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Postoperative complications in elective and non-elective neurosurgery

Complicações pós-operatórias em neurocirurgia eletiva e não eletiva

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Keywords
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Abstract

Objective: To evaluate the incidence of postoperative complications and mortality among patients submitted to elective or non-elective neurosurgery.

Methods: Prospective cohort study in adult patients, followed from preoperative period until hospital discharge or death.

Results: One hundred and twenty seven patients were included in elective surgery group and 75 patients in non-elective surgery group. The elective group had more vomiting (p=0.010) and pain (p<0.001) and the non-elective group presented more intracranial hypertension (p=0.001), anisocoria (p=0.002), cerebral vasospasm (p=0.043), light-unresponsive pupil (p=0.006) and reoperation (p=0.046). The mortality rate was 5.5% in the elective surgery group and 26.7% in the non-elective surgery group (p<0.001).

Conclusion: Elective procedures in neurosurgery are related to higher frequencies of systemic complications while non-elective surgeries had significantly higher rates of neurological complications and mortality.

Resumo

Objetivo: Avaliar a incidência de complicações pós-operatorias e mortalidade entre pacientes submetidos a neurocirurcia eletiva e não eletiva.

Metodos: Estudo de coorte prospectivo com pacientes adultos, acompanhados desde o período pré-operatório até a alta hospitalar ou óbito.

Resultados: Foram incluídos 127 pacientes no grupo cirúrgico eletivo e 75 pacientes no grupo cirúrgico não eletivo. O grupo eletivo teve mais vômitos (p=0,010) e dor (p<0,001) e o grupo não eletivo apresentou mais hipertensão intracraniana (p=0,001), anisocoria (p=0,002), vasoespasmo cerebral (p=0,043), pupilas não fotorreagentes (p=0,006) e reoperação (p=0,046). A taxa de mortalidade foi de 5,5% no grupo de cirurgia eletiva e 26,7% no grupo de cirurgia não eletiva (p<0,001).

Conclusão: Os procedimentos eletivos em neurocirurgia estão relacionados a maior frequência de complicações sistêmicas, enquanto as cirurgias não eletivas tiveram taxas significativamente mais altas de complicações neurológicas e mortalidade.

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Introduction

Neurosurgical patients are at high risk of neurological and systemic complications even in elective procedures. Inherent complexities of this population, extended hospital stays, urgent and emergency procedures and secondary complications end-up increasing the basal risk.[1]

The most commonly observed neurological complications in the postoperative period of elective skull surgeries include decreased level of consciousness,[1] cerebral vasospasms,[2] refractory seizures,[1,3] reoperation,[4-6] hemiparesis and intraparenchymal hematoma.[7,8] In non-elective surgeries, intracranial hypertension,[9] motor deficits,[10] recurrent subdural hematoma,[10,11] intraparenchymal hemorrhage,[12] vasospasms,[13] and seizures[10,14] are also reported.

Systemic complications in the postoperative period of elective neurosurgeries include nausea and vomiting,[15] hypotension, respiratory distress,[1] and surgical site infection.[16] For non-elective surgeries, pain[17] and nosocomial infections are also observed.[5]

The overall mortality rate has been reported to be only 1%[1,18] after elective neurosurgery, as compared to 29% after emergency neurosurgery,[19] with postoperative complications increasing the risk of death in both groups.[5,18] The early recognition and management of the complications are crucial for the outcome of these patients.

The purposes of this study were to report and compare post-operative complications rates after elective and non-elective neurosurgeries.

Methods

This prospective study was conducted in a university hospital in São Paulo, Brazil. All patients submitted to elective or non-elective procedures and above 18 years old were included. Exclusion criteria were pregnancy, presence of infections or abnormal coagulation at admission, previous thrombolytic treatment, transference to another hospital during the postoperative period and absence of pre-operative computed tomography (CT) scan.

