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BEATRIZ BARBOSA DE VASCONCELOS

A INVAGINAÇÃO BASILAR CURSA COM ALTERAÇÕES NA MORFOMETRIA DO CANAL DO NERVO HIPOGLOSSO?

IS BASILAR INVAGINATION RELATED WITH STENOSIS OF THE HYPOGLOSSAL NERVE CANAL?

JOÃO PESSOA
2021

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Trabalho de Conclusão de Curso apresentado à Coordenação do Curso de Graduação em Medicina do Centro de Ciências Médicas da Universidade Federal da Paraíba, como parte dos requisitos à obtenção do título de bacharel em Medicina.

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RESULTADO: Aprovado

João Pessoa, 06 de Maio de 2021.

Este trabalho de conclusão de curso é inteiramente dedicado aos meus pais, Sandra e Vasconcelos. Os dois maiores incentivadores das realizações dos meus sonhos, a minha fonte de afeto, amor, sabedoria e força. Muito obrigada!

RESUMO

Introdução: A invaginação basilar (IB) tipo B é uma anomalia da junção craniovertebral (JCV) caracterizada pelo deslocamento da coluna cervical e margem anterior do forame magno em direção cefálica, para a fossa posterior do crânio. Os côndilos occipitais, que contém o canal do nervo hipoglosso (CH), são frequentemente hipoplásicos nessa anomalia. **Objetivos:** Analisar se pacientes com IB mostram alterações nos diâmetros transversos (calibre) do CH. **Metodologia:** estudo caso-controle retrospectivo com exames de RM do crânio provenientes de um banco de dados de um serviço privado de radiologia. Foram incluídos no estudo exames de sujeitos maiores de 18 anos e sem distinção de sexo. As mensurações foram feitas na sequência volumétrica isotrópica T1 (MPRAGE), com espessura de corte sagital e coronal entre 0,9 e 1,1mm. Um grupo com IB (n=36) e um grupo controle (n=31) formaram a amostra. Os diâmetros interno (DI) e externo (DE) do CH foram mensurados no plano coronal através do software de visualização e processamento de imagens Osirix® (V.3.9.2). O teste de Kolmogorov-smirnov com ajuste de Lilliefors foi usado para avaliar a normalidade das variáveis e o teste de Levene usado para avaliar a homogeneidade das variâncias. O teste t de Student avaliou a diferença entre os grupos. Todas as análises foram no intervalo de confiança de 95% usando a versão 20 do programa SPSS. **Resultados:** o grupo controle apresentou valores dos DE direito e esquerdo com média de 4,7 ±0,8mm e 4,6 ±0,9mm, enquanto o DI direito e esquerdo teve média de 4,4 ±0,9mm e 4,3 ±0,8mm, respectivamente. O grupo caso mostrou valores de DE direito e esquerdo com média de 3,3 ±0,9mm e 3,1 ±0,9mm e os DI direito e esquerdo apresentaram média de 2,8 ±0,7mm e 2,7 ±0,7mm, respectivamente. Os valores médios do DE e DI foram menores do grupo com IB, com diferença estatisticamente significante (P<0,001). **Conclusão:** pacientes com IB tipo B apresentaram estreitamento de CH quando comparados à indivíduos saudáveis.

PALAVRAS-CHAVE:

- Nervo hipoglosso
- Platibasia
- Imagem por ressonância magnética
- Impressão basilar

ABSTRACT

OBJECTIVE: To analyze the association between basilar invagination (BI) and stenosis in the hypoglossal canal (HC). **METHODS:** A case-control study with magnetic resonance images (MRIs) of the head from a local database was performed. The study used MRIs of 36 patients with BI (type B) and 31 controls, both groups over 18 years of age and without sex distinction. The internal (ID) and external (ED) diameters of the HC were measured on the coronal plane using the Osirix® in its free version 3.9.2 (Mac-Apple platform). We used the Kolmogorov-Smirnov test (with Lilliefors adjustment) to evaluate the normality of the variables, the Levine test to verify the homogeneity of the variances, and Student's t test to verify differences between groups. All analyses were within the 95% confidence interval. **RESULTS:** Control group presented right and left ED values of 4.7 ± 0.8 mm and 4.6 ± 0.9 mm, respectively, while the right and left ID showed 4.4 ± 0.9 mm and 4.3 ± 0.8 mm, respectively. The group with BI showed right and left ED values of 3.3 ± 0.9 mm and 3.1 ± 0.9 mm, and the right and left ID had values of 2.8 ± 0.7 mm and 2.7 ± 0.7 mm, respectively. Both ED and ID were smaller in the group with BI ($P < 0.001$). **CONCLUSIONS:** Patients with BI of type B presented the narrowing of HC when compared with control participants.

KEY WORDS:

- Basilar impression
- Hypoglossal nerve
- Magnetic resonance imaging
- Platybasia

SUMÁRIO

INTRODUÇÃO

Basilar invagination (BI) type B is an abnormality of the craniovertebral junction characterized by a superior projection of the anterior contour of the foramen magnum into the posterior cranial fossa.[1-5] Its symptoms are a result of compression of the spinal cord, brainstem, and cerebellum.[6] Disturbances in cerebrospinal fluid circulation may also occur, leading to syringomyelia, and, in more severe cases, hydrocephalus.[1,4,7-10] Clinical signs of BI type B have slowly evolved over the years, usually manifesting in adults older than 40 years.[8] Symptoms may be varied and nonspecific, due to the complexity of the neural components involved. Magnetic resonance imaging (MRI) is the gold standard exam in the diagnosis and prognosis of this disease.[6,11]

The occipital bone includes the occipital condyles and the hypoglossal canal (HC), which derive embryologically from the vertebral area surrounding the foramen magnum.[12] The hypoglossal nerve, