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Prognosis in Traumatic Brain Injury

Indicadores prognósticos no trauma cranioencefálico

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Abstract

Objective To characterize the profile of TBI victims who required neurosurgical approach in two reference hospitals in the metropolitan area of Florianópolis, state of Santa Catarina, Brazil, and to identify the prognostic increase in the Pupil Reactivity Score when subtracted from the Glasgow Coma Score, found in the Glasgow-P. Additionally, to present demographic, etiological, clinical, and tomographic data, and associate them with the outcome of death.

Methods Medical record data and computed tomography (CT) scans of patients with TBI undergoing neurosurgical procedures from January 2014 to April 2019, at 2 reference hospitals in the metropolitan area of Florianópolis, state of Santa Catarina, Brazil – Hospital Regional de São José Dr. Homero de Miranda Gomes (HRSJ-HMG, in the Portuguese acronym) and Hospital Governador Celso Ramos (HGCR, in the Portuguese acronym).

Results The results of the 318 cases studied indicated that the male gender predominated (87.7%). The most affected age group was between 35 and 65 years old (47.5%). The main cause was motorcycle accidents (26.1%), followed by a fall from a height (16.4%). Most patients required admission to the intensive care unit (ICU) (85.8%), with an average duration of 13 days. The average total hospital stay was 28 days. Most cases needed external ventricular drain (EVD) (64.8%). The predominant tomographic classification was Marshall II (43.4%), followed by Marshall IV (26.1%). Most patients presented with extra-axial hematoma (64.2%), with subdural hematoma (SDH) being the most frequent (45%). Most patients presented with sequelae at hospital discharge (43.4%).

Conclusion There was no clinically relevant increase between the Glasgow and Glasgow-P scores for the tested outcomes (need for decompressive craniectomy, midline shift, presence of basal cisterns obliteration, need for ICU admission, and death).

Keywords
- traumatic brain injury
- neurosurgery
- prognosis
- prevention and control
- epidemiology

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Resumo

Objetivos Caracterizar o perfil das vítimas de trauma cranioencefálico (TCE) que necessitaram de abordagem neurocirúrgica em dois hospitais de referência na Grande Florianópolis, SC, Brasil, e identificar o incremento prognóstico do Escore de Reatividade Pupilar quando subtraído do Escore de Coma de Glasgow, resultando no Glasgow-P. Ademais, apresentar dados demográficos, etiológicos, clínicos e tomográficos, e associá-los ao desfecho óbito.

Métodos Foram analisados dados de prontuários e exames tomográficos de pacientes com TCE submetidos a procedimentos neurocirúrgicos no período de janeiro de 2014 a abril de 2019, em 2 hospitais de referência na Grande Florianópolis – Hospital Regional de São José Dr. Homero de Miranda Gomes (HRSJ-HMG) e Hospital Governador Celso Ramos (HGCR).

Resultados Para os 318 casos analisados, os resultados mostraram que o sexo masculino predominou (87,7%). A faixa etária mais acometida foi de 35 a 65 anos (47,5%). A principal causa foi acidente motociclístico (26,1%), seguido por queda de nível (16,4%). A maioria dos pacientes necessitou de internação na unidade de tratamento intensive (UTI) (85,8%), com duração média de 13 dias. O tempo médio total de internação hospitalar foi de 28 dias. Houve necessidade de derivação ventricular externa (DVE) na maior parte dos casos (64,8%). A classificação tomográfica predominante foi Marshall II (43,4%), seguida pelo Marshall IV (26,1%). A maioria dos pacientes apresentou hematoma extra-axial (64,2%), sendo o hematoma subdural (HSD) o mais frequente (45%). A maoria dos pacientes apresentou sequelas na alta hospitalar (43,4%).

Conclusão Não houve um incremento clinicamente relevante entre os escores Glasgow e Glasgow-P para os desfechos testados (necessidade craniectomia descompressiva, desvio da linha média (DLM), presença de obliteração de cisternas basais, necessidade de internação em UTI e óbito).

Palavras-chave
- traumatismos craniocerebrais
- neurocirurgia
- prognóstico
- prevenção
- epidemiologia

Introduction

The Center for Disease Control and Prevention (CDC) defines traumatic brain injury (TBI) as a change in normal brain function caused by external forces or penetrating head injury.[1] Considered a "silent epidemic," TBI is the leading cause of death and disability in children and young adults worldwide, being involved in almost half of all deaths from trauma.[2] Many years of productive life are lost and many people suffer years with disability after brain injury, with a predicted burden that exceeds that of conditions such as cerebrovascular disease and dementia.[3]

Traumatic brain injury is a disorder that affects 50 million people each year and more than half of the population of the world throughout their lifetimes, with enormous economic consequences for individuals, families, and the society. Costs relating to the TBI in Europe in 2010 were estimated at € 33 billion,[4] and in the US, estimates reported costs ~ USD 60.4 billion.[5]

The incidence and mortality rates of traumatic brain injury vary widely across countries and regions. In low-income countries, the highest incidence is related to traffic accidents; however, in high-income countries, TBI increasingly affects elderly people, mainly due to falls.[6]

According to data from the Hospital Information System of the Informatics Department of the Unified Health System (SIH/DATASUS, in the Portuguese acronym),[7] during the study period – from January 2014 to April 2019–there were 16,639 admissions due to external causes at the Hospital Regional de São José Doutor Homero Miranda Gomes (HRSJ-HMG, in the Portuguese acronym) and, among these, 385 evolved to death. In the Hospital Governador Celso Ramos (HGCR, in the Portuguese acronym), 12,490 admissions due to external causes were registered, with 207 deaths. In the period from 2014 to 2018, there was an increase of ~ 17.8% in the number of admissions due to external causes in the study hospitals, with a reduction of ~ 20.9% between 2018 and 2019, and when considering the total period, from 2014 to 2019, the reduction was of 6.8%. The increase was the most significant between 2015 and 2016, totaling an increase of ~ 10% in the number of hospitalizations. The total cost related to external causes in both hospitals during the study period was BRL 45,621,725, with an average cost per hospitalization of BRL 1,566.20.[7]

Even knowing the limitations of databases, which result from underreporting, the relevance of this topic is evident, both for health and for the economy, mainly because TBI is largely avoidable. In this sense, the benefits of reducing its occurrence are comprehensive, so prevention measures should be instituted. In this context, robust epidemiological data are essential to quantify the public health burden caused by TBI, aiming to inform prevention policies and the understanding of healthcare needs, in addition to the appropriate allocation of health funds.

Objectives

To characterize the profile of TBI victims who required neurosurgical approach in two reference hospitals in the metropolitan area of Florianópolis, state of Santa Catarina, Brazil, and to identify the prognostic increase in the Pupil Reactivity Score (PRS) when subtracted from the Glasgow Coma Score (GCS), found in Glasgow-P (GCS-P). Additionaly, to present demographic, etiological, clinical, and tomographic data, identifying its overall distribution and profile regarding the gender, age group, and severity of the TBI, in addition to associating them with the outcome of death during the in-hospital stay.

Methods

All procedures performed in the present work complied with the norms established by Resolution 466/12 of the National Health Council of Brazil (CNS, in the Portuguese acronym), whose function is to regulate research involving human beings. After the research was approved by the Plataforma Brasil database and was authorized by the Committee on Ethics in Research of the HGCR and of the HRSJ-HMG – with the Certificates of Presentation of Ethical Appreciation, respectively, 18212819.4.3001.5360 and 18212819.4.3002.0113–, data were collected from electronic medical records and a spreadsheet elaborated for the present study was completed.

This is a retrospective, analytical, longitudinal, and multicenter cohort study based on the analysis of data from electronic medical records and computed tomography (CT) of patients with TBI undergoing neurosurgical procedures from January 2014 to April 2019 in 2 reference hospitals in the metropolitan area of Florianópolis (HRSJ-HMG and HGCR).

The Micromed system (Joinville, SC, Brazil) was used to collect data in both hospitals and, to obtain the skull CTs, the Integrated System of Telemedicine and Telehealth (Sistema de Telemedicina Catarinense [Florianópolis, SC, Brazil]) was used, and measurements were performed using the Weasis Medical Viewer (University Hospital of Geneva, Switzerland), version 3.6.2.

The initial sample includes all of the following codes of neurosurgical procedures among patients with TBI from January 2014 to April 2019:

1. Surgical treatment of extradural hematoma (0403010276)
2. Surgical treatment of intracerebral hematoma (0403010284)
3. Surgical treatment of intracerebral hematoma with complementary technique (0403010292)
4. Surgical treatment of acute subdural hematoma (0403010306)
5. Surgical treatment of chronic subdural hematoma (0403010314)
6. Surgical treatment of depressed skull fracture (0403010268)
7. Cranial trepanation for neurosurgical propaedeutics / intracranial pressure (ICP) monitoring (0403010349)
8. Decompressive craniectomy (0403010020)
9. External ventricular drainage (0403010098)

The ►Fig. 1 and ►Fig. 2 shows the sampling flow.

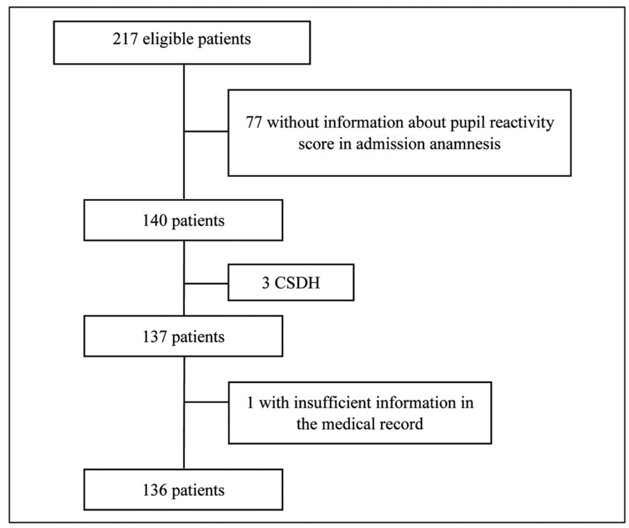


Fig. 1 HRSJ-HMG exclusion flowchart.

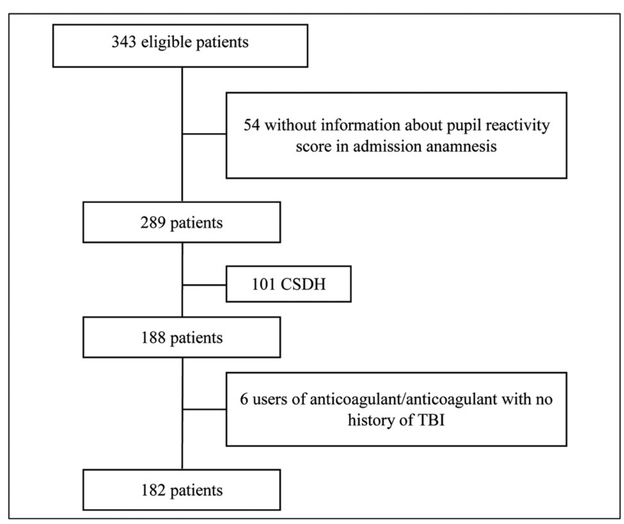


Fig. 2 HGCR exclusion flowchart.
Abbreviation: CSDH, chronic subdural hematoma.

Statistical Analysis

The final database contained 318 patients and, to carry out the descriptive analysis of the categorical variables of interest, the absolute and relative frequencies were used, while in the description of the numerical variables, position measures, central trend and dispersion were used.

Different tests were performed via univariate analysis to verify the association between the variables of interest and the Glasgow Coma Scale (GCS) and Glasgow Coma Scale - Pupils score (GCS-P), as well as in relation to the death outcome. Thus, for categorical variables, the Fisher exact test and the chi-squared test were used; numerical variables, the Mann-Whitney test and the Kruskal-Wallis test were used.