Preoperative data were obtained from medical charts. Patients were followed on a daily basis from the surgical procedure to hospital discharge or death. Variables included in the analysis were: age, gender, past medical history, diagnosis, type of care unit, Glasgow Coma Scale (GCS), pre-operative length of stay and type of surgery (elective or non-elective, the latter including urgency and emergency procedures).

The postoperative period data was divided into immediate (first 24 hours) and late postoperative (> 24 hours). The following variables were analyzed: GCS or Ramsay sedation scale, type of care unit (neurosurgical intensive care unit or neurosurgical ward), and length of the postoperative stay, total hospitalization time, neurological and systemic complications, and outcomes (discharge or death).

Sample size calculation was based on number of surgeries per month that fulfilled the inclusion criteria. The number of surgeries was observed for three months and considering a 95% confidence interval, a sample of 171 patients was calculated in a period of 10 months.

All analysis were performed using the SPSS19™ (SPSS Institute Inc., Chicago, IL, USA). The descriptive analysis was carried out by means of absolute and relative frequencies. The calculation of the relative risk (RR) was performed using Poisson regression with covariance matrix and logit logistic function. The confidence interval (CI) of the RR was estimated by Poisson distribution. The hypothesis test used was based on the Wald test, Student's t-test, and Fisher's exact test. Kaplan-Meier survival analyses were used to estimate the mean and median survival rates. The hypothesis test for equality of means according to factors was done via the non-parametric log-rank test (or Mantel-Cox). All tests took into consideration a two-tailed α of 0.05 and a 95% CI.

The development of the study met the standards of ethics in research involving human beings (CEP 0707/10 - Research Ethics Committee of the Universidade Federal de São Paulo/ Hospital São Paulo).

Results

A total of 229 patients were screened, out of which 27 were excluded (15 due to transference to another hospital in the postoperative period, five patients were under chronic anticoagulation, four had an preoperative infection, three refused to participate in the study), resulting in a total of 202 patients included in the study and divided in 2 groups: elective group (n=127) and non-elective group (n=75).

The median age of the patients in the elective group was 50 years (range, 19-80 years) and in the non-elective group was 53 years (range, 18-91 years) (p=0.35) and 46.7% were men in the elective group while 64.0% in the non-elective group (p=0.01). A predominance of patients with diagnostic of brain tumors was observed in the elective group (51.9 *vs* 2.7%, p = 0.001) while traumatic brain injury was the most frequent diagnosis in the non-elective group (0.8 and 38.7%, p <0.001). The frequency of intracranial aneurysms was similar between groups (22.8 and 21.3%, p = 0.92).

The preoperative median of GCS was 15 (range, 11-15) in patients of elective group and 14 (range, 3-15) in patients of non-elective group (p<0.001). The median preoperative period was 5 days (range, 1-62 days) in elective surgeries and 2 days (range, 1-12 days) in the non-elective group (p<0.001).

Patients who underwent elective surgery had a history of seizures more frequently (10.2%, p=0.006) whereas patients who underwent non-elective surgery had more often a history of alcoholism (p=0.024) and were free of previous comorbitities (p<0.001).

Most patients from the elective surgery group underwent craniotomy (78.7%), whereas in the non-elective surgery group, craniectomy (45.3%) and burr hole trepanation (37.3%) were the most frequently performed procedures (p<0.001). The average anesthesia and surgery time (12.2 ± 4.6 hours vs 7.6 ± 4.6 hours, p<0.001) was longer among patients from the elective surgery.

Immediate postoperative period

After the procedure, 114 (89.8%) patients from the elective group and 60 (80%) patients from the non-elective group were admitted to the intensive care unit (ICU) (p=0.052). Using the Ramsay sedation scale, patients from the non-elective group were more sedated in the immediate postoperative period (median of 6, p<0.001).

Neurological and systemic complications rate per patient were similar between groups (45.5% vs 52.9%, p=0.402, elective vs non-elective; 98.3% vs 98.5%, p>0.99, elective vs non-elective, respectively). Types and rates of specific complications are shown in table 1.

