divergence from the current research may be related to the fact that the previously mentioned study is a retrospective cohort with many patients, since surgical treatment is the main choice in those with neurological symptoms, radiographic evidence of cerebral compression and acceptable surgical risk.[31,32]

Of the medical records analyzed, 59.3% of the patients had some comorbidity prior to neurosurgery. However, in different literature33, a lower percentage was found, 30.7%, when verified in individuals undergoing resection of cranial tumors. Furthermore, they report [34] the finding of 19%

of TBI victims with chronic comorbidities. A possible explanation for this finding is the fact that the patients are older, a fact mentioned by other authors35, where 64.3% who underwent some neurosurgery were between 40 and 61 years old, which partially converges with the research current.

When evaluating the present sample, 53.9% of the individuals submitted to neurosurgery had previously had systemic arterial hypertension (SAH). Concordant data were found in studies [36] in the United States, where 36.4% of patients who underwent tumor resection had SAH, and of these, 52.9% progressed to complications, placing this condition as a major risk factor.. Autthors[23] show that this comorbidity is one of the reasons for postoperative complications, when associated with advanced age, time of surgery and prolonged stay in the intensive care unit. Furthermore, it is reported that high blood pressure (BP) is a risk factor for intracerebral hemorrhage, gliomas, cerebrovascular accident (CVA) and cerebral aneurysm. [37,38,39,40,41], conditions that may require neurosurgical management. It was observed that the increase in BP was significantly associated with emergency surgeries, with 75% of patients undergoing this type of surgery having hypertension as a postoperative complication. No data were found in the literature consistent with this association. However, as previously mentioned, SAH is a risk factor for some pathologies, which may require a future emergency surgical procedure, such as rupture of intracerebral aneurysms and hemorrhagic CVA.[42,43]

Postoperative headache is a poorly understood condition [44]. In the current study, the prevalence of headache was 24.7%. However, data from the world literature show that this percentage varies according to the surgical technique performed. [45]. One study[46] reported that 24.6% of patients who underwent embolization of cranial aneurysms developed headache. On the other hand, this percentage was significantly higher in another study [47], where 58% of individuals submitted to tumor resection presented the condition, lasting up to seven days. Some mechanisms, such as nerve compression, meningeal inflammation and dural adhesions are discussed in order to explain the occurrence of headache.[44], In addition, it was seen that the correlation between tumor size and surgical approach can influence.[48]

In the present study, postoperative delirium was found in 19.7% of the patients analyzed. The occurrence of delirium varies greatly between studies. Evidences[49] show that 24.2% of individuals undergoing microvascular decompression developed delirium. It was seen that these patients were mostly male, of a more advanced age group, with a previous history of arterial hypertension and who used anticonvulsants. [50], which in part is consistent with the current research. A possible explanation for the occurrence of delirium is that most neurosurgical patients are more susceptible to neuroendocrine and electrolyte disturbances, such as syndrome of inappropriate antidiuretic hormone secretion and diabetes insipidus.[51]

Fever is one of the most common post-surgical complications seen in medical and surgical settings.[52]. Bibliographic data[53] show that the occurrence of fever in the postoperative period is associated with antibiotic therapy, the use of a central venous catheter and prolonged mechanical ventilation, where 55.7% of the patients had a febrile episode. In the current research, only 16.7% of the patients had fever, which is in agreement with the literature, since the incidence of postoperative fever, reported in most studies, is within a range of 13.2% to 70%, in a wide spectrum of neurosurgical specialties54,55. Postoperative fever was statistically significantly associated with emergency surgeries, found in 75% of those who underwent this type of neurosurgery. No data regarding such association were found in the literature. However, it has been reported that hyperthermia that appears one or two days after surgery is usually caused by stress or trauma, and after this period, postoperative fevers often have more serious causes, such as infected wounds.[56]. The incidence of infected wounds in craniotomies ranges from 2.2% to 19.8%, and urgent/emergency surgeries are one of the factors for the development of this condition and, therefore, of fever.[57,58]

Paresis and hemiparesis were found in 11.4% of patients with neurosurgical complications. evidence [59,60] bring paresis as an intercurrence after glioma resection surgery and in patients with Parkinson's disease undergoing stereotactic surgery. Studies [61] explain the oculomotor nerve paresis after bilateral hematoma drainage due to rapid unilateral decompression, resulting in the distortion of midline structures, causing a transient contralateral transtentorial herniation. In addition, neurosurgical intervention independently can generate lesions of brain structures, resulting in paresis and hemiparesis.[62]

Post-surgical hemorrhages are one of the most serious complications of neurosurgical procedures, being associated with a significant mortality.[63] Intraparenchymal hematomas, although less common than subdural and epidural hematomas, can also lead to significant morbidity.[64] The frequency of this type of hemorrhage in a large-scale post-craniotomy analysis[65] ,was 10.8%, partially agreeing with the present research, where 9.1% of the patients had it. Postoperative hemorrhage can be explained by the presence of some previous risk factors, such as metabolic syndromes (systemic arterial hypertension, diabetes, and coronary artery disease), in addition to the use of anticoagulants or having an extensive surgical excision.[63]

Hypokalemia is often complex, involving both potassium losses from the body and potassium changes in cells. [66]. It is defined as a serum potassium concentration < 3,5 mEq/L[67]. In the present study, 9.1% of patients undergoing surgeries restricted to the skull had hypokalemia. When the relationship with emergency neurosurgery is evaluated, its prevalence rises to 91.7%, showing a statistically significant association. However, there are no numerical data on hypokalemia as a postoperative complication in neurosurgery. However, it is a common electrolyte disturbance in the intensive care unit, and some points may justify the occurrence of this condition, such as the use of ß2-adrenergic drugs, which inhibit the entry of potassium into the cell, or diuretics, the induction of coma with thiopental in patients with subarachnoid hemorrhage and the presence of hypothermia in the patient [66,68]. Hypokalemia is known to be a frequent complication seen after traumatic brain injury. [69], which are also one of the most common emergencies seen in neurosurgery [70], thus being the second leading cause of neurosurgery in the current research.

Regarding meningitis after neurosurgical procedures, references show that the occurrence of this condition varies according to the procedure performed: from 1.52% to 8.6% in craniotomies [71,72] and reaching up to 22% in insertions of external ventricular drains [73]. In the study in question, it was 9.1%, in agreement with the references cited above. Factors trying to explain the development of meningitis, such as having a concomitant infection at the incision site and duration of more than four hours of surgery [74]. In addition, colonization of ventricular catheters seems to be the main cause for the emergence of meningeal infection. [75]

The occurrence of emesis, in the research in question, was significantly associated with emergency surgeries, which occurred in 88.9% of the patients. According to authors [76], after neurosurgery, the estimated frequency of vomiting is 39%, with female gender, previous history of postoperative nausea and vomiting, prolonged surgery time and preoperative anxiety being some of the risk factors.[77,78]

CONCLUSION

The present study analyzed the main complications of neurosurgery restricted to the skull in elective and emergency surgeries. In addition, it was observed whether previous comorbidities and the type of surgery could interfere with the appearance of these adversities.

In short, among the most prevalent complications in surgeries restricted to the skull, headache (24.7%), delirium (19.7%), fever (16.7%), paresis and/or hemiparesis (11.4%), intraparenchymal hematoma (9.1%), hypokalemia (9.1%) and meningitis (9.1%).

Furthermore, the data obtained showed a statistically significant association between fever, hypokalemia, increased blood pressure and emesis as the most prevalent complications in emergency surgeries.

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