To correlate the GCS and the GCS-P with numeric and ordinal variables, Spearman correlation and a simple linear regression were used.

A logistic regression was also adjusted for the study of varying outcome with dichotomous behaviors and the construction of receiver operating characteristic (ROC) curves, and the Backward method was used for the selection of variables (procedure to remove, at a time, the highest value variable, repeating the procedure until there are only significant variables in the model). Additionally, significance was set at 5% and Pseudo R^2, Maximum variance inflation factor (VIF), and Hosmer-Lemeshow test statistics have been used to check the model adjustment quality.

To verify whether the adjusted models were adequate and had good predictive ability, some fit quality measures were calculated, as follows: area under the ROC curve (AUC), sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy (ACC).

The software used in statistical analyzes was R Studio, version 3.6.0 (R Foundation, Vienna, Austria).

Results

The descriptive analysis of the categorical variables demonstrated that males predominated among patients (87.7%). The most affected age group was between 35 and 65 years old (47.5%), with a mean age of $\sim$ 41 years old, and half of the patients were $\leq$ 36 years old. The day with the highest number of cases was Sunday (20.1%), the month was May (11.6%), and the quarter was the 2nd of the year (29.9%). The causes of TBI were motorcycle accidents (26.1%), ground level fall (16.4%), falls from one's own height (14.2%), running over (12.3%), aggression (11%), automobile accident (9.4%), gunshot (2.8%), and others (7.9%). Most patients had severe TBI (53.1%) at hospital admission. Most of them did not have associated traumatic injuries (48.4%); however, when there was an associated injury, in general, they were multiple injuries (27.4%). When there was an isolated injury, besides TBI, orthopedic trauma was predominant (8.2%).

Most patients needed hospitalization at the ICU (85.8%), with a duration from 8 to 14 days of hospitalization (21.4%), with a mean duration of 13 days (6 patients were not recorded in this calculation because they had been transferred to other hospitals). Regarding the total time of hospital stay, most patients (23.8%) stayed up to 7 days, with an average time of $\sim$ 28 days (although it is important to point out that 3 patients were not considered in this statistic because they had been transferred). Most patients survived (65.7%); however, 43.4% of them had sequelae at hospital discharge, most of which were multiple sequelae (23.3%). Regarding isolated sequelae at hospital discharge, the most frequent was physical sequela (6.6%), followed by cognitive ones (4.7%), and by the absence of interaction with the environment (4.7%). Intracranial pressure monitoring was necessary in most cases (64.8%). The predominant Marshall CT classification was Marshall II (43.4%), followed by Marshall IV (26.1%). Most patients presented with extra-axial hematoma (64.2%), and acute subdural hematoma (ASDH) was the most frequent (45%). The midline shift (MLS) was 4.14 mm, and the greatest was 26 mm; however, in 15 patients it was not possible to measure the MLS as it was possible to retrieve the skull CT images (►**Tables 1**, **2**, and **3**).

Aiming to study how lethality was characterized within the two hospitals studied, its behavior was observed according to the periods presented in the database. Thus, it can be observed that the total lethality was 31.76%. The year with the highest lethality during the study period was 2018, with a lethality of 45.45%, and the quarter with the highest lethality was the 4th quarter, with a lethality of 36.36%.

In the univariate analysis, the chi-squared test and the Fisher exact test were used to compare the variables with deaths and, to calculate the 95% confidence interval (CI) for the odds ratio (OR), a logistic regression was used for each of the variables, considering death as the outcome variable.

The analysis showed that individuals with moderate TBI had a 74% increase in the chance of death (OR = 1.74; 95%CI: 1.17–2.59; $p = 0.013$) when compared with mild TBI. There was a significant association ($p = 0.038$) between the GCS-P and death, and most patients (87.8%) with a GCS-P of 15 did not die. In addition, the OR showed that each one-unit increase in the GCS-P was associated with an average 7% decrease in the risk of death.

There was a significant association ($p = 0.048$) between the presence of subarachnoid hemorrhage (SAH) and death, and most individuals (73.7%) who did not have SAH did not die either. Patients who required external ventricular drain (EVD) had a 175% increase in the chance of death (OR = 2.75; 95%CI; 1.59–4.77; $p < 0.001$). Patients underwent decompressive craniectomy showed a 105% increase in the chance of death (OR = 2.05; 95%CI: 1.23–3.41; $p = 0.008$). There was a significant association ($p < 0.001$) between length of stay in the ICU and death, and most (88.6%) patients who did not need to be admitted to the ICU did not die. Likewise, there was a significant association ($p = 0.020$) between ASDH and death, in which most individuals (74.1%) who did not have ASDH did not die either (►**Table 4**).

Table 1 Descriptive analysis of variables

Variables		N	%
Gender	Female	39	12,3%
	Male	279	87,7%
Age (years old)	15–34	138	43,4%
	35–65	151	47.5%
	> 65	29	9.1%
Origin	Florianópolis	46	14.5%
	São José	45	14.2%
	Palhoça	36	11.3%
	Others – metropolitan area of Florianópolis	45	14.2%
	Outside the metropolitan area of Florianópolis	146	45.9%
Level of schooling	Basic education	144	45.3%
	High school	86	27.0%
	Higher education	21	6.6%
	Others	67	21.1%
Year of the attendance	2014	60	18.9%
	2015	65	20.4%
	2016	76	23.9%
	2017	67	21.1%
	2018	33	10.4%
	2019 (until April)	17	5.3%
Days of the week	Sunday	64	20.1%
	Monday	52	16.4%
	Tuesday	31	9.7%
	Wednesday	35	11.0%
	Thursday	31	9.7%
	Friday	48	15.1%
	Saturday	57	17.9%
Days of the Week 2	Monday to Friday	197	61.9%
	Weekend	121	38.1%
Month	January	27	8.5%
	February	31	9.7%
	March	26	8.2%
	April	34	10.7%
	May	37	11.6%
	June	24	7.5%
	July	27	8.5%
	August	36	11.3%
	September	20	6.3%
	Octuber	20	6.3%
	November	19	6.0%
	December	16	5.0%
	Indeterminate	1	0.3%

Table 1 (*Continued*)

Variables		N	%
Quarter	1st Quarter	84	26.4%
	2nd Quarter	95	29.9%
	3rd Quarter	83	26.1%
	4th Quarter	55	17.3%
	Indeterminate	1	0.3%
TBI classification	Mild TBI	105	33.0%
	Moderate TBI	44	13.8%
	Severe TBI	169	53.1%
Pupils on admission	Isocorics no abnormalities	203	63.8%
	Anisocorics	33	10.4%
	Midriatics	20	6.3%
	Miotics	59	18.6%
	No information	3	0.9%
Cause of TBI	Motorcycle accident	83	26.1%
	Fall (level)	52	16.4%
	Fall (own height)	45	14.2%
	Trampling	39	12.3%
	Aggression	35	11.0%
	Automobile accident	30	9.4%
	Gunshot	9	2.8%
	Others	25	7.9%
Associated trauma	No associated injuries	154	48.4%
	Multiple injuries	87	27.4%
	Orthopedic	26	8.2%
	Face	24	7.5%
	Thorax	20	6.3%
	Spinal cord injury (SCI)	5	1.6%
	Abdominal	2	0.6%
Need for ICU	No	45	14.2%
	Yes	273	85.8%
ICU time (days)	Zero	44	13.8%
	1–3	26	8.2%
	4–7	52	16.4%
	8–14	68	21.4%
	15–21	67	21.1%
	> 21	55	17.3%
	Transferred	6	1.9%
Hospitalization time (days)	≤ 7	75	23.8%
	8–14	61	19.4%
	15–30	67	21.3%
	31–60	74	23.5%
	> 60	38	12.1%

(*Continued*)

Table 1 (*Continued*)

Variables		N	%
Death	No	209	65.7%
	Yes	101	31.8%
	Transferred	8	2.5%
Sequelae	No	69	21.7%
	Yes	138	43.4%
	Death	101	31.8%
	No information / transferred	10	3.1%
Which sequelae at hospital discharge	Death	101	31.8%
	No sequela /not informed /transferred	79	24.8%
	Multiple	74	23.3%
	Physical	21	6.6%
	Vegetative state	15	4.7%
	Cognitive	15	4.7%
	Present and uninformed sequela	8	2.5%
	Swallowing disorders/speech-language	4	1.3%
	Phychological	1	0.3%
Glasgow outcome scale (GOS)	Transferred	9	2.9%
	1 (Death)	100	31.4%
	2 (Vegetative state)	22	6.9%
	3 (Severe disability)	65	20.4%
	4 (Moderate disability)	38	11.9%
	5 (Mild disability/or good recovery)	84	26.4%
External ventricular drain (EVD)	No	112	35.2%
	Yes	206	64.8%
Descompressive craniectomy	No	228	71.7%
	Yes	90	28.3%
Neurosurgery	EVD (isolated)	106	33.3%
	Evacuation of extra-axial hematoma (with or without EVD)	79	24.8%
	Descompressive craniectomy + evacuation of intracranial hematoma (with or without EVD)	77	24.2%
	Surgical treatment of skull fracture/depressed skull fracture (isolated or associated)	29	9.1%
	Descompressive craniectomy (with or without EVD)	14	4.4%
	Evacuation of intracranial hematoma (with or without EVD)	13	4.1%

Table 1 (*Continued*)

Variables		N	%
Marshall CT classification	Marshall I	4	1.3%
	Marshall II	138	43.4%
	Marshall III	45	14.2%
	Marshall IV	83	26.1%
	Marshall V	27	8.5%
	Marshall VI	10	3.1%
	Unclassified	11	3.5%
Subarachnoid hemorrhage (SAH)	No	175	55.0%
	Yes	142	44.7%
	No information	1	0.3%
Obliteration of basal cisterns	No	181	56.9%
	Yes	125	39.3%
	No information	12	3.8%
MLS (mm)	Zero	155	48.7%
	> 0 and < 5	34	10.7%
	≥ 5 and < 12	85	26.7%
	≥ 12 and < 15	13	4.1%
	≥ 15	16	5.0%
	Not measured	15	4.7%
Cerebral herniation	No	223	70.1%
	Yes	92	28.9%
	No information	3	0.9%
Extra-axial hematoma	No	113	35.5%
	Yes	204	64.2%
	No information	1	0.3%
Acute subdural hematoma (ASDH)	No	174	54.7%
	Yes	143	45.0%
	No information	1	0.3%
Acute epidural hematoma (AEDH)	No	236	74.2%
	Yes	81	25.5%
	No information	1	0.3%
Maximun hematoma thickness (mm) – AEDH	≤ 10	245	77.0%
	> 10 and < 30	36	11.3%
	≥ 30	17	5.3%
	Not measured	20	6.3%
Maximun hematoma thickness (mm) – ASDH	≤ 10	233	73.3%
	> 10 and < 30	42	13.2%
	≥ 30	1	0.3%
	Not measured	42	13.2%
Intraparenchymal hemorrhage/cerebral contusion	No	113	35.5%
	Yes	204	64.2%
	No information	1	0.3%
Intraventricular hemorrhage (IVH)	No	289	90.9%

(*Continued*)

Table 1 (*Continued*)

Variables		N	%
	Yes	28	8.8%
	No information	1	0.3%
Skull base fracture	No	177	55.7%
	Yes (without depressed skull fracture)	138	43.4%
	Yes (depressed skull fracture)	1	0.3%
	No information	2	0.6%
Convexity fracture	No	186	58.5%
	Yes (without depressed skull fracture)	107	33.6%
	Yes (depressed skull fracture)	23	7.2%
	No information	2	0.6%

Abbreviation: TBI, traumatic brain injury.

