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Frontal Sinus Fractures and Traumatic Brain Injury: Predictors of Mortality in Surgical Management

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Abstract

Study Design: This is anobservational, retrospective, analytical study.
Objective: The aim was todetermine a statistical basis for a future line of research based on the epidemiology of a center located in a developing country, as well as defining indirect mortality predictors.
Methods: Clinical files were reviewed based on diagnosis of Traumatic Brain Injury (TBI), according to the International Classification of Diseases 10th Revision (ICD-10). Sociodemographic variables as well as treatment modality of the condition during hospitalization was recorded. The patient sample was divided into two groups. Student's T-test was performed in variables with normal distribution and Chi-square test in independent random variables with standard normal distribution. For correlations, Pearson's correlation coefficient was used, taking the *P*-value <.05 as statistically significant.
Results: A total of 150 participants were included in this study, from which 125 were male (83.3%). The average age was 28.58 ± 16.55 years. The median hospitalization time was 9 days. Forty-five patients (30%) were treated conservatively. Fifteen patients died during hospitalization. The factors considered as predictors of mortality in the general population corresponded to Motor Vehicle Accident, Frontonasal Duct Obstruction, Neuroinfection, Glasgow Coma Scale (GCS) at admission, as well as GCS at discharge. In the patients who underwent surgery, predictors of mortality corresponded to Motor Vehicle Accident, Bilateral Frontal Craniotomy, Surgical Bleeding >475 cc, Neuroinfection, as well as GCS at admission and discharge.
Conclusions: The creation of adequate diagnostic and therapeutic algorithms in traumatic brain injury management is needed, especially in developing countries. More specific studies are needed, particularly analytical and multicentric studies, which may allow the development of these algorithms.

Keywords

frontal sinus fracture, traumatic brain injury, skull injury, craniocerebral trauma, cranial surgery, frontal region trauma

Introduction

The paranasal sinuses are pneumatized structures covered by columnar epithelium and a mucous similar to that of the cavities of the upper airway. Sinuses are structures that initiate their development during the embryonic stage; however, it is not until the second decade of life that the frontal sinus completes its formation.[1,2]

Interestingly, these viscerocranium structures can present important normal anatomical variations, specifically in size and morphology, within populations that share similar ethnic and sociodemographic characteristics.

Despite the different hypotheses about their function, the one with the greatest consistency describes the security provision, given by these structures, to the encephalic substance.[3]

Fractures of the facial region are recognized as relevant pathologies in terms of patient morbidity and mortality, as well as their biological, psychological, and social implications on patients and their families.[1] Among the factors involved, the

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ones considered to be most important are the loss of function and the damage to facial aesthetic.[2] The frontal bone is the most resistant bone of the viscerocranium, being able to withstand between 400 and 1000 kilograms before suffering a fracture[3]; therefore, fractures of the upper third of the face involve a greater impact mechanism than those of the other two-thirds of the face.

Frontal fractures are considered rare in terms of prevalence, as opposed to mandible or malar fractures, which constitute the most common maxillofacial fracture of this same region.[4]

Morales-Olivera and collaborators have noted the lack of epidemiological studies regarding facial trauma in general; similarly, available data regarding frontal sinus fractures specifically are even scarcer.[5] On the other hand, Avello-Canisto and collaborators have indicated that this type of fracture occurs as a consequence of severe facial trauma, commonly presented as frontal impact in automobile accidents or against blunt structures.[6]

The clinical manifestations of these types of fractures are variable and will depend on the encephalic or sensatory organ involvement, as well as associated facial structure damage.[7] Furthermore, the associated sequalae resulting from these fractures will vary depending on the extent of the lesion, including compromised visual, auditory, or olfactory function.[8]

Therefore, a standardized, multidisciplinary, emergency approach should be prioritized as a strategy to limit short-, medium-, and long-term damage, in addition to restrict the compromise of vital structures in patients with frontal bone involvement. The developed strategies must consider the patient's associated factors, including age, history of chronic degenerative diseases, socioeconomic status, and the environment of the incident itself (the associated mechanism of damage and the characteristics of involved motor vehicles, within other factors), as well as the promptness in referral onto a center with management capabilities in this type of fracture.[9]

Furthermore, Canisto et al have suggested clinical factors that could be associated with poor prognosis for the patient, including the intensity of the involved trauma, degree of associated brain and eye involvement, age, and delay on medical management.[10]

The therapeutic approach for this type of fracture in our center has not been standardized and algorithmized. It was sought to determine the epidemiological factors, as well as indirect predictors of mortality, for epidemiological determination within our center and precedent establishment for subsequent creation of an efficient therapeutic algorithm applicable to our population.

