Computed Tomography Predictors of Vascular Injury in Cranioencephalic Trauma Patients

Preditores tomográficos de lesão vascular em pacientes com traumatismo cranioencefálico

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Abstract

Objective A frequent challenge for the neurosurgeon when treating a patient with cranioencephalic trauma is to determine whether the patient has a vascular lesion, when to suspect it, and what studies to request. In this context, the objective of the present study was to identify the variables on cranial computed tomography (CT) scans that predict vascular injury in digital subtraction angiography in patients with cranioencephalic trauma.

Methods We conducted a cross-sectional study of patients with cranioencephalic trauma admitted to the Hospital Universitario del Valle between June 2016 and June 2019. Subjects with available simple CT images of the skull and digital subtraction angiography were included.

Results A total of 138 subjects who met the inclusion criteria were identified. The average age was 32 years, 82% were men, and the most frequent mechanism of injury was firearm wound (59%). The variables associated with vascular injury were fracture of the base of the temporal skull and sphenoid fracture.

Conclusion The presence of fractures of the base of the temporal skull and sphenoid fractures is associated with vascular injury in patients with cranioencephalic trauma.

Keywords
- traumatic brain injuries
- vascular system injuries
- X-ray computed tomography

Resumo

Objetivo Um desafio frequente para o neurocirurgião no cuidado de um paciente com traumatismo crânio-encefálico é determinar se o paciente tem lesão vascular, quando suspeitar que tem, e quais estudos pedir. Neste contexto, o objetivo deste estudo foi identificar as variáveis da tomografia computadorizada (TC) de crânio que predizem lesão vascular na angiografia por subtração digital em pacientes com traumatismo crânio-encefálico.

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Métodos Fez-se um estudo transversal de pacientes com traumatismo crânio-encefálico internados no hospital (cego) entre junho de 2016 e junho de 2019. Foram incluídos também pacientes com imagens de TC simples do crânio e angiografia de subtração digital disponíveis.

Resultados Foram identificados um total de 138 sujeitos que cumpriam os critérios de inclusão. A média de idade foi de 32 anos, 82% eram homens, e o mecanismo da lesão mais frequente foi o ferimento por arma de fogo (59%). As variáveis associadas à lesão vascular foram a fratura da base do crânio temporal e a fratura esfenoidal.

Conclusão A presença de fraturas da base do crânio temporal e fraturas do esfenoide está associada à lesão vascular em pacientes com traumatismo crânio-encefálico.

Palavras-chave
- lesões encefálicas traumáticas
- lesões do sistema vascular
- tomografia computadorizada por raios X

Introduction

Cerebrovascular injuries associated with cranioencephalic trauma can be classified according to their location, which can be extracranial or intracranial.[1] They are caused by external forces to the skull or neck and their contents,[2] compromising the microvasculature, the great vessels, or both.[3] The present study focuses on intracranial lesions, whose diagnosis is challenging. The most frequently occurring intracranial vascular lesions are pseudoaneurysms,[4,5] venous sinus thrombosis, arterial dissections, and arteriovenous fistulas, the most frequent of which is cavernous carotid fistula.

A frequent challenge for the neurosurgeon when treating a patient with cranioencephalic trauma is to determine whether the patient has a vascular lesion, when to suspect it, and what studies to request.[6] There are recommendations or criteria for screening in the literature, such as those of the Japanese guidelines for the management of cranioencephalic trauma.[2] According to some authors, the true positive rates of these screening methods are only between 31.3% and 42%.[2] Therefore, complementary clinical and radiological criteria should be established to more accurately determine who will benefit from additional studies or interventions to clarify the presence of a vascular lesion.[7] Such efforts are of utmost importance because, despite their low prevalence of approximately 1%, these pathologies are accompanied, in a large extent, by hemorrhagic and ischemic complications in up to 50% of the cases if the pathology involves the internal carotid artery, and in $\sim$ 25% of the cases if the vertebral arteries are involved.[8]

In this context, the present study aimed to characterize the radiological findings on simple computed tomography (CT) scans of the skull that are most frequently associated with intracranial vascular lesions in patients with cranioencephalic trauma.

Materials and Methods

A cross-sectional, retrospective study was conducted. Through convenience sampling, we included patients with cranioencephalic trauma and with suspected vascular injury who were admitted to the Hospital Universitario del Valle between June 2016 and June 2019 and underwent simple CT and digital subtraction angiography. The present study was conducted in accordance with the Declaration of Helsinki, and adhered to the Good Clinical Practice guidelines.

A descriptive analysis was performed. For the continuous variables, measures of central tendency were estimated, and, for the categorical variables, frequencies and percentages were calculated. The distribution of the variables was verified by histograms and box and whisker plots.