Table 2 Descriptive analysis of numeric variables

Variable	Valid *n*	Mea*n*	S.D.	Min.	Median	Max.
Age (years old)	318	40.58	17.11	15	38	93
ICU time (days)	312	12.62	11.17	0	10	79
Total hospital stay (days)	315	27.88	28.13	0	18	207
MLS (mm)	303	4.14	5.45	0	0	26

Abbreviations: ICU, intensive care unit; MLS, midline shift, S.D., standard deviation.

To assess the impact of the variables of interest together on patient death, a logistic regression was adjusted using the following variables: gender, age, GCS-P, pupils on admission, associated injuries, ICU time, EVD; need for decompressive craniectomy, Marshall CT classification, SAH, obliteration of basal cisterns, MLS, ASDH, AEDH, and intraventricular hemorrhage

Table 3 Lethality distribution

Period		Lethality (%)
Total		31.76%
Year	2014	35.00%
	2015	27.69%
	2016	34.21%
	2017	25.37%
	2018	45.45%
	2019 (until April)	23.53%
Quarter	1st quarter	27.38%
	2nd quarter	33.68%
	3rd quarter	31.33%
	4th quarter	36.36%

According to the final model, it may be concluded that patients with orthopedic trauma showed a 466% increase in the chance of death (OR = 5.66; 95%CI: 1.08–29.52; $p = 0.040$), and that individuals with thoracic trauma showed a 276% increase in the chance of death (OR = 3.76; 95%CI: 1.27–11.11; $p = 0.017$) compared with patients without associated injuries. There was a significant influence of the time of hospitalization in the ICU in the case of death, wherein additional day of hospitalization in the ICU is associated with an average decrease of 7% in the chance of death (OR = 0.93; 95%CI: 0.9–0.96; $p < 0.001$).

Patients submitted to EVD had an increase of ~ 561% in the chance of death (OR = 6.61; 95%CI: 3.26–13.4; $p < 0.001$). There was a significant influence of decompressive craniectomy in case of deaths, that is, patients who needed decompressive craniectomy, when compared with patients who did not need the procedure, showed a 265% increase in their chance of death (OR = 3.65; 95%CI: 1.88–7.1; $p < 0.001$).

There was a significant influence of the MLS on the outcome death. Patients who had an MLS between zero and 5 mm had a 172% increase in the chance of death

Table 4 Univariate analysis with death outcome

Variables		N	%	Survivors		Death		95%CI (OR)*	pp-value
				N	%	N	%		
Gender	Female	39	12,3%	24	61,5%	15	38,5%	1	00,438†
	Male	279	87,7%	193	69,2%	86	30,8%	0,71 [0.3–1.43]	
Age (years old)	15–34	138	43.4%	92	66.7%	46	33.3%	1	00.171†
	35–65	151	47.5%	109	72.2%	42	27.8%	0.77 [0.47–1.27]	
	> 65	29	90.1%	16	55.2%	13	44.8%	1.62 [0.72–3.66]	
Cause of TBI	Automobile accident	30	90.4%	21	70.0%	9	30.0%	1	00.554†
	Motorcycle accident	83	26.1%	58	69.9%	25	30.1%	1.04 [0.44–2.46]	
	Trampling	39	12.3%	24	61.5%	15	38.5%	1.19 [0.57–2.50]	
	Fall (own height)	45	14.2%	27	60.0%	18	40.0%	1.91 [0.85–4.32]	
	Fall (level)	52	16.4%	38	73.1%	14	26.9%	1.18 [0.48–2.89]	
	Aggression	35	11.0%	28	80.0%	7	20.0%	0.59 [0.24–1.41]	
	Gunshot	9	20.8%	6	66.7%	3	33.3%	0.82 [0.37–1.79]	
	Others	25	70.9%	15	60.0%	10	40.0%	1.02 [0.53–1.96]	
Associated trauma	No associated injuries	154	48.4%	103	66.9%	51	33.1%	1	00.158‡
	Multiple injuries	87	27.4%	58	66.7%	29	33.3%	0.90 [0.25–3.21]	
	Orthopedic	26	80.2%	16	61.5%	10	38.5%	4.62 [1.01–21.11]	
	Face	24	70.5%	21	87.5%	3	12.5%	0.92 [0.16–5.17]	
	Thorax	20	60.3%	16	80.0%	4	20.0%	2.94 [1.12–7.69]	
	SCI	5	10.6%	2	40.0%	3	60.0%	1.15 [0.24–5.57]	
	Abdominal	2	00.6%	1	50.0%	1	50.0%	1.64 [0.39–6.90]	
Classification of TBI	Mild TBI	105	33.0%	83	79.0%	22	21.0%	1	**00.013**†
	Moderate TBI	44	13.8%	27	61.4%	17	38.6%	1.74 [1.17–2.59]	
	Severe TBI	169	53.1%	107	63.3%	62	36.7%	0.68 [0.39–1.17]	
GCS-P	1	40	12.6%	20	50.0%	20	50.0%	0.93 [0.89–0.98]	**00.038**†
	2	12	30.8%	6	50.0%	6	50.0%		
	3	78	24.5%	56	71.8%	22	28.2%		
	4	6	10.9%	3	50.0%	3	50.0%		
	5	8	20.5%	5	62.5%	3	37.5%		

(*Continued*)

Table 4 (*Continued*)

Variables		N	%	Survivors		Death		95%CI (OR)*	*pp-value*
				N	%	N	%		
	6	11	30.5%	9	81.8%	2	18.2%		
	7	7	20.2%	3	42.9%	4	57.1%		
	8	8	20.5%	5	62.5%	3	37.5%		
	9	12	30.8%	7	58.3%	5	41.7%		
	10	15	40.7%	11	73.3%	4	26.7%		
	11	9	20.8%	4	44.4%	5	55.6%		
	12	8	20.5%	5	62.5%	3	37.5%		
	13	22	60.9%	16	72.7%	6	27.3%		
	14	41	12.9%	31	75.6%	10	24.4%		
	15	41	12.9%	36	87.8%	5	12.2%		
Pupils on admission	Isocorics no abnormalities	203	63.8%	145	71.4%	58	28.6%	1	00.291‡
	Anisocorics	33	10.4%	19	57.6%	14	42.4%	2.47 [0.52–11.69]	
	Midriatics	20	60.3%	13	65.0%	7	35.0%	1.60 [0.39–6.52]	
	Miotics	59	18.6%	39	66.1%	20	33.9%	2.09 [0.81–5.38]	
	No information	3	00.9%	1	33.3%	2	66.7%	0.99 [0.43–2.29]	
Marshall CT classification	Marshall I	4	10.3%	3	75.0%	1	25.0%	1	**00.030†**
	Marshall II	138	43.4%	107	77.5%	31	22.5%	0.87 [0.09–8.65]	
	Marshall III	45	14.2%	31	68.9%	14	31.1%	1.35 [0.13–14.20]	
	Marshall IV	83	26.1%	50	60.2%	33	39.8%	1.98 [0.20–19.86]	
	Marshall V	27	80.5%	15	55.6%	12	44.4%	2.40 [0.22–26.12]	
	Marshall VI	10	30.1%	4	40.0%	6	60.0%	4.50 [0.34–60.15]	
	Unclassified	11	30.5%	7	63.6%	4	36.4%	1.71 [0.13–22.51]	
EVD	No	112	35.2%	91	81.3%	21	18.8%	1	**<0.001†**
	Yes	206	64.8%	126	61.2%	80	38.8%	2.75 [1.59–4.77]	
Descompressive craniectomy	No	228	71.7%	166	72.8%	62	27.2%	1	**00.008†**
	Yes	90	28.3%	51	56.7%	39	43.3%	2.05 [1.23–3.41]	
ICU time (days)	Zero	44	13.8%	39	88.6%	5	11.4%	1	**<0.001†**
	1–3	26	80.2%	12	46.2%	14	53.8%	***	

Table 4 (*Continued*)

Variables		N	%	Survivors		Death		95%CI (OR)*	*pp-value*
				N	%	N	%		
	4–7	52	16.4%	21	40.4%	31	59.6%		
	8–14	68	21.4%	44	64.7%	24	35.3%		
	15–21	67	21.1%	51	76.1%	16	23.9%		
	> 21	55	17.3%	44	80.0%	11	20.0%		
	Transferred	6	1.9%	6	100%	0	0.0%		
Reference trauma center	HGCR	182	57.2%	123	67.6%	59	32.4%	1	00.866†
	HRSJ-HMG	136	42.8%	94	69.1%	42	30.9%	0.93 [0.58–1.50]	
SAH	No	175	55.0%	129	73.7%	46	26.3%	1	**00.048†**
	Yes	142	44.7%	87	61.3%	55	38.7%	***	
	No information	1	00.3%	1	100%	0	0.0%		
ASDH	No	174	54.7%	129	74.1%	45	25.9%	1	**00.020‡**
	Yes	143	45.0%	87	60.8%	56	39.2%	***	
	No information	1	00.3%	1	100%	0	00.0%		
AEDH	No	236	74.2%	156	66.1%	80	33.9%	1	00.330‡
	Yes	81	25.5%	60	74.1%	21	25.9%	***	
	No information	1	00.3%	1	100%	0	000%		

Abbreviations: ASDH. acute subdural hematoma; CI, confidence interval; CT, computed tomography; GCS, Glasgow coma scale; HGCR, Hospital Governador Celso Ramos; HRSJ-HMG, Hospital Regional de São José Dr. Homero de Miranda Gomes; ICU, intensive care unit; OR, odds ratio; SAH, subarachnoid hemorrhage; SCI, spinal cord injury; AEDH, acute epidural hematoma.

*95% confidence interval (CI) for odds ratio (OR).

†Chi-squared test.

‡Fisher exact test.

***Variables that have three asterisks in their 95% confidence interval for the odds ratio exhibited very large values for their intervals, as their statistics were overestimated due to the fact that there are empty groups at some levels of their respective variables, which compromised the estimation of their ranges.

Table 5 Final model logistic regression multivariate analysis with the outcome of death

Variables	N	%	Survivors		Death		95%CI (OR)	*p-value**
			N	%	*n*	%		
Gender								
Female	39	12.3%	24	61.5%	15	38.5%	1	
Male	279	87.7%	193	69.2%	86	30.8%	0.74 [0.3–1.84]	0.521
Age (years old)								
15–34	138	43.4%	92	66.7%	46	33.3%	1	
35–65	151	47.5%	109	72.2%	42	27.8%	0.88 [0.47–1.66]	0.690
> 65	29	9.1%	16	55.2%	13	44.8%	1.80 [0.6–5.41]	0.292
Pupils on admission†								
Isocorics no abnormalities	203	63.8%	145	71.4%	58	28.6%	1	
Anisocorics	33	10.4%	19	57.6%	14	42.4%	0.89 [0.46–1.73]	0.728
Midriatics	20	6.3%	13	65.0%	7	35.0%	1.61 [0.66–3.93]	0.298
Miotics	59	18.6%	39	66.1%	20	33.9%	1.48 [0.55–3.97]	0.434
Associated trauma								
No associated injuries	154	48.4%	103	66.9%	51	33.1%	1	
Multiple injuries	87	27.4%	58	66.7%	29	33.3%	1.92 [0.44–8.49]	0.388
Orthopedic	26	8.2%	16	61.5%	10	38.5%	5.66 [1.08–29.52]	**0.040**
Thorax	20	6.3%	16	80.0%	4	20.0%	3.76 [1.27–11.11]	**0.017**
Face	24	7.5%	21	87.5%	3	12.5%	1.38 [0.23–8.29]	0.723
SCI	5	1.6%	2	40.0%	3	60.0%	1.01 [0.2–5.13]	0.992
Abdominal	2	0.6%	1	50.0%	1	50.0%	2.98 [0.6–14.82]	0.182
EVD								
No	112	35.2%	91	81.3%	21	18.8%	1	
Yes	206	64.8%	126	61.2%	80	38.8%	6.61 [3.26–13.4]	< **0.001**
Descompressive craniectomy								
No	228	71.7%	166	72.8%	62	27.2%	1	
Yes	90	28.3%	51	56.7%	39	43.3%	3.65 [1.88–7.1]	< **0.001**
SAH‡								
No	175	55%	129	73.7%	46	26.3%	1	
Yes	142	44.7%	87	61.3%	55	38.7%	1.50 [0.69–3.28]	0.305
ASDH‡								
No	174	54.7%	129	74.1%	45	25.9%	1	
Yes	143	45%	87	60.8%	56	39.2%	1.70 [0.84–3.42]	0.138
AEDH‡								
No	236	74.2%	156	66.1%	80	33.9%	1	
Yes	81	25.5%	60	74.1%	21	25.9%	1.49 [0.68–3.27]	0.319
Intraventricular hemorrhage‡								
No	289	90.9%	198	68.5%	91	31.5%	1	
Yes	28	8.8%	18	64.3%	10	35.7%	1.75 [0.63–4.85]	0.279
Obliteration of basal cisterns								
No	181	56.9%	135	74.6%	46	25.4%	1	
Yes	125	39.3%	74	59.2%	51	40.8%	0.89 [0.22–3.69]	0.877
No information	12	3.8%	8	66.7%	4	33.3%	0.53 [0.21–1.31]	0.166