Methods

Study Design

An analytical, observational, and retrospective study was developed, where a review of the clinical records of each individual participant was performed. Clinical, imaging, and surgical data of patients with Traumatic Brain Injury (TBI) between the years 2015 and 2021 was collected. Those who presented a frontal sinus fracture with associated TBI, based on the use of the International Classification of Diseases (ICD-10) referring to fractures of the frontal bone and frontal sinus, grouped as S0-2,[11] were included.

Patients who had a prior history of acute trauma, as well as those who underwent cranioplasty or similar interventions in a secondary instance, were excluded. Participants whose clinical records or computed tomography imaging wasn't available were eliminated. This study was developed within the University Hospital "Dr José Eleuterio González," a single, third-level, referral medical center belonging to Universidad Autónoma de Nuevo León. An alphanumeric Excel database was created from compiled participant data to organize relevant information.

Finally, consent for this study was given by the Institutional Review Board of Ethics and Research Committee, with registration number PI21-00389.

Variables

Sociodemographic variables, such as age, sex, nationality, and years of schooling, were compiled. Information regarding initial clinical presentation of the patients, such as Glasgow Coma Scale (GCS) score, presence of comorbidities such as chronic degenerative diseases, drug addictions, as well as their initial laboratories, which focused on blood biometry data, was collected.

Data regarding patient's condition previous and posterior to medical management, such as presence of neurological focalization, cerebrospinal fluid fistula, and associated complications (e.g., infection, fever, seizures, or death), were reviewed.

Information concerning surgical management and its characteristics, such as surgery duration, time window from door to surgery initiation, type of surgery, and material used, was reviewed as well.

Sample Size

The sample was gathered by convenience method of sampling, since the studied sample corresponded to the total number of patients who were hospitalized in the authors' center during 2015–2021.

Statistical Analysis

The sample was initially divided into two separate groups (surgical management vs non-surgical management) with the aim of determining variables of clinical significance. IBM SPSS software (version 23.012), RStudio (version 4.0.2), and the ggplot2 package were used for analysis.

To compare data between groups, Student's *t*-test was utilized in variables with normal distribution, whereas Chi-square test was applied in independent random variables with standard normal distribution.[12] For correlations, Pearson's correlation coefficient was used.

A *P*-value <.05 was considered statistically significant. The variables that resulted statistically significant in the univariate analysis, within the general population and in those who underwent surgery, were subjected to a multivariate logistic regression model to predict mortality.

Results

Sociodemographic Characteristics

A total of 457 clinical records were evaluated under the requested ICD-10. A total of 150 subjects who met inclusion criteria were included. The average population age was 32.95 ± 14.48 years, being 125 (86.4%) male patients.

Predominant comorbidities in our population corresponded to alcoholism, which was present in 78 patients (52%), smoking in 62 patients (41.3%), and obesity in 25 patients (16.6%). The additional comorbidities are listed in Table 1.

The group who underwent any type of intervention presented a higher percentage of male participants, a lower age range, as well as a greater number of comorbidities, including toxicosis, alcoholism, smoking, obesity, and type 2 diabetes, from which smoking was found as statistically significant (Table 2). A total of 119 patients (79.3%) had a follow-up of at least 6 months in the outpatient clinic.

Trauma Characteristics

The most common associated trauma mechanism was blunt trauma by direct assault, which includes batter with a blunt object, which represented 43 patients (28.7%), followed by trauma associated to motor vehicle accident (37 patients; 24.7%), and free fall from a distance >2 meters (29 patients; 19.3%).

The main associated trauma mechanism in the interventional group corresponded to blunt trauma by direct assault, which was present in 36 patients (35%), while the main associated trauma mechanism in the non-interventional group corresponded to free fall from a distance >2 meters, which was present in 17 patients (38%), both representing statistically significant variables. A detailed dissection of associated trauma mechanisms by group is represented in Table 2.