Table 1. Neurological and systemic complications during the immediate postoperative period

Characteristics	Elective (n=127) n (%)	Non-elective (n=75) n (%)	p-value	RR (CI95%)
Neurological				
Intracranial hypertension	1(0.8)	8(10.7)	0.013†	0.07(0.01-0.57)
Intraparenchymal hemorrhage	3(2.4)	2(2.7)	0.893†	0.88(0.15-5.18)
Pneumocephalus	16(12.6)	3(4.0)	0.061†	3.15(0.94-10.45)
Periorbital hematoma	18(14.2)	11(14.7)	0.923*	0.97(0.48-1.93)
Anisocoria	5(4.7)	14(18.7)	0.002*	0.21(0.08-0.56)
Cardiovascular				
Arterial hypotension	16(12.6)	15(20.0)	0.160*	0.630(0.33-1.19)
Arterial hypertension	44(34.6)	26(34.7)	0.998*	0.99(0.67-1.47)
Vasoactive drugs	24(18.9)	30(40.0)	0.001*	0.47(0.30-0.74)
Sinus bradycardia	18(14.2)	12(16.0)	0.724*	0.88(0.45-1.73)
Sinus tachycardia	45(35.4)	29(38.7)	0.643*	0.91(0.63-1.32)
Gastrointestinal				
Vomiting	23(18.1)	1(1.3)	0.010†	13.58(1.87-98.5)
Metabolic				
Potassium disorders	4(3.1)	9(12.0)	0.022†	0.26(0.08-0.82)
Hyperglycemia	86(67.7)	43(57.3)	0.155*	1.18(0.93-1.48)
Intensive insulin therapy	3(2.4)	2(2.7)	0.890†	0.88(0.15-5.18)
Hyperthermia	26(20.5)	26(34.7)	0.026*	0.59(0.37-0.93)
Hypothermia	19(15.0)	18(24.0)	0.109*	0.62(0.35-1.11)
Headache	33(26.0)	5(6.7)	0.003*	3.89(1.59-9.55)

*Chi-square test; †Fisher's exact test; RR - Relative risk; CI - Confidence interval

Late postoperative period

The GCS and Ramsay sedation scale were similar in both groups during the postoperative period (p>0.99). Neurological and systemic complications rate per patient were also similar between