Table 5 (*Continued*)

Variables	N	%	Survivors		Death		95%CI (OR)	*p-value**
			N	%	*n*	%		
MLS (mm)								
Zero	155	48.7%	115	74.2%	40	25.8%	1	
> 0 and < 5 mm	34	10.7%	25	73.5%	9	26.5%	2.72 [1.07–6.93]	**0.036**
≥ 5 mm and < 12 mm	85	26.7%	55	64.7%	30	35.3%	0.75 [0.3–1.87]	0.532
≥ 12 mm and < 15 mm	13	4.1%	8	61.5%	5	38.5%	0.37 [0.14–0.97]	**0.043**
≥ 15 mm	16	5%	5	31.3%	11	68.8%	0.67 [0.25–1.78]	0.416
Not measured	15	4.7%	9	60.0%	6	40.0%	0.54 [0.21–1.38]	0.198
Marshall CT classification								
Marshall I	4	1.3%	3	75.0%	1	25.0%	1	
Marshall II	138	43.4%	107	77.5%	31	22.5%	1.54 [0.06–37.34]	0.791
Marshall III	45	14.2%	31	68.9%	14	31.1%	1.07 [0.04–31.32]	0.971
Marshall IV	83	26.1%	50	60.2%	33	39.8%	1.42 [0.04–45.26]	0.842
Marshall V	27	8.5%	15	55.6%	12	44.4%	3.33 [0.11–98.13]	0.485
Marshall VI	10	3.1%	4	40.0%	6	60.0%	4.61 [0.13–162.45]	0.400
Unclassified	11	3.5%	7	63.6%	4	36.4%	2.65 [0.04–163.73]	0.643
ICU time (days)							0.93 [0.9–0.96]	< **0.001**
GCS-P							0.94 [0.87–1.01]	0.108
VIF Maximum	43.40				6.00			
Hosmer – Lemeshow test	0.170				0.575			
R[†]	28.0%				23.0%			

Abbreviations: ASDH. acute subdural hematoma; CI, confidence interval; CT, computed tomography; GCS-P, Glasgow P; ICU, intensive care unit; MLS, midline shift; OR, odds ratio; SAH, subarachnoid hemorrhage.
*Regarding the variables that were not significant, the p-value refers to the initial model. And for significant variables, the p-value refers to the final model.
†Three patients had no information about their pupils on admission.
‡The presence of SAH, ASDH, AEDH and intraventricular hemorrhage were not determined in one patient.

(OR = 2.72; 95%CI: 1.07–6.93; $p = 0.036$). However, patients with an MLS ≥12 and < 15 mm, when compared with a patient with an MLS equal to zero, showed a 63% decrease in the chance of death (OR = 0.37; 95%CI: 0.14–0.97; $p = 0.043$).

The maximum VIF of the final model was 6. Therefore, it can be concluded that this model does not have multicollinearity problems, since no VIF was > 10. By the Hosmer–Lemeshow test, the model presented a suitable adjustment ($p = 0.575$), not rejecting the null hypothesis of the adjustment of the regression model used. The R^2 of the final model showed that significant variables to the model were able to explain 23.0% of the variability of the outcome variable (death) of individuals (►**Table 5**).

To evaluate the predictive measures of the GCS-P and the GCS, logistical regressions were adjusted to study their relationship with the following variables: need for decompressive craniectomy, MLS, presence of basal cistern obliteration, need for hospitalization in the ICU, and death.

►**Fig. 3** presents graphically the ROC curves for the outcomes "decompressive craniectomy" and "MLS." In this way, it can be concluded that, in the case of need for decompressive craniectomy, the GCS curve had a better behavior when compared with that of the curve related to the GCS-P, since it had a larger area below the curve (AUC = 0.574). However, it is important to point out that the difference between the curves was < 0.05, indicating that there was no clinically relevant increment between the scores. Similarly, in the case of MLS, the curve related to the GCS behaved better in relation to the representative curve of the GCS-P, since it presented a larger area below the curve (AUC = 0.538). However, the difference between the curves was < 0.05, without a clinically relevant increment between the scores.

►**Fig. 4** shows graphically the ROC curves for the outcomes "obliteration of basal cisterns" and "needed for ICU hospitalization." Thus, it can be concluded, for the case of obliteration of basal cisterns, that the GCS-P curve had a better behavior when compared with that of the GCS-

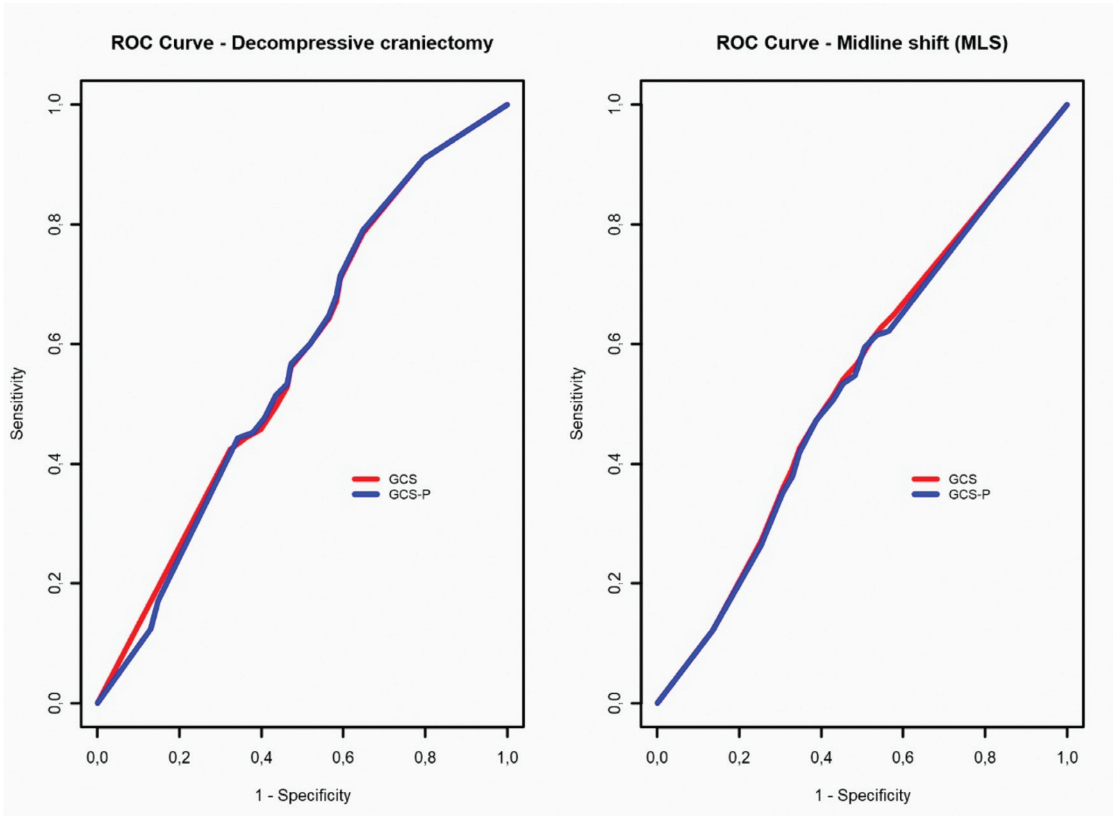


Fig. 3 ROC curve for Decompressive Craniectomy and Midline Shift (MLS).

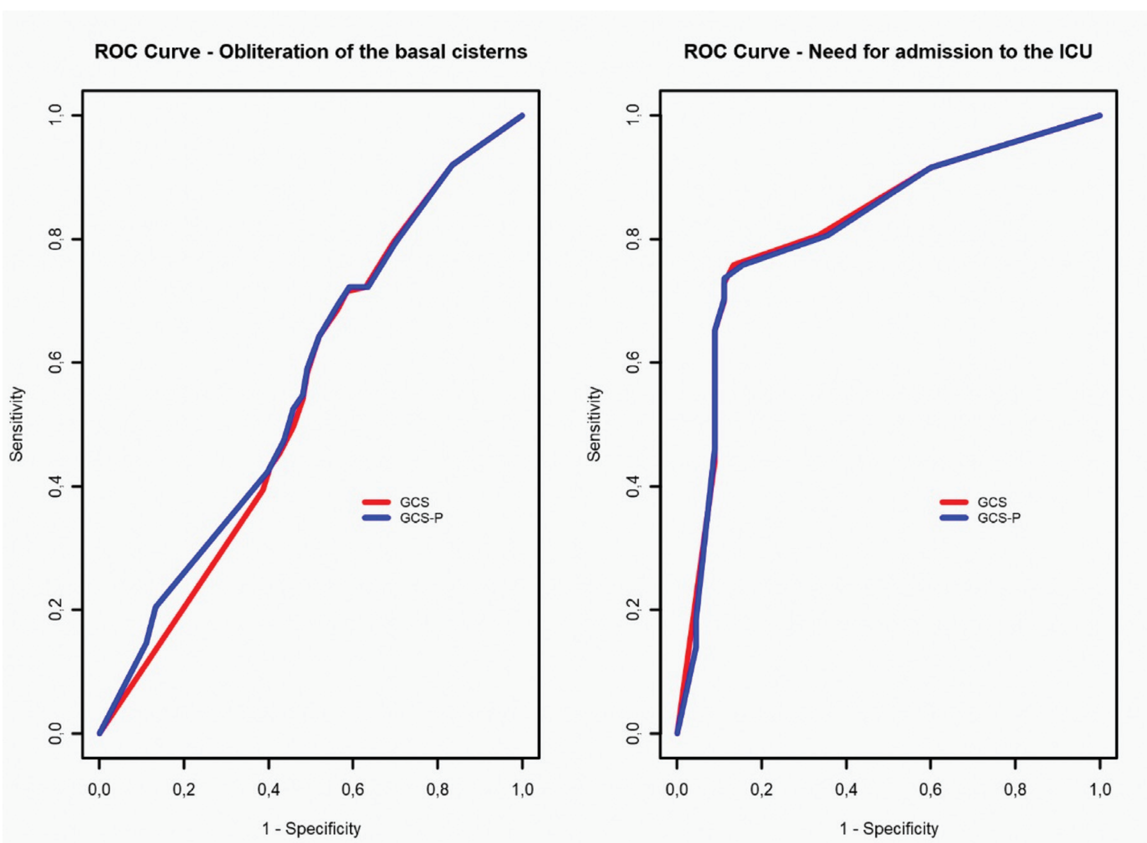


Fig. 4 ROC curve for obliteration of basal cisterns and need for admission to the ICU.