On admission evaluation, 21 patients (14%) had cerebrospinal fluid (CSF) fistula and 79 patients (50.3%) had neurological focalization, with no significant difference between groups. A total of 81 patients (54%) presented involvement of external and internal tables of the frontal sinus. The most common intracranial involvement corresponded to epidural hematoma, which was present in 41 patients (27.3%), from which 36 patients (34.3%) were in the interventional group. No differences were found in terms of laterality. The most common causes of mortality within our sample corresponded to Neuroinfection in 5 patients (3.3%), Intracerebral Hemorrhage in 3 patients (2%), and Epidural Hematoma in 2 patients (1.3%).

In the interventional group, involvement of both frontal sinus tables was present in 65 patients (61.9%). In the non-intervention group, the most affected table of the frontal sinus corresponded to the external table, which was presented in 25 patients (55.6%), which was statistically significant.

Nasofrontal duct obstruction was found, by computed tomography, in 71 patients (47.3%), which corresponded to less than 15% (14 patients) of the patients in the non-intervention group and more than 50% (57 patients) in the interventional group, presenting statistical significance.

A greater number of depressed fractures were present in the interventionism-group, in comparison to the non-interventionism group, in which the most common pattern of fracture corresponded to linear fractures (Table 2).

Intervention Characteristics

The most common surgical approach developed in our center corresponded to bilateral frontal craniotomy, which was performed in 52 patients (49.5%). The second most common surgical approach corresponded to squirlectomy and osteosynthesis, which was performed in 33 patients (31.4%). The third most common approach corresponded to unilateral frontal craniotomy, which was performed in 17 patients (11.3%) (Table 1).

No significant differences were found between the Glasgow Coma Scale on admission and at discharge in either group or between groups. A total of 134 patients (86.4%) were transferred postoperatively to recovery room, while the rest had to be transferred previously to the intensive care unit for specialized care, where they remained for an average of 4 days (±2.1 days).

A significant difference was found when comparing days until home discharge between groups, corresponding to 9 days (7–14 days) on the intervention group and 6 days (5–13 days) in the control group.

In the intervention group, transoperative bleeding average corresponded to 390 cc (155–600 cc), and the average surgical duration was 240 minutes (151.5–300 minutes). The most common type of surgical wound performed was the Sauter type in 51 patients (48.6%), while the most used prophylaxis antibiotic was Amoxicillin with clavulanic acid, which was administered in 80 patients (53.3%).

The most common complication developed corresponded to neuroinfection, which was developed in 7 patients (4.6%), followed by local infection (3.3%), and soft tissue infection (1.3%). No bone infection was reported.

Table 1. General Population Characteristics.

Population Characteristics	Total Study Population (N = 150)
Age in years	28.58 ± 16.55
Gender	
Female	25 (16.7%)
Male	125 (83.3%)
Comorbidities	
Alcoholism	78 (52%)
Smoking	62 (41.3%)
Drug addiction	31 (20.6%)
Obesity	25 (16.6%)
Diabetes mellitus type 2	17 (11.3%)
Arterial hypertension	20 (13.3%)
Others	16 (10.6%)
Surgery characteristics	
Presurgical CSF fistula	21 (14%)
Post-surgical CSF fistula	6 (4%)
Type of intervention	
Conservative treatment	45 (30%)
Bilateral frontal craniotomy	52 (34.7%)
Unilateral frontal craniotomy	17 (11.3%)
Squirlectomy and osteosynthesis	33 (22%)
Material used	
Pericranium	48 (30.9%)
Gelfoam	32 (20.6%)
Bone wax	32 (20.6%)
Muscle	29 (18.7%)
Surgicel	12 (7.7%)
Fascia	1 (.6%)
Fat	1 (.6%)
Glasgow at admission[a]	14 (12–15)
Glasgow at discharge[a]	15 (14–15)
Waiting days for surgery[a]	1 (0–2)
Surgery waiting time (hours)[a]	8 (4–17)
Operative bleeding (cc)[a]	390 (155–600)
Duration of surgery (min)[a]	240 (151.5–300)
Type of surgical wound performed	
Souter	51 (48.6%)
Trauma flap	15 (14%)
Bicoronal	14 (13.3%)
Through original traumatic injury	7 (6.6%)
Wound reopening	6 (5.3%)
Italic S-shaped wound	5 (4.6%)
Hemisauter	5 (4.6%)
Horseshoe wound	2 (2%)
Prophylactic antibiotics	
Amoxicillin	80 (53.3%)
Cephalothin	60 (40%)
Ceftriaxone	41 (27.3%)
Clindamycin	21 (14%)
Vancomycin	1 (.6%)
Prophylactic antimycotic	
Metronidazole	1 (.6%)