Table 2. Neurological and systemic complications during the postoperative period

Characteristics	Elective (n=127) n (%)	Non-elective (n=75) n (%)	p-value	RR (CI95%)
Neurological				
Intracranial hypertension	14(11.0)	37(49.6)	0.001*	0.22(0.13-0.38)
Intraparenchymal hemorrhage	7(5.5)	5(6.7)	0.735†	0.83(0.27-2.51)
Intraventricular hemorrhage	2(1.6)	5(6.7)	0.080†	0.23(0.04-1.18)
Vasoespasm	2(1.6)	6(8.0)	0.043†	0.19(0.04-0.41)
Focal seizures	4(3.4)	1(1.3)	0.438†	2.36(0.26-20.4)
Generalized seizures	3(3.4)	2(2.7)	0.893†	0.88(0.15-5.18)
Hydrocephalus	1(0.8)	2(2.7)	0.316†	0.30(0.27-3.20)
CSF leak	5(3.9)	4(5.3)	0.643*	0.73(0.20-2.66)
Periorbital edema	40(31.4)	24(32.5)	0.941*	0.98(0.64-1.49)
Periorbital hematoma	31(24.4)	19(25.3)	0.883*	0.96(0.58-1.54)
Light-unresponsive pupil	6(4.7)	13(17.3)	0.006*	0.27(0.08-0.68)
Aphasia	5(3.9)	3(4.0)	0.482†	0.98(0.24-4.00)
Reoperation	10(7.9)	13(17.3)	0.046*	0.45(0.21-0.98)
Cardiovascular				
Arterial hypotension	26(20.5)	35(46.7)	0.001*	0.43(0.28-0.66)
Arterial hypertension	94(74.0)	63(84.0)	0.082*	0.88(0.76-1.01)
Vasoactive drug	31(24.4)	46(61.3)	<0.001*	0.40(0.28-0.57)
Arrhythmia	2(1.6)	5(6.7)	0.080†	0.23(0.04-1.18)
Sinus bradycardia	33(26.0)	36(69.3)	0.001*	0.54(0.37-0.79)
Sinus tachycardia	75(59.1)	55(73.3)	0.033*	0.81(0.66-0.98)
Cardiac arrest	6(4.7)	20(26.7)	0.001*	0.18(0.07-0.42)
Venous thromboembolism	1(0.8)	1(1.3)	0.708†	0.59(0.04-9.30)
Pulmonary embolism	1(0.8)	2(2.7)	0.316†	0.30(0.03-3.20)
Gastrointestinal				
Nausea	25(19.7)	10(13.3)	0.258*	1.48(0.75-2.90)
Vomiting	35(27.6)	25(33.3)	0.382*	0.83(0.54-1.27)
Gastroesophageal reflux	4(3.1)	14(18.7)	0.001†	0.17(0.06-0.49)
Renal				
Acute kidney injury	2(1.6)	8(10.7)	0.014†	0.15(0.03-0.68)
Urinary retention	13(10.2)	13(17.3)	0.148*	0.59(0.29-1.21)
Metabolic				
Potassium disorders	29(22.8)	38(50.7)	0.001*	0.45(0.31-0.67)
Calcium disorders	33(26.0)	33(44.0)	0.008*	0.59(0.40-0.87)
Sodium disorders	42(33.1)	44(58.7)	0.001*	0.56(0.41-0.77)
Hypoglycemia	17(13.3)	26(34.7)	0.001*	0.39(0.23-0.66)
Hyperglycemia	86(67.7)	55(73.3)	0.390*	0.92(0.77-1.11)
Infectious				
Hypothermia	64(50.4)	42(56.0)	0.435*	0.90(0.69-1.17)
Hyperthermia	65(51.2)	54(72.0)	0.002*	0.71(0.57-0.89)
Bloodstream infection	7(5.5)	6(8.0)	0.488*	0.69(0.24-1.97)
SSI	3(2.4)	4(5.3)	0.277†	0.44(0.10-1.93)
Meningitis	2(1.6)	5(6.7)	0.080†	0.24(0.05-1.19)
Pulmonary infection	10(7.9)	23(30.7)	<0.001*	0.26(0.13-0.51)
Urinary tract infection	6(4.7)	8(10.7)	0.117*	0.44(0.16-1.23)
Headache	83(65.4)	21(28.0)	<0.001*	1.98(1.42-2.76)

*Chi-square test; †Fisher's exact test; RR - Relative risk; CI - Confidence interval; CSF - Cerebrospinal fluid; SSI - Surgical site infection

groups (71,7 *vs* 79.7%, elective *vs* non-elective, p=0.24; 99.2 *vs* 98.6%, p>0.99, elective vs non-eletive, respectively). Major complications like intracranial hypertension, light-unresponsive pupil, and hemodynamic instability among others occurred more often in the non-elective group. Types and rates of specific late complications are shown in table 2.

The median stay in the ICU during the postoperative period in elective group was three days (range, 1-63 days) and 11 days (range, 1-54 days) for non-elective group (p<0.001). The total median

postoperative periods were five days for elective surgery patients (range, 1-63 days) and 11 days (range, 1-88) for non-elective surgery patients (p<0.001). The hospitalization period was 12 days (range, 5-76 days) for the elective surgery and 15 days for non-elective surgery patients (range, 3-91 days) (p=0.090).

Seven patients (5.5%) from the elective surgery group and 20 patients (26.7%) from the emergency surgery group died during the postoperative period (p<0.001). Brain death was diagnosed in three patients from the elective surgery group and in eight patients from the non-elective surgery group (p=0.030; RR, 0.21). Kaplan Meyer survival curves from both groups are shown in figure 1.