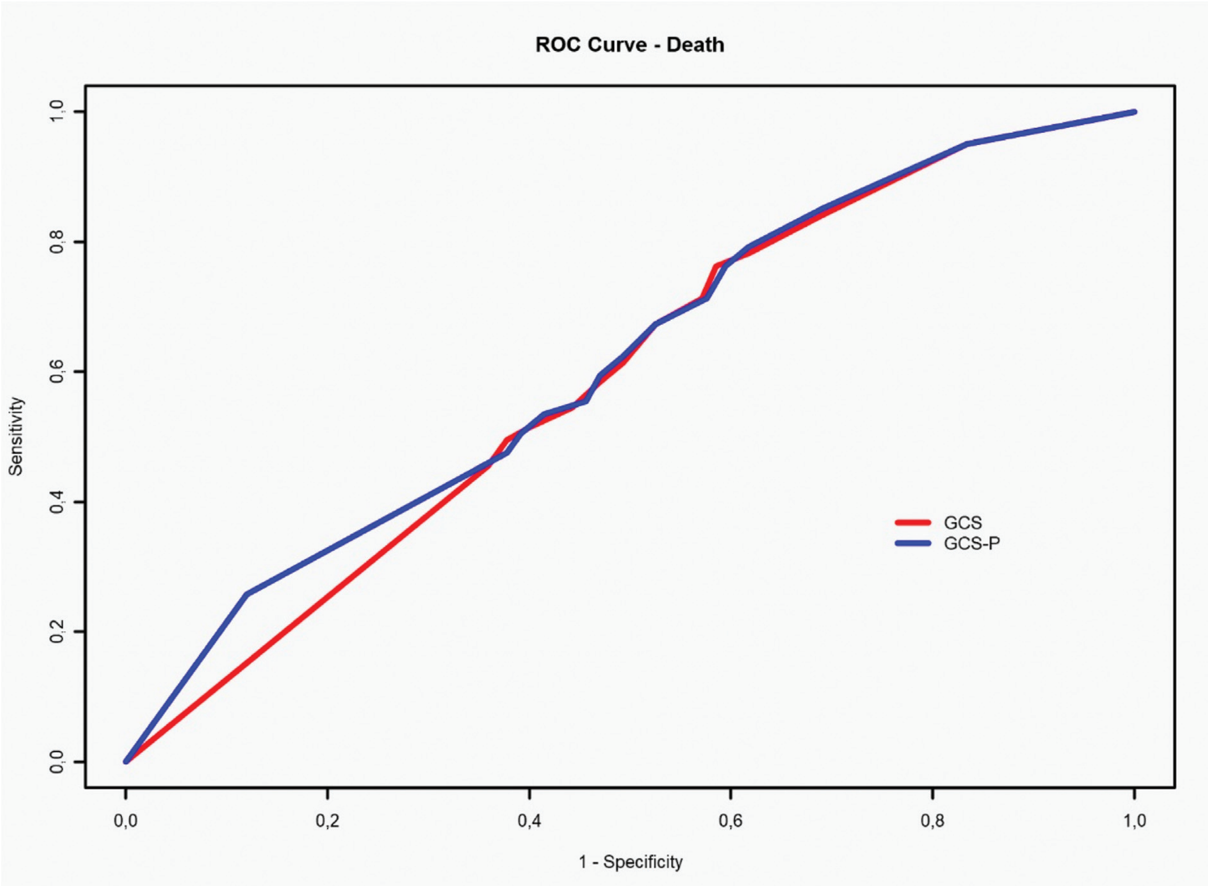


Fig. 5 ROC curve for death.

related curve, since it has had a larger area under the curve (AUC = 0.563). However, the difference between the curves was < 0.05, indicating that there was no clinically relevant increase between the scores. In case of need for ICU hospitalization, the GCS-related curve behaved superiorly to the GCS-P curve, since it had a larger area under the curve (AUC = 0.820). However, similarly, the difference between the curves was < 0.05, indicating that there was no clinically relevant increase between the scores.

►**Fig. 5** presents graphically the ROC curve for the outcome "death." From it, we can verify that the curve related to the GCS-P behaved in a better way compared with the curve related to the GCS, since it has had a higher value of the area below the curve (AUC = 0.612). Nonetheless, the difference between the curves was < 0.05, indicating that there was no clinically relevant increment between the scores.

Discussion

The present study reinforced some variables as prognostic predictors, according to previous studies and models already established. Variables such as patient age, GCS, pupillary reactivity, and tomographic aspects have already been widely validated in previous studies as the most important prognostic characteristics in patients with TBI.[8–10]

In univariate analysis, it was identified that the following variables were strongly associated with the outcome death: TBI classification based on admission GCS, GCS-P, Marshall CT classification, EVD, decompression craniectomy, hospitalization time in the ICU, SAH, ASDH, obliteration of basal cisterns, and MLS. In the multivariate model, it was demonstrated that orthopedic trauma, thoracic trauma, hospitalization time in the ICU, EVD, decompressive craniectomy, and MLS between zero and 5 mm are predictors independent of the occurrence of death at time of discharge.

As the junction of variables for the creation of prognostic predictor models is a useful tool in clinical decision-making, there are several studies proposing prognostic markers for neurotrauma. Among the pioneers with well-delineated models, one can cite The International Mission for Prognosis and Analysis of Clinical Trials[11,12] (IMPACT) and The Corticosteroid Randomization After Significant Head Injury.[8] The IMPACT aims to estimate the prognosis for the next 6 months after TBI and points to 3 variables as being the most important: GCS, pupillary response, and tomographic features. The second study, CRASH, aims to calculate the probability of death within 14 days after TBI and the probability of neurological sequelae arising 6 months after the trauma, using for the calculation the following variables: age, motor response, pupils, tomographic features, and biochemical markers. More recently, a study[13] used the IMPACT and CRASH databases combined with the Pupillary Reactivity Score (PRS) and the GCS, culminating in the creation of a new score with both pieces of information: GCS-P, which is the GCS by arithmetically subtracting the PRS. In it, 2, 1, and 0 are the numbers assigned to the PRS for unresponsive pupils, unilateral reagent, and bilateral reagents, respectively.

Thus, although the outcome of traumatic events in an individual is not certain, research in recent decades has provided greater clarity in terms of prognostic probabilities. Therefore, the present study compared the GCS and the new scale with the subtraction of the PRS, through the accuracy of the numerical models, based on the results of the AUC. The results obtained when comparing both scores with the outcome variables "need for decompressive craniectomy," "MLS," "presence of basal cistern obliteration", "need for ICU admission", and "death" showed that there was no clinically relevant increase between them.

The National Traumatic Coma Data Bank (TCDB) classification,[14,15] described by Marshall, is one of the most widely used tomographic criteria. Thus, Marshall I classifies the CT as normal (mortality of 9.6%); Marshall II, when there are small hemorrhagic lesions, with the cisterns present and without deviation of the midline structures (mortality of 13.5%); Marshall III, when cisterns are erased or absent, without MLS (mortality 34%); and Marshall IV, when a MLS > 5 mm occurs, usually accompanied by erased or absent cisterns and no lesion $> 25\ cm^3$ (mortality 56.2%). Additionally, there are 2 categories used for lesions $> 25\ cm^3$, classified in surgically addressed lesions (Marshall V) and nonsurgically addressed lesions (Marshall VI). In the present study, there was a significant association between the tomographic findings present in the Marshall CT classification and the number of deaths; however, Marshall II cases had a decrease in the chance of death in relation to Marshall I cases in the univariate analysis.

In relation to MLS, corroborating the results of the present work, Zumkeller et al.[16] reported that deviations < 12 mm are possibly tolerated, that with deviations > 12 mm the survival rate decreases considerably, and that deviations > 28 mm were incompatible with life. Similarly, Eisenberg et al. observed 70% of deaths in patients with an MLS > 15 mm.[17] Given that the presence of MLS is an indication of increased ICP, it is expected that the greater the deviation, the worse the prognosis; however, there are other factors that may interfere with this reasoning, such as the location of intracranial lesions and the presence of bilateral abnormalities. Then, the absolute value of the deviation is less relevant than other tomographic parameters.

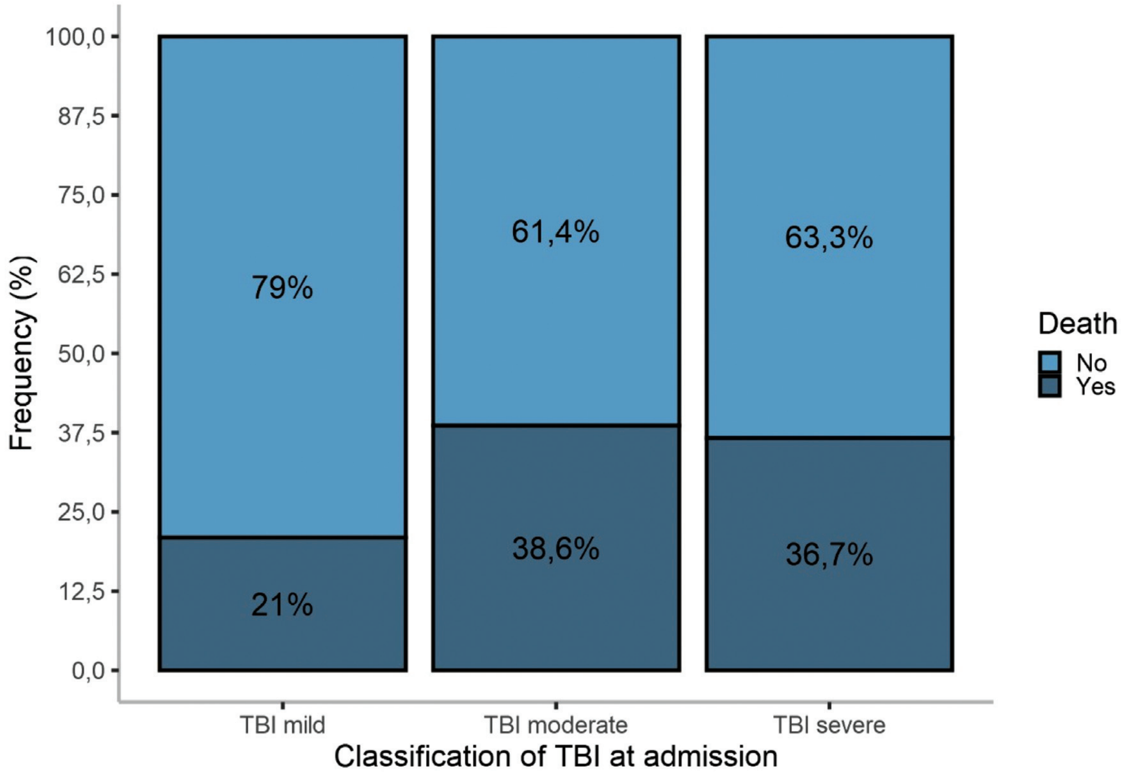
The AEDH showed better prognoses when compared with the ASDH, which had already been evidenced in other studies.[14,18] A controversial fact was the higher number of deaths for AEDH ≤ 10 mm when compared with AEDH between 10 and 30 mm; however, this result may have as a confounding factor the association with other primary or secondary lesions, both encephalic and in other locations. This bias is also a hypothesis to justify the higher number of deaths in cases of moderate TBI (38.6%) when compared with cases of severe TBI (36.7%). Although many studies show a direct relationship between the GCS at admission and the increase in the number of deaths, ►**Graphic 1** shows this contradiction in the distribution of deaths in relation to moderate and severe TBI.