(continued)

Table 1. (continued)

Population Characteristics	Total Study Population (N = 150)
Complications	
Neuroinfection	7 (4.6%)
Local wound infection	5 (3.3%)
Soft tissue infection	2 (1.3%)
Onset of infection after admission (days)[a]	2.5 (2–3.75)
Fever after admission	18 (12%)
Cisternostomy	12 (8%)
Death	15 (10%)
Days of hospital stay[a]	9 (6–13.25)
Outpatient follow-up	119 (79.3%)

Note.
[a]Represents the use of the median and interquartile index to represent the data.

From the initial patients who presented CSF fistula, 6 patients (4%) persisted with this pathology; thus, due to decreased CSF pressure, patients were subjected to lumbar cisternostomy, which reported a mortality rate of 15 patients (10%) during postsurgical hospitalization and 3 patients (2%) during the first 6 months of postsurgical follow-up, both in the intervention group.

To determine the cutoff point for surgical bleeding as a predictor of mortality in our population an ROC curve was developed, which is presented in Figure 1. The developed multivariate regression model to predict mortality was controlled by age, sex, and intracranial involvement. Within the regression model in the general population, the associated predictors of mortality, which acquired statistical significance, corresponded to Motor Vehicle Accident (P = .001, aOR = 7.78, 95% CI 2.29–26.49), Frontonasal Duct Obstruction (P = .01, aOR = 6.39, 95% CI 1.56–26.18), Neuroinfection (P = .04, aOR = 6.97, 95% CI 1.10–44.31), GCS at Admission (P = < .001, aOR = 1.48, 95% CI 1.20–1.83), and GCS at Discharge (P = <.001, aOR = 1.63, 95% CI 1.30–2.06).

Alternatively, in the regression model which included the population which underwent surgical intervention, the associated predictors of mortality, which acquired statistical significance, corresponded to Motor Vehicle Accident (P = .002, aOR = 9.36, 95% CI 2.23–39.29), Bilateral Frontal Craniotomy (P = .02, aOR = 5.37, 95% CI 1.29–22.32), Surgical Bleeding ≥ than 475 cc (P = .03, aOR = 5.69, 95% CI 1.25–25.98), Neuroinfection (P = .04, aOR = 6.87, 95% CI 1.08–43.67), GCS at Admission (P = .005, aOR = 1.42, 95% CI 1.11–1.80), and GCS at Discharge (P = .001, aOR = 1.63, 95% CI 1.21–2.19). The complete information of the multivariate regression models performed is displayed in Figure 2.

Discussion

The results found in this study were consistent in comparison to similar retrospective studies and current scientific literature that have focused on frontal sinus fracture. Available literature suggests that this type of fracture presents in males with more frequency than females. In our study, male population represented more than 85% of our sample, which is a similar male prevalence reported by Stephen et al[13] in 2005, with 88% of males. Likewise, other similar studies report a male prevalence of more than 70%.[13-17] Our study also reported an age average of 32.95 ± 14.48 years, which is slightly lower than the reported age average in American literature, where the 35–45-year-old age group corresponded to the most affected.[16]

The most common mechanism of trauma within our population was blunt trauma by direct assault, which differs from other centers most common mechanism, as reported by Torres-Criollo et al[17] in 2020. This inconsistency in the type of mechanism with reported literature may be associated to exclusive evaluation and report of depressed skull fractures within the population of the previous study.

Furthermore, infection has been established as the most common complication associated with this type of fracture, while neuroinfection is the most feared associated complication. Loannides et al[18] reported a similar percentage of neuroinfection as in our population, although neuroinfection rate has been estimated to develop in, approximately, 6% of patients with this condition.[18,19]

Swinson et al[20] propose that the materials utilized within the surgical intervention for correction of structural defects produced by trauma may vary according to surgeons and centers preference and availability but emphasizing that bone grafting should be preferred over other types of materials. In our center, similar to Owens et al, [21] autologous pericranial grafting was the most used material for correction of structural defects. The usage of this material is preferred within our center because of the absence of economic resources and additional materials.