A univariate analysis was performed using logistic regression to establish the association between the TC and angiography findings. In addition, a multivariate analysis was performed using logistic regression with stepwise selection and an inclusion probability of 0.1. Statistical analyses were performed with the Stata (StataCorp LLC, College Station, TX, United States) software, version 3.

Results

A total of 138 subjects were identified from the search of the trauma registry databases of the Hospital Universitario del Valle and the angiography service of the institution Hospital Universitario del Valle. A total of 138 subjects were included, and 82% were men ($n = 112$) with an average age of 32.1 ± 16.04 years. The most frequently reported trauma mechanism was gunshot wound, reported in 59% of the cases ($n = 81$), followed by blunt trauma, reported in 36% of the cases ($n = 49$), and sharps injury, reported in 5% of the cases ($n = 7$).

The results of the logistic regression showed an association between temporal fractures and the presence of lesions on angiography (odds ratio [OR]: 2.1; 95% confidence interval [95%CI]: 0.98 to 4.53), and no association regarding the location of bleeding or fractures. Concerning the Glasgow coma scale (►**Fig. 1**), 66 patients (48.18%) presented a Glasgow of 15 on admission, and 23 patients had a Glasgow of 8 or lower on admission (16.79%); on the other hand, 48 patients were admitted with a Glasgow between 9 and 14 (35.1%).

A regression analysis was performed to evaluate the association with venous sinus injury, and a significant relationship with fractures of the temporal base and of the sphenoid bone (►**Table 1**) was found. No statistically significant association was found with pseudoaneurysm. In the

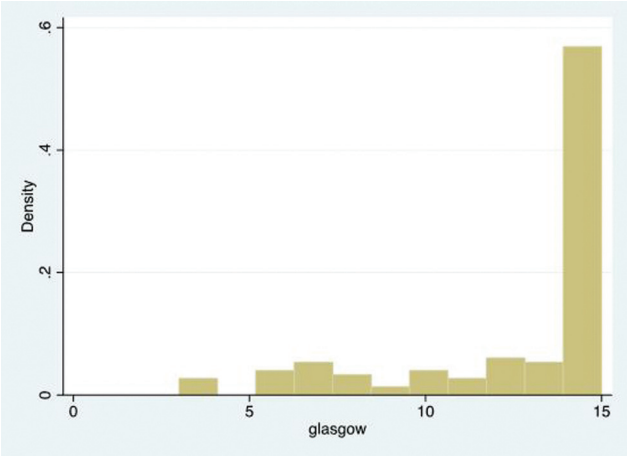

Fig. 1 Distribution of Glasgow scores upon admission.

multivariate analysis to evaluate the association with the incidence of vascular dissection, a relationship was found with temporal base fractures (OR: 4.6; 95%CI: 1.4 to 14.9), but not with sphenoid hemosinus.

Discussion

The present study evaluated different markers on simple cranial CT scans to establish their association with the presence of vascular lesions, and found that temporal base fractures are associated with the diagnosis of arterial dissection and venous sinus lesions. Traumatic pseudoaneurysms are lesions in which all the layers of the vessel are compromised; they are classified as false aneurysms. Pseudoaneurysms generate the formation of a hematoma, which is transformed into a material rich in collagen and presents the appearance of an aneurysmal sac on neuroimaging studies. In contrast, in a true traumatic aneurysm, the adventitia of the vessel is preserved.[9] The clinical manifestations of aneurysms and traumatic pseudoaneurysms might include intracranial bleeding or persisting epistaxis, decreased visual acuity, and headache. There are specific radiological findings on the simple cranial CT scan that enable the suspicion of a vascular lesion, including the presence of projectile fragments near the base of the skull, the presence of a hematoma near the site of entry of the penetrating trauma,[10] and intracranial hemorrhage. The treatment of this condition is usually transcranial or endovascular surgical management.[9]

Regarding arteriovenous fistulas, the most common location is between the internal carotid artery (ICA) and the cavernous sinus.[11] The pathophysiology is based on the transmission of energy and torsional forces to the cavernous ICA at its point of dural fixation to the clinoid process. The compromise is usually unilateral, and the symptoms and signs are generated by the compromise of the venous drainage of the orbit and the increase in intraorbital pressure, which causes proptosis, limitations to extraocular movements, diplopia, chemosis, orbital murmur, and scleral injection.[9] An important and rare complication of fistulas is intracranial hemorrhage secondary to cortical venous hypertension, which is an emergency, and management is usually interventional.[12] Carotid-cavernous fistulas can be classified as direct or indirect; the latter occurs when there is substitution of the dural branches of the external or internal carotid.[11] The Barrow classification establishes that fistulas can be classified as: type A, when they are direct and have high flow without supply from the external carotid; type B, when they have low flow from the meningeal-feeding branches of the internal carotid; type C, when they have low flow and are fed exclusively by the internal carotid; and type D, when they have low flow but are fed by branches of the internal and external carotid.[10]