Obliteration of the basal cisterns is considered an indicator of high intracranial pressure and is related to worse prognosis.[19] Therefore, management of cerebral swelling and of high ICP is an essential component of the acute treatment of TBI.[20] Thereby, the objective of decompressive craniectomy is to increase the compartment to reduce the increase of ICP caused by cerebral edema.[21,22] In this way, patients who need such an approach, in general, are more seriously affected, thus contributing to a larger number of deaths, as observed in this subgroup.

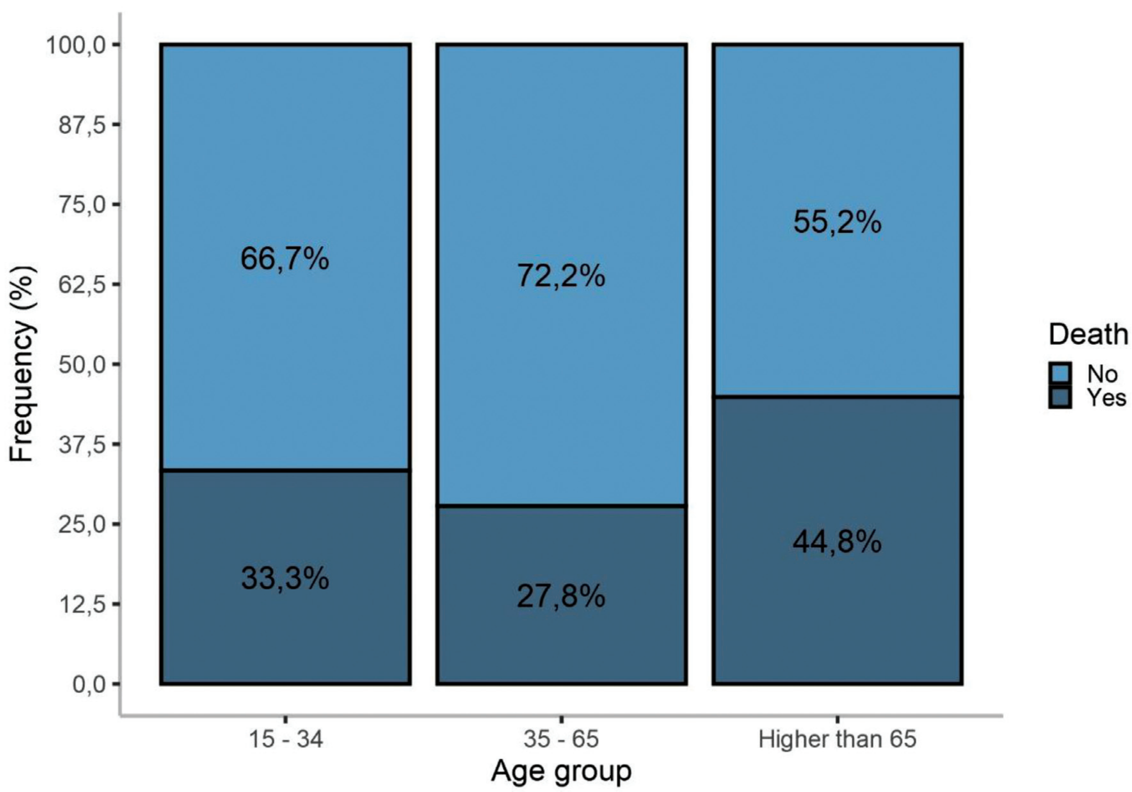
In the multivariate model, among the associated lesions, patients with thoracic and orthopedic trauma had a greater chance of death, which may be due to the impairment of the pulmonary function and to the decrease in volume, contributing to the worsening of secondary brain lesions because of hypoxia and hypotension, mainly.[23–25]

Throughout the world, TBI standards are changing,[30] with increase in traffic acidentes mainly in low-income countries and the growing problem of falls among the elderly mainly in high-income countries. Accordingly, the age in which the trauma occurs correlates with the prognosis, since the causes of the accidents depend on the age group, and that the chances of systemic complications are larger among the elderly. The present research showed the prevalence of falling from a height among the elderly over 65, which is the age group that presented the largest number of deaths (►**Graphic 2**). However, ground-level falls occur more frequently in the age group between 35 to 65 years and motorcycling and automotive accidents predominated among adults under 34 years (►**Graphic 3**). Regardless of the cause, TBI results in high morbidity and mortality, in addition to representing a risk factor for dementia.[27] Therefore, an in-depth knowledge of its epidemiology is essential for a more effective guidance on TBI prevention strategies in different populations.

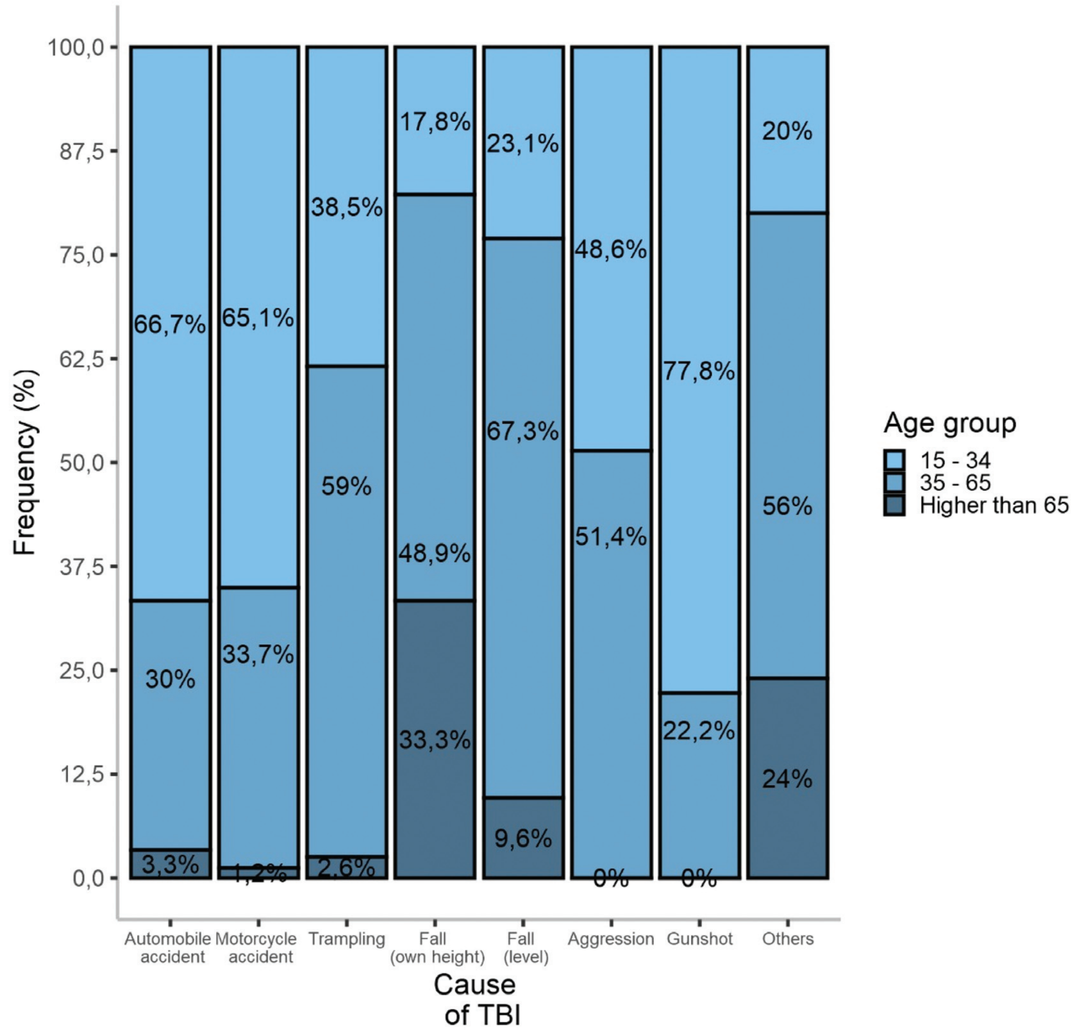
Considering that the literature on the subject is large and of variable quality,[28] various prognostic models in neurotrauma have already been proposed;[11,29,30] however, their application in practice runs into some obstacles, such as the additional time involved in data collection, coupled with the uncertainty of applicability. A Canadian study with intensivists, neurosurgeons, and neurologists involved in the care of patients with severe TBI evidenced a variability of approaches,[31] reinforcing the importance of more consistent models to predict the neurological outcome. In this context, their use is associated with support in decision-making and



Graphic 1 Death by TBI classification.



Graphic 2 Death by age group.



Graphic 3 Causes by age group.

better communication about risks among health professionals, patients, and their families.[31]

The retrospective identification of the profile of TBI victims from two reference hospitals in the metropolitan area of Florianopolis allowed a critical analysis to be performed, focusing both on public policies and on the care flows of the institutions. However, because this is a documental-based study, with the use of medical records as a source of data, it has been observed that much information is not properly recorded or is lost. Therefore, investment is needed in systems for efficient data collection and sharing, aiming at the formation of more robust and reliable databases, as well as at the standardization of methods for epidemiological monitoring.

Limitations

The main limitation of the present study was the difficulty in having good historical data with the possible occurrence of bias due to errors in medical records. When considering the use of the initial GCS for prognosis, the two most important problems are the reliability of the initial measurement and its lack of accuracy when factors such as prehospital medications or intubation are present.

Another obstacle encountered during the present study was the difficulty in gaining access to all tomographic images, especially to the older ones. To minimize losses, all possible information was collected from CT scan reports; however, Marshall measurements and classifications were missing for some cases.

Conclusion

1. There was no clinically relevant increment between the GCS and the GCS-P for the outcomes tested.
2. Male gender predominated among the patients. The most affected age range was between 35 and 65 years old, with a mean age of $\sim$ 41 years old, and half of the patients were $\leq$

36 years old. The day with the highest number of cases was Sunday, the month was May, and the quarter was the 2nd quarter of the year. The leading cause was motorcycle accidents, followed by falls. Most patients presented with severe TBI at hospital admission. The main associated injury was orthopedic trauma. Most patients required admission to the ICU for an average of 13 days. Regarding the total length of hospital stay, the mean time was ~ 28 days. Most patients presented with sequelae at hospital discharge, with a predominance of multiple sequelae. Most cases needed EVD. The predominant Marshall CT classification was Marshall II, followed by Marshall IV. Most patients presented with extra-axial hematoma, and ASDH was the most frequent.

3. In the univariate analysis with death as the outcome, there was a significant association with the variables TBI classification, GCS-P, Marshall CT classification, EVD, decompressive craniectomy; length of stay at the ICU, SAH, ASDH, obliteration of basal cisterns, and MLS.
4. The final logistic regression model for the multivariate analysis showed that:
   - Patients who had orthopedic trauma or thoracic trauma presented, respectively, increases of 466 and 276% in the chance of death when compared with patients without associated injuries.
   - Each additional day of ICU stay is associated with a 7% decrease in the chance of death.
   - Patients with EVD showed a 561% increase in the chance of death when compared with patients without EVD.
   - The need for decompressive craniectomy meant a 265% increase in the chance of death when compared with a patient who did not need it.
   - Patients who had an MLS between zero and 5 mm had a 172% increase in the chance of death. However, patients with an MLS between 12 and 15 mm, when compared with patients with an MLS equal to zero, presented a 63% decrease in the chance of death.

Institutions in Which the Present Work was Performed
Hospital Regional de São José Doutor Homero de Miranda Gomes (HRSJ-HMG).
Hospital Governador Celso Ramos (HGCR).

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Appendix

The following tables provide a descriptive analysis, respectively, of the following variable levels: GCS, sequelae at discharge, days of hospitalization, days of ICU stay, death, Marshall CT classification, and decompressive craniectomy, regarding the values of the variable GCS-P (►**Tables 6** to **12**).