On their population, Bell et al[22] reported an average hospitalization of 8.9 days, which is similar to our

Table 2. Characteristics of the Population Who Underwent Surgery in Comparison to Those With Conservative Management.

	Surgery Group	Control Group	
Variable	N = 105	N = 45	P
Male	92 (87.6%)	33 (73.3%)	.717
Age in years	28.64 ± 15.8	28.45 ± 18.4	.951
Comorbidities			
Diabetes mellitus type 2	13 (12.4%)	4 (8.9%)	.536
High blood pressure	11 (10.5%)	9 (20%)	.116
Obesity	20 (19%)	5 (11.1%)	.232
Smoking	51 (48.6%)	11 (24.4%)	**.006**
Alcoholism	57 (54.3%)	20 (44.4%)	.269
Drug addiction	26 (24.8%)	5 (11.1%)	.058
Trauma mechanism			
Direct assault	36 (34.3%)	7 (15.6%)	**.020**
Automobile accident	26 (24.8%)	7 (15.6%)	.090
Motorcycle accident	12 (11.4%)	3 (6.7%)	.554
Fall from height	12 (11.4%)	17 (37.8%)	**<.001**
Firearm	3 (2.9%)	2 (4.4%)	1.00
Other	16 (15.2%)	9 (20%)	.473
CSF fistula pre-surgery	17 (16.2%)	4 (8.9%)	.238
Neurological focalization	48 (45.7%)	23 (52.3%)	.465
Glasgow			
Admission	14 (12–15)	14 (12.5–15)	.733
Discharge	15 (14–15)	15 (14.5–15)	.877
Involvement of tables			.129
Internal	6 (5.7%)	6 (13.3%)	
External	34 (32.4%)	18 (40%)	
Both	65 (61.9%)	21 (46.7%)	
Nasofrontal duct obstruction	6 (5.7%)	7 (15.6%)	.062
Type of hematoma			
Epidural	36 (34.3%)	10 (22.2%)	.142
Subdural	18 (17.1%)	10 (22.2%)	.464
Subarachnoid	14 (13.3%)	12 (26.7%)	**.048**
Parenchymal	14 (13.3%)	3 (6.7%)	.238
Contusion	16 (15.2%)	9 (20%)	.473
Pneumocephalus	16 (15.2%)	2 (4.4%)	.062
Complete displacement	32 (30.8%)	11 (26.2%)	.583
Laterality			.316
Left	45 (43.3%)	16 (35.6%)	
Right	44 (42.3%)	18 (40%)	
Bilateral	15 (14.4%)	11 (24.4%)	
Type of fracture			
Depressed	62 (59.6%)	6 (13.3%)	**<.001**
Linear	42 (40.4%)	39 (86.7%)	**<.001**
Labs at admission			
Hemoglobin	14.1 (12.3–15.2)	13.4 (12.1–14.4)	.165
Leukocytes	14.6 (11.3–18)	14.8 (11.7–18.5)	.626
Neutrophils	11.4 (7.5–14.7)	11 (8–15.4)	.916
Lymphocytes	1.89 (1.14–2.89)	1.8 (1.1–3.3)	.667
Platelets	234 (183.5–285)	245 (214.5–271.5)	.264
MPV	7.87 (6.89–9)	7.43 (6.6–8.3)	.075

(continued)

Table 2. (continued)

Variable	Surgery Group N = 105	Control Group N = 45	P
Labs at discharge			
Hemoglobin	11.9 (10.3–13.7)	12.7 (11.4–13.9)	.062
Leukocytes	12.1 (10–15.5)	12.6 (10.9–16.2)	.448
Neutrophils	9.8 (7.14–13.3)	10.5 (7.68–13.8)	.409
Lymphocytes	1.42 (1.1–2.16)	1.3 (.8–1.8)	.143
Platelets	223 (167–280)	220 (183–254)	.936
MPV	7.38 (6.57–8.29)	7.29 (6.7–8.2)	.785
Days of hospital stay	9 (7–14)	6 (5–13)	**.008**

Bold values indicates the statistical significance.