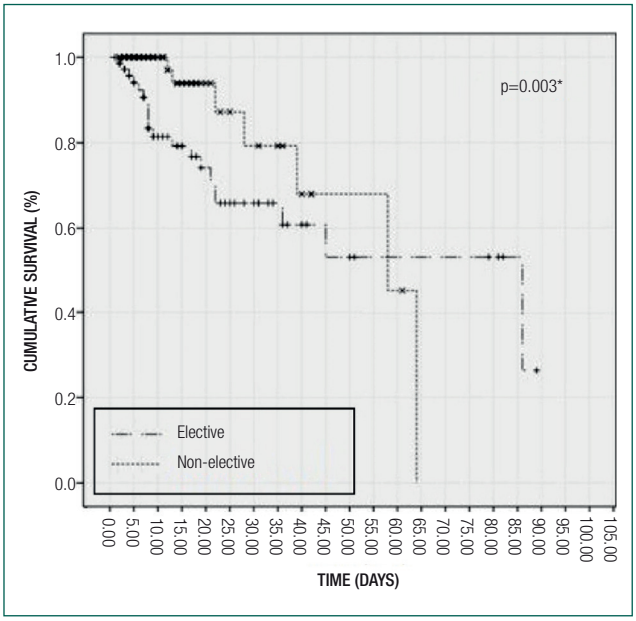

Figure 1. Kaplan-Meier survival curve
*Log Rank (Mantel-Cox)

The patients from the non-elective surgery group were hospitalized for a significantly shorter period before death compared to patients from the elective surgery group (p=0.003). Until day 5 after surgery, the probability of death among the patients from the non-elective group was approximately 10%, whereas it was 0% for the elective surgery group. Until day 10 of the postoperative period, the probability of death remained zero for the elective surgery patients, and reached 20% for the non-elective surgery group. After 25 days of hospitalization, the probability of death had increased to 35% for non-elective surgery patients and 20% for elective surgery patients.

Discussion

The limitation of this study is related to the pre-operative evaluation, where only prior neurological complications were found and monitored during the postoperative period and the systemic complications were not, it were only noted on the pathological history.

In recent study that assessed postoperative complications in patients who underwent surgical treatment for epilepsy and resection of brain metastases, no intracranial hypertension was observed during the postoperative period.[4] By contrast, among 270 patients who underwent decompressive craniectomy in a previous study, 91 (33.7%) went on to develop a herniation in the postoperative period.[14] Here, the intracranial hypertension's incidence was found to be greater among patients who underwent non-elective as compared to elective surgery patients. The lack of studies that compare these two surgical possibilities makes the comparison more difficult. However, it has been well-established that in patients having undergone decompressive craniectomy, persistent intracranial hypertension is often observed after the surgical procedure.[9,12] In this study, pupillary changes were examined in the postoperative period in patients who underwent emergency skull surgery. Based on the literature, pupillary changes that occur in the pre-operative period are associated with a worse prognosis.[9,20]

According to previous studies, vasospasms are reportedly observed during the postoperative period in 53.8% of patients having undergone resection of acoustic neuroma,[2] whereas in patients having undergone surgery for ruptured aneurysms, vasospasms have been reported in 22.3% of all cases.[13] Conversely, in our study, only 1.6% of patients who underwent elective surgery suffered vasospasms. However, it is worth noting that detailed examinations were only per-

formed for symptomatic patients, and the actual incidence rate may hence be higher. Similarly, in patients having undergone non-elective surgery in our study, the vasospasm incidence was higher (8.0%) in the postoperative period, but still substantially lower than the results presented in the literature.