Table 6 Descriptive analysis: GCS-P x GCS

GCS/ GCS-P	3		4		5		6		7		8		9		10		11		12		13		14		15	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	40	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
2	8	66.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	33.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
3	76	97.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	2.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
4	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	66.7%	0	0.0%	2	33.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
5	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	5	62.5%	1	12.5%	2	25.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
6	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9	81.8%	2	18.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
7	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	6	85.7%	0	0.0%	1	14.3%	0	0.0%	0	0.0%
8	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	8	100.0%	0	0.0%	0	0.0%	0	0.0%
9	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	12	100.0%	0	0.0%	0	0.0%
10	0	0.0%	1	6.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	14	93.3%	0	0.0%
11	0	0.0%	1	11.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	8	88.9%
12	0	0.0%	7	87.5%	0	0.0%	1	12.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
13	0	0.0%	0	0.0%	22	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
14	0	0.0%	0	0.0%	0	0.0%	41	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
15	0	0.0%	0	0.0%	0	0.0%	0	0.0%	41	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Abbreviations: GCS, Glasgow coma scale; GCS-P, Glasgow P.

Table 7 Descriptive analysis: GCS-P x Sequelae

GCS-P x Sequelae	Cognitive		Swallowing disorders/ Speech-language		Psychological		Physical		Multiple		Death		Vegetative state		No sequela/ Not informed/ Transferred		Present and uninformed sequela	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	1	2.5%	0	0.0%	0	0.0%	1	2.5%	9	22.5%	20	50.0%	4	10.0%	3	7.5%	2	5.0%
2	1	8.3%	1	8.3%	0	0.0%	0	0.0%	3	25.0%	6	50.0%	1	8.3%	0	0.0%	0	0.0%
3	5	6.4%	1	1.3%	0	0.0%	6	7.7%	22	28.2%	22	28.2%	5	6.4%	16	20.5%	1	1.3%
4	0	0.0%	0	0.0%	0	0.0%	1	16.7%	0	0.0%	3	50.0%	1	16.7%	1	16.7%	0	0.0%
5	0	0.0%	0	0.0%	0	0.0%	2	25.0%	3	37.5%	3	37.5%	0	0.0%	0	0.0%	0	0.0%
6	1	9.1%	0	0.0%	0	0.0%	0	0.0%	5	45.5%	2	18.2%	1	9.1%	2	18.2%	0	0.0%
7	1	14.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	57.1%	1	14.3%	1	14.3%	0	0.0%
8	1	12.5%	0	0.0%	0	0.0%	0	0.0%	2	25.0%	3	37.5%	0	0.0%	2	25.0%	0	0.0%
9	0	0.0%	0	0.0%	0	0.0%	1	8.3%	5	41.7%	5	41.7%	0	0.0%	1	8.3%	0	0.0%
10	3	20.0%	1	6.7%	0	0.0%	3	20.0%	2	13.3%	4	26.7%	0	0.0%	1	6.7%	1	6.7%
11	0	0.0%	0	0.0%	0	0.0%	2	22.2%	2	22.2%	5	55.6%	0	0.0%	0	0.0%	0	0.0%
12	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	37.5%	3	37.5%	0	0.0%	2	25.0%	0	0.0%
13	1	4.5%	1	4.5%	0	0.0%	2	9.1%	1	4.5%	6	27.3%	1	4.5%	10	45.5%	0	0.0%
14	1	2.4%	0	0.0%	0	0.0%	3	7.3%	11	26.8%	10	24.4%	0	0.0%	15	36.6%	1	2.4%
15	0	0.0%	0	0.0%	1	2.4%	0	0.0%	6	14.6%	5	12.2%	1	2.4%	25	61.0%	3	7.3%

Abbreviations: GCS-P, Glasgow P.

Table 8 Descriptive analysis: GCS-P x Hospitalization time (days)

GCS-P/Hospitalization time (days)	≤ 7 days		8–14 days		15–30 days		31–60 days		> 60 days	
	N	%	N	%	N	%	N	%	N	%
1	9	22.5%	6	15.0%	7	17.5%	9	22.5%	9	22.5%
2	3	25.0%	1	8.3%	3	25.0%	5	41.7%	0	0.0%
3	10	13.3%	11	14.7%	21	28.0%	22	29.3%	11	14.7%
4	3	50.0%	0	0.0%	1	16.7%	1	16.7%	1	16.7%
5	1	12.5%	2	25.0%	1	12.5%	2	25.0%	2	25.0%
6	1	9.1%	1	9.1%	2	18.2%	5	45.5%	2	18.2%
7	1	14.3%	2	28.6%	1	14.3%	2	28.6%	1	14.3%
8	0	0.0%	3	37.5%	1	12.5%	3	37.5%	1	12.5%
9	3	25.0%	1	8.3%	4	33.3%	3	25.0%	1	8.3%
10	2	13.3%	6	40.0%	5	33.3%	2	13.3%	0	0.0%
11	1	11.1%	2	22.2%	2	22.2%	3	33.3%	1	11.1%
12	3	37.5%	1	12.5%	1	12.5%	2	25.0%	1	12.5%
13	9	40.9%	6	27.3%	2	9.1%	3	13.6%	2	9.1%
14	12	29.3%	11	26.8%	6	14.6%	8	19.5%	4	9.8%
15	17	41.5%	8	19.5%	10	24.4%	4	9.8%	2	4.9%

Abbreviation: GCS-P, Glasgow P.

Table 9 Descriptive analysis: GCS-P x ICU time (days)

GCS-P/ICU time (days)	Transfer-red		Zero		1–3 days		4–7 days		8–14 days		15–21 days		> 21 days	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	0	0.0%	2	5.0%	3	7.5%	8	20.0%	6	15.0%	11	27.5%	10	25.0%
2	0	0.0%	0	0.0%	1	8.3%	3	25.0%	3	25.0%	3	25.0%	2	16.7%
3	5	6.4%	2	2.6%	1	1.3%	11	14.1%	22	28.2%	16	20.5%	21	26.9%
4	0	0.0%	0	0.0%	1	16.7%	1	16.7%	2	33.3%	1	16.7%	1	16.7%
5	0	0.0%	0	0.0%	0	0.0%	1	12.5%	3	37.5%	3	37.5%	1	12.5%
6	0	0.0%	0	0.0%	0	0.0%	1	9.1%	2	18.2%	5	45.5%	3	27.3%
7	0	0.0%	0	0.0%	0	0.0%	3	42.9%	2	28.6%	0	0.0%	2	28.6%
8	0	0.0%	0	0.0%	0	0.0%	1	12.5%	4	50.0%	2	25.0%	1	12.5%
9	0	0.0%	0	0.0%	2	16.7%	2	16.7%	4	33.3%	2	16.7%	2	16.7%
10	0	0.0%	1	6.7%	2	13.3%	2	13.3%	6	40.0%	3	20.0%	1	6.7%
11	0	0.0%	0	0.0%	1	11.1%	1	11.1%	4	44.4%	2	22.2%	1	11.1%
12	0	0.0%	2	25.0%	1	12.5%	1	12.5%	1	12.5%	2	25.0%	1	12.5%
13	1	4.5%	8	36.4%	2	9.1%	4	18.2%	1	4.5%	2	9.1%	4	18.2%
14	0	0.0%	11	26.8%	5	12.2%	6	14.6%	4	9.8%	11	26.8%	4	9.8%
15	0	0.0%	18	43.9%	7	17.1%	7	17.1%	4	9.8%	4	9.8%	1	2.4%

Abbreviations: GCS-P, Glasgow P; ICU, intensive care unit.

Table 10 Descriptive analysis: GCS-P x death

GCS-P/death	No		Yes		Transferred	
	n	%	*n*	%	*n*	%
1	20	50.0%	20	50.0%	0	0.0%
2	6	50.0%	6	50.0%	0	0.0%
3	51	65.4%	22	28.2%	5	6.4%
4	3	50.0%	3	50.0%	0	0.0%
5	5	62.5%	3	37.5%	0	0.0%
6	9	81.8%	2	18.2%	0	0.0%
7	3	42.9%	4	57.1%	0	0.0%
8	5	62.5%	3	37.5%	0	0.0%
9	7	58.3%	5	41.7%	0	0.0%
10	11	73.3%	4	26.7%	0	0.0%
11	4	44.4%	5	55.6%	0	0.0%
12	4	50.0%	3	37.5%	1	12.5%
13	15	68.2%	6	27.3%	1	4.5%
14	31	75.6%	10	24.4%	0	0.0%
15	35	85.4%	5	12.2%	1	2.4%

Abbreviation: GCS-P, Glasgow P.

Table 11 Descriptive analysis: GCS-P x Marshall CT classification

GCS-P/ Marshall	Marshall I		Marshall II		Marshall III		Marshall IV		Marshall V		Marshall VI		Unclassi-fied	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
1	0	0.0%	17	42.5%	6	15.0%	12	30.0%	3	7.5%	2	5.0%	0	0.0%
2	1	8.3%	3	25.0%	1	8.3%	5	41.7%	0	0.0%	0	0.0%	2	16.7%
3	0	0.0%	40	51.3%	13	16.7%	18	23.1%	3	3.8%	1	1.3%	3	3.8%
4	0	0.0%	3	50.0%	1	16.7%	0	0.0%	0	0.0%	1	16.7%	1	16.7%
5	0	0.0%	4	50.0%	1	12.5%	3	37.5%	0	0.0%	0	0.0%	0	0.0%
6	0	0.0%	4	36.4%	1	9.1%	3	27.3%	1	9.1%	1	9.1%	1	9.1%
7	0	0.0%	3	42.9%	3	42.9%	0	0.0%	1	14.3%	0	0.0%	0	0.0%
8	0	0.0%	2	25.0%	2	25.0%	3	37.5%	1	12.5%	0	0.0%	0	0.0%
9	1	8.3%	3	25.0%	4	33.3%	2	16.7%	2	16.7%	0	0.0%	0	0.0%
10	0	0.0%	6	40.0%	0	0.0%	6	40.0%	2	13.3%	0	0.0%	1	6.7%
11	0	0.0%	3	33.3%	0	0.0%	3	33.3%	3	33.3%	0	0.0%	0	0.0%
12	0	0.0%	4	50.0%	0	0.0%	3	37.5%	1	12.5%	0	0.0%	0	0.0%
13	0	0.0%	5	22.7%	5	22.7%	6	27.3%	3	13.6%	1	4.5%	2	9.1%
14	0	0.0%	19	46.3%	5	12.2%	9	22.0%	4	9.8%	3	7.3%	1	2.4%
15	2	4.9%	22	53.7%	3	7.3%	10	24.4%	3	7.3%	1	2.4%	0	0.0%