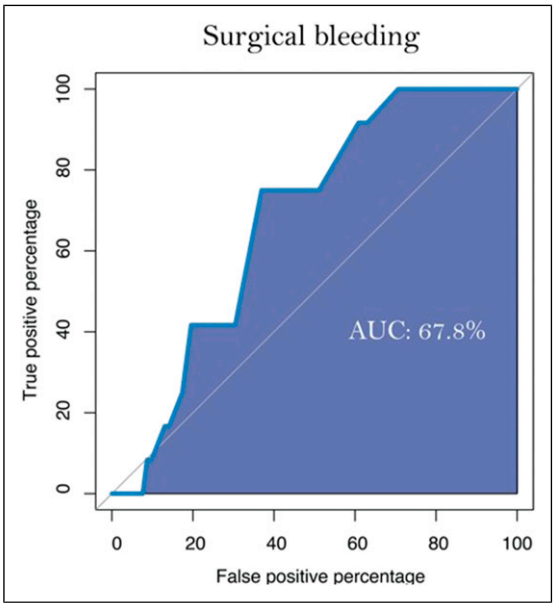

Figure 1. ROC curve describing the surgical bleeding cutoff point of significance.

population, with 9 days of follow-up. Notably, most of their patients did not require surgical management and were consequently treated conservatively, which differs from our management distribution. In their associated fracture mechanism, trauma associated with motor vehicle accident and blunt trauma by direct assault were listed within the most common causes. For their surgical management, similar to our center, autologous pericranial grafting was considered as the preferred material and systematically used. Regarding their mortality and complication rate, its percentages were relatively low (5.1% and 6.9%, respectively), which can be associated with the existence of a previously established surgical protocol for these types of fractures within their institution, thus, demonstrating the importance of the creation and standardization of surgical protocols for an adequate management of frontal sinus fractures.

Our study findings are similar to those reported outside of Mexico, therefore, serving as an epidemiological and surgical reference in developing countries such as our own. However, we identified a variation in management selection in comparison to other authors, where clinical observation is preferred over intervention with the goal of frontal sinus preservation, suggesting that surgical management of frontal sinus fracture should be employed exclusively if nasofrontal duct obstruction, CSF leakage, or threatening intracranial involvement is present. This management selection, in addition to the recommendation of prophylactic antibiotic usage, may result in the reduction of mortality and complication rate in short and long term.[23-26]

Another management possibility in frontal sinus fractures, as described by Jing et al,[27] is the usage of cranialization in cases of comminuted fractures of the posterior table. At our center, cranialization was performed in most of the patients within the interventionist group due to the complexity of these cases. In a clinical study conducted in Brazil, the described prevalence of nasofrontal duct obstruction corresponded to 2 patients (6.8%), which notably differs from our population, where 71 patients (47.3%) presented this associated complication. Additionally, their intracranial involvement, considering hemorrhages and hematomas, corresponded to 54.2%, which slightly contrast with our population intracranial involvement (46%).[28]

An additional clinical study developed in Mexico, which included 20 patients with frontal sinus fractures who were non-surgically managed, implied that a non-interventionist management, when selected with an individualized approach, may be a feasible treatment modality, although it may as well be associated with complications, such as CSF leakage and frontal abscesses, in approximately 20% of patients. These results are considerable; however, it is important to consider that trauma mechanism as well as intracranial involvement is not depicted. Additionally, only

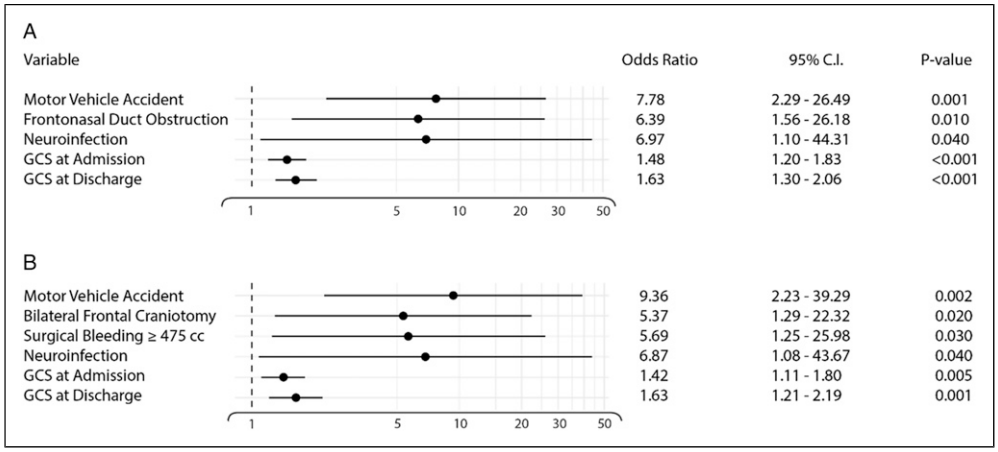

Figure 2. Multivariate regression model controlled by age, sex, and intracranial involvement represented in a Forrest Plot. (A) Selected variables of the general population introduced to the multivariate regression model. (B) Selected variables of the patients who underwent surgical intervention introduced to the multivariate regression model.