Table 1 Logistic regression for venous sinus injury

Variable	Odds ratio	95% confidence interval	*p*-value
Temporal skull base fracture	4.3	1.6–11.8	0.004
Sphenoid skull base fracture	0.09	0.01–0.72	0.023

Vascular injuries secondary to head trauma are associated with complications with a very high percentage of morbidity and mortality, and present a diagnostic challenge because they can be asymptomatic; therefore, it is necessary to include different radiological criteria in the diagnostic process. Among the criteria that help determine the need to perform a vascular study is the Denver scale for closed trauma.[13] It is widely known that the "gold standard" for ruling out a traumatic vascular injury is cerebral angiography with digital subtraction, which has greater diagnostic capacity in the case of pathologies such as aneurysms and pseudoaneurysms.[14] However, the current recommendation is to perform CT angiography with a minimum of 16 channels, a procedure that has decreased the rate of associated infarcts from 15.2% to 3.8%.[13] With this measure, the time between diagnosis and the start of treatment has been shortened, since cranial CT scan is a technique that can be rapidly performed and has great value for determining vascular lesions.[15] This radiodiagnostic method can be implemented as a predictor of intracerebral vascular lesions.[13]

Conclusions

The limitations of the present study lie in its retrospective nature and its limited power due to the sample size. Prospective studies with larger samples could identify additional predictors. Given the results obtained from the present study, it can be concluded that the presence of temporal and sphenoid skull base fracture can predict the finding of venous sinus injury. In addition, fractures of the base of the temporal skull are associated with arterial dissections.

Informed Consent and Patient Details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s) and/or volunteers.

Author Contributions
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Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Monson KL, Converse MI, Manley GT. Cerebral blood vessel damage in traumatic brain injury. Clin Biomech (Bristol, Avon) 2019;64:98–113
2 Kobata H. Diagnosis and Treatment of Traumatic Cerebrovascular Injury: Pitfalls in the Management of Neurotrauma. Neurol Med Chir (Tokyo) 2017;57(08):410–417
3 Tunthanathip T, Phuenpathom N, Saehaeng S, Oearsakul T, Sakarunchai I, Kaewborisutsakul A. Traumatic cerebrovascular injury: Prevalence and risk factors. Am J Emerg Med 2020;38(02): 182–186
4 Abdalkader U, Kaliaev A, Nguyen T. Endovascular Management of Ruptured Traumatic Middle Meningeal Artery Pseudo aneurysm and Arteriovenous Fistula. J Vasc Endovasc Ther. 2019;4 (02):1–4
5 Zheng Y, Lu Z, Shen J, Xu F. Intracranial Pseudoaneurysms: Evaluation and Management. Front Neurol 2020;11:582
6 Amorim RL, Morais BA, Pereira FOC, et al. Evaluation of Head Computed Tomography Assessment of Brain Swelling after Acute Traumatic Brain Injury: A Pilot study. Arq Bras Neurocir Brazilian Neurosurg. 2019;38(04):257–262
7 Alons IME, Goudsmit BFJ, Jellema K, van Walderveen MAA, Wermer MJH, Algra A. Prediction of vascular abnormalities on CT angiography in patients with acute headache. Brain Behav 2018;8(06):e00997
8 Miley JT, Rodriguez GJ, Qureshi AI. Traumatic Intracranial Aneurysm Formation following Closed Head Injury. J Vasc Interv Neurol 2008;1(03):79–82
9 Larsen DW. Traumatic vascular injuries and their management. Neuroimaging Clin N Am 2002;12(02):249–269
10 Guyot LL, Kazmierczak CD, Diaz FG. Vascular injury in neurotrauma. Neurol Res 2001;23(2-3):291–296
11 Torres Zambrano M, Rubio Rodríguez W, Conde Cardona G, et al. Síntomas neurológicos de fístula carotídeo carvenosa: reporte de caso. Acta Neurol Colomb 2017;33(04):274–278
12 Fusco MR, Harrigan MR. Cerebrovascular dissections: a review. Part II: blunt cerebrovascular injury. Neurosurgery 2011;68(02): 517–530, discussion 530
13 Brommeland T, Helseth E, Aarhus M, et al. Best practice guidelines for blunt cerebrovascular injury (BCVI). Scand J Trauma Resusc Emerg Med 2018;26(01):90
14 Catapano JS, Lang MJ, Koester SW, et al. Digital subtraction cerebral angiography after negative computed tomography angiography findings in non-traumatic subarachnoid hemorrhage. J Neurointerv Surg 2020;12(05):526–530
15 Mata-Mbemba D, Mugikura S, Nakagawa A, et al. Early CT findings to predict early death in patients with traumatic brain injury: Marshall and Rotterdam CT scoring systems compared in the major academic tertiary care hospital in northeastern Japan. Acad Radiol 2014;21(05):605–611