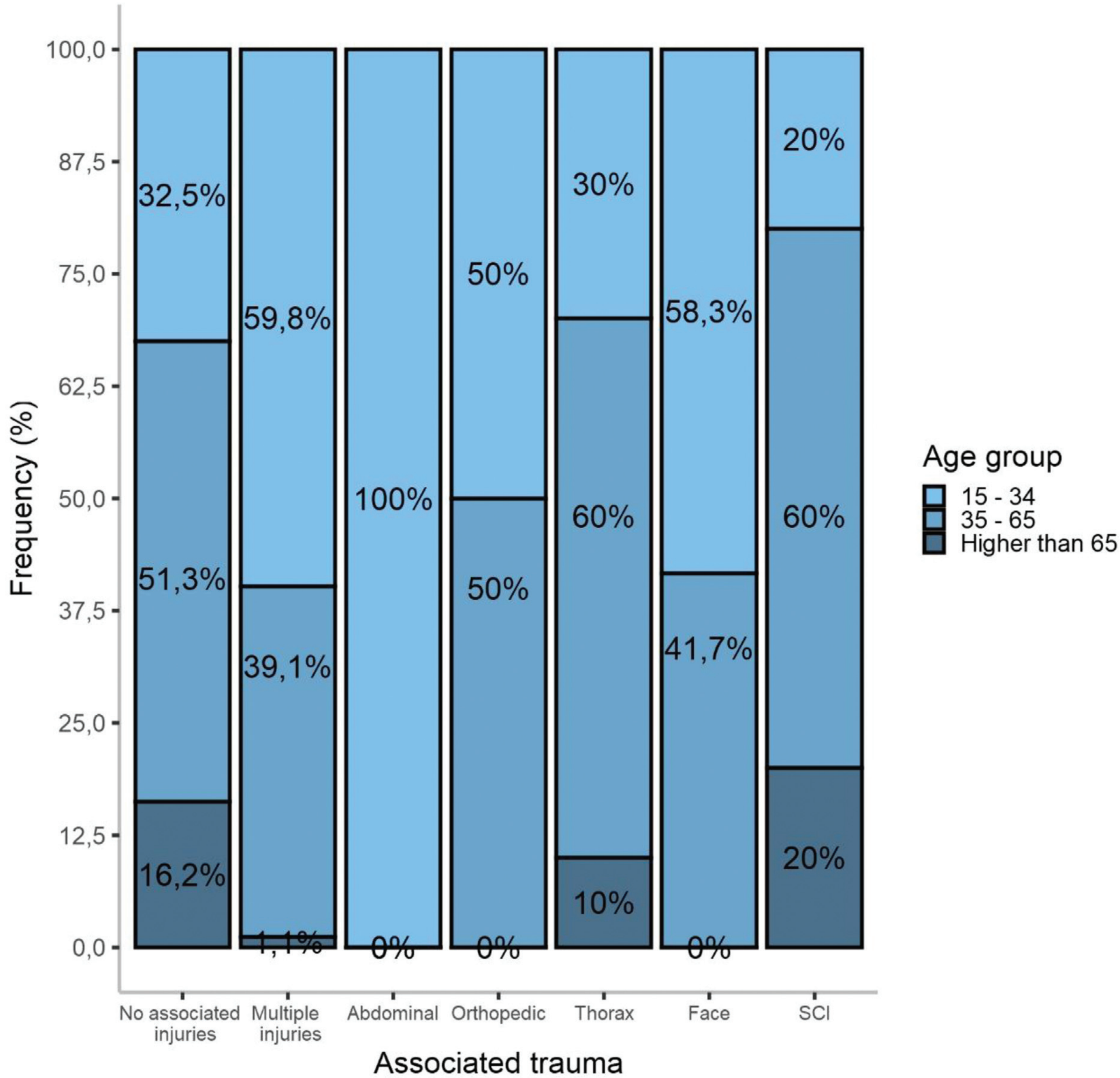
Abbreviations: CT, computed tomography; GCS-P, Glasgow P.

Table 12 Descriptive analysis: GCS-P x decompressive craniectomy

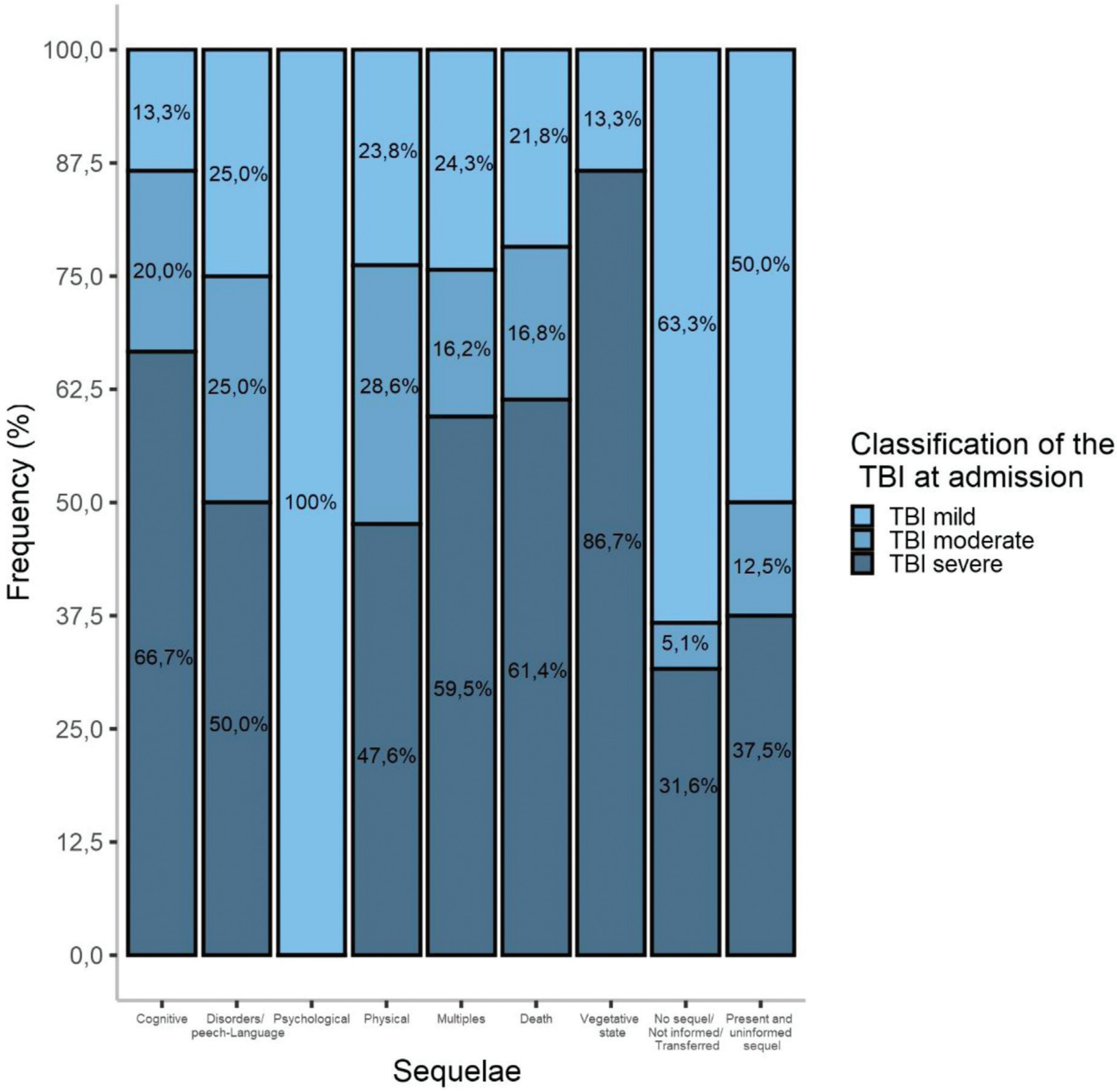
GCS-P/Decompressive craniectomy	No		Yes	
	N	%	N	%
1	27	67.5%	13	32.5%
2	8	66.7%	4	33.3%
3	57	73.1%	21	26.9%
4	4	66.7%	2	33.3%
5	7	87.5%	1	12.5%
6	6	54.5%	5	45.5%
7	5	71.4%	2	28.6%
8	5	62.5%	3	37.5%
9	7	58.3%	5	41.7%
10	12	80.0%	3	20.0%
11	6	66.7%	3	33.3%
12	7	87.5%	1	12.5%
13	15	68.2%	7	31.8%
14	25	61.0%	16	39.0%
15	37	90.2%	4	9.8%

Abbreviations: GCS-P, Glasgow P.

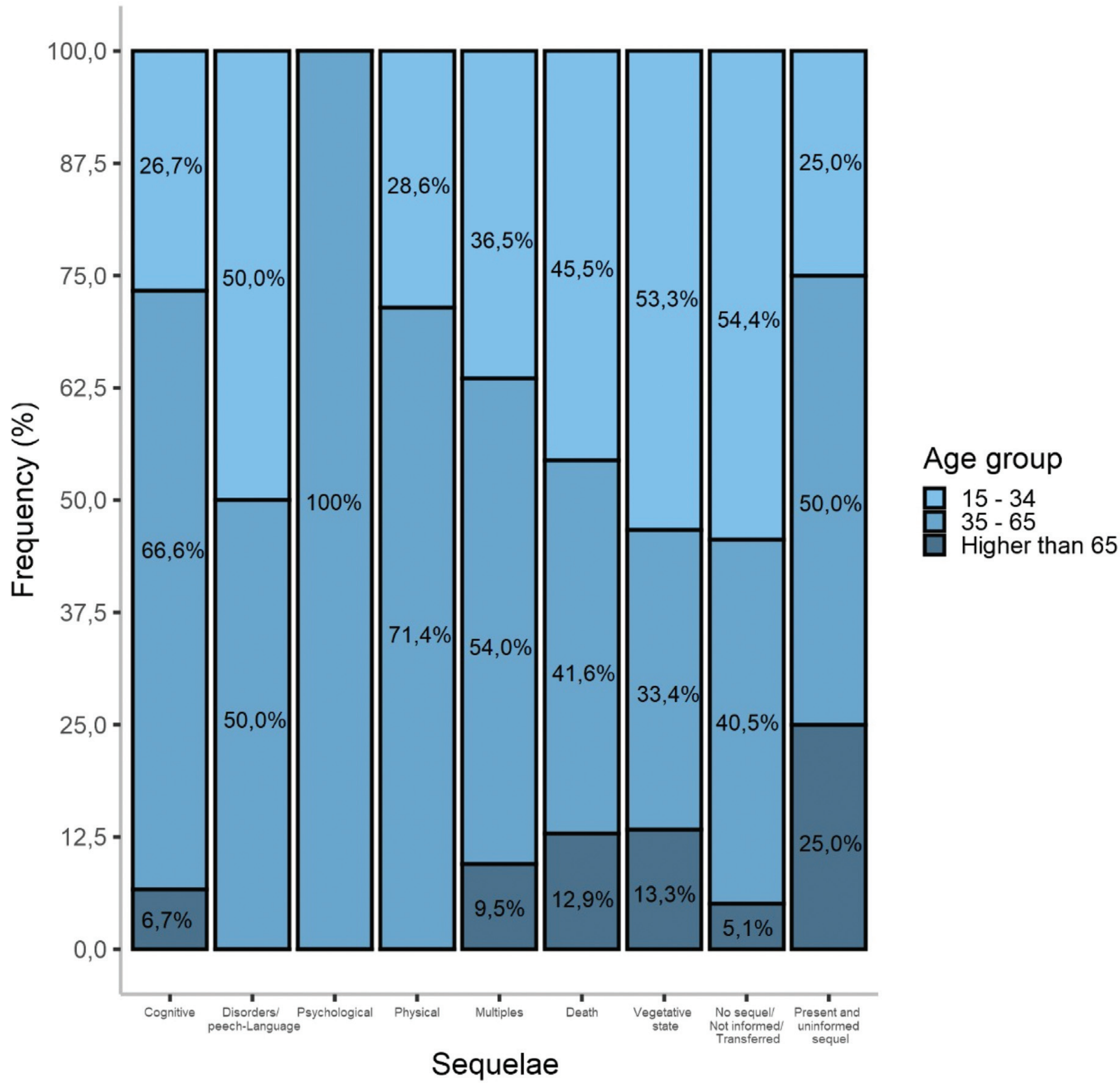
The following graphs show the relationship between, respectively: age group and associated trauma, TBI classification and sequelae at hospital discharge and age group and sequelae at hospital discharge (►**Graphs 4** to **6**).



Graphic 4 Age group and associated trauma.



Graphic 5 TBI classification and sequelae at hospital discharge.



Graphic 6 Age group and sequelae at hospital discharge.