a limited number of patients have long-term follow-up.[29] Alternatively, in another Mexican study in which surgical management of frontal sinus fractures was exclusively evaluated, it was determined that their main associated fracture mechanisms corresponded to blunt trauma by direct assault from a third party on a public road, which is consistent with our population. The most associated fracture corresponded to an orbital fracture. While the surgical approach within this population was not specified, it concluded in cranialization of the frontal sinus.[30]

When evaluating the 15 deceased patients within our intervention group, we recognized a higher prevalence of associated factors, such as an associated high-power trauma mechanism (trauma associated to motor vehicle accident), an extensive surgical approach (bilateral frontal craniotomy), presence of nasofrontal duct obstruction, a transsurgical bleeding greater than 475 milliliters, as well as postsurgical infection.

Within our regression model, it was evidenced that the presence of clinical factors, associated trauma mechanism, as well as the development of specific surgical approaches, may predispose suboptimal clinical outcomes and mortality, thus, suggesting that an adequate evaluation of the clinical and non-clinical characteristics could be of importance when estimating mortality as an outcome in patients who have traumatic brain injury with associated frontal sinus fractures. Nevertheless, additional prospective studies are needed to establish adequate evaluation protocols of patients with facial trauma, as well as feasible and secure surgical algorithms, within low- and middle-income countries.

The limitations of the present study are in its methodological composition, being a descriptive, observational, and retrospective study. It is of importance to remark the necessity of further prospective, analytical, and multicentric studies, which may allow further evaluation of relevant prognostic factors, in addition to discern adequate management algorithms, consequently, improving the existing limitations within this study. Additionally, it is important to note that the current study did not account for concomitant injuries in our patients, potentially serving as a confounding factor. This omission underscores the need for caution when interpreting the study results, as the presence of additional injuries alongside the primary focus may introduce complexities that could influence the observed outcomes. Furthermore, it is imperative to acknowledge that the elevated odds ratio identified in the current study for certain interventions may be associated with selection bias. This observation stems from the propensity for more invasive surgical approaches to be employed in cases characterized by severe traumatic injuries. It is crucial to interpret these findings in the context of patient selection, where the severity of trauma may influence the choice of interventions, thereby impacting the observed odds ratios. Careful consideration of the clinical nuances surrounding traumatic brain injuries and frontal sinus fractures is essential for a comprehensive understanding of the study results.

Conclusion

Frontal sinus fractures are, although uncommon, a clinically relevant type of fracture commonly produced from a high-energy traumatic injury, which associates with significant morbidity and mortality.

Current scientific literature regarding frontal sinus fractures, as well as their clinical and management characteristics, is scarce and generally focused on accompanied facial fractures of the intermediate and lower third of the viscerocranium, which, in comparison, are more common.

An adequate evaluation of the epidemiological and clinical characteristics of patients with frontal sinus fractures within tertiary level centers may promote the development of greater clinical studies, which may elucidate the common associated pathogenesis, pathological factors which could promote poor clinical outcomes, as well as the adequate management pathway considering patient-specific characteristics.

Continuous efforts in facial trauma should be promoted, especially within institutions that evaluate and manage this type of fracture without a stablished therapeutic algorithm. Further development of clinical studies focused on frontal sinus fractures will promote the comprehension of this pathology, which, additionally, may facilitate the generation of standardized, evidence-based, therapeutic algorithms which consider patient-specific clinical and epidemiological factors. The creation of this type of patient-specific therapeutic algorithms may associate with better clinical outcomes in patients with frontal sinus fractures.

Author's Notes

Previous Presentations: Poster presentation at "Congreso de Neurocirugía del Noreste" of the "Sociedad de Cirugía Neurológica" of Mexico, where it obtained the second place in its category. Poster presentation at "32° Congreso Nacional de Investigación e Innovación en Medicina," Universidad Autónoma de Nuevo León, Mexico.

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