Reoperation for hematoma formation or recurrence, cerebral edema, and hydrocephalus are more common in patients who have undergone emergency skull surgery compared to elective surgery patients, because of a greater neurological instability in these patients. In a previous study, patients who underwent elective surgery for resection of brain metastases were examined in order to assess the need for a new surgical procedure, and it was found that 13.9% needed reoperation,[4] which is a substantially higher rate than what was observed in this study. Among patients who underwent emergency surgery for spontaneous cerebellar hematomas, 15.8% reportedly needed a new surgical procedure, similar to our results.[21]

In this study, the incidence of headache was higher than other study that observed postoperative complications after craniotomy for brain tumor surgery.[17] Headache has moreover been identified in 60% of patients undergoing surgery for acute-on-chronic subdural hematomas in a previous study.[22] In our study, 28% of patients who underwent emergency surgery experienced headache, but it is worth mentioning that although the median rate in the Ramsay sedation scale was similar in the two groups, emergency surgery patients remained in deep sedation longer in the postoperative period, thus reducing the reports and signs of pain during this period.

Patients who undergo elective skull surgery reportedly experience nausea and vomiting in 33% of cases, which is similar to the results of our study, 18.1% of patients from the elective surgery group.[15] Interestingly, it has been demonstrated that female sex and the absence of steroids intra-operatively are associated with an increased risk of nausea and vomiting.[15]

In patients who underwent emergency skull surgery there were more cases of hypotension, arrhythmia, and cardiac arrest, and greater use of vasoactive drugs in comparison with elective surgery patients. One study that followed patients who underwent electives and emergencies neurosurgeries identified only 0.6% of cardiac arrest.[6]

In the postoperative period, patients from the emergency surgery group experienced more cases of acute kidney injury (AKI). In studies with patients who underwent emergency skull surgery for TBI and SDH drainage, AKI was diagnosed in only 1.3 to 2.5% of patients.[9,22] Patients from the emergency surgery group moreover had a greater incidence of hypotension with the need for vasoactive drugs, which may be related to the AKI.[23]

Patients in the emergency surgery group also had a higher incidence of hypoglycemia and use of intensive insulin protocols than patients in the elective surgery group. This result may be associated with the higher mortality rate in the emergency surgery group. A study that followed patients after resection of brain tumor found 1.5% of patients with manifestations of poor glycemic control, hypoglycemic coma in most cases.[24]

Cases of hyperthermia in the postoperative period may indicate an infectious state, or even a change caused by a failure in the central control of temperature. Studies that included patients who underwent skull surgeries identified pneumonia during the postoperative period in 0.5%-4.1% of patients.[5,7-9] In our study, the incidence of pneumonia in the postoperative period was higher among emergency surgery patients. One study found 3.0% of unplanned reitubation and 7.6% of failure to wean from ventilator for more than 48 hours in the postoperative period of neurosurgery but the incidence of pneumonia was 3.6%.[6]

Few studies to date have assessed the mortality of patients resulting from elective or emergency skull surgeries. In this study, the mortality rate was higher in the non-elective surgery group compared to in the elective surgery group (26.7% vs. 5.5%, respectively). The mortality rates observed in previous studies with emergency surgery patients vary from 1.4% to 35.0%.[10,19,22,25] Some studies with emergency surgery patients analyzed factors associated with the risk of death: low scores in the GCS

and anisocoria were identified as important factors associated with a worse prognosis.[6,9,20] Accordingly, in this study, patients who underwent emergency surgery had lower scores in the GCS compared to the elective surgery patients.

Conclusion

No differences between the two groups of patients regarding the number of neurological and systemic complications were observed in this study. Patients who underwent elective surgery suffered more vomiting and headache events in the immediate postoperative period, and headache in the postoperative period. Conversely, patients who underwent non-elective surgery experienced more anisocoria events in the immediate postoperative period, and in the postoperative period, besides higher rates of IH, vasospasm, light-unresponsive pupil, need for reoperation, use of vasoactive drugs, hypotension, tachycardia and sinus bradycardia, cardiac arrest, gastric reflux, electrolyte alterations, hypoglycemia, hyperthermia, and pneumonia. The mortality rate was higher among patients who underwent emergency surgery.

Collaborations

Siqueira EMP e Diccini S declare that they contributed to the conception of the project, analysis and interpretation of the data, writing of the article, relevant critical review of intellectual content and final approval of version for publication.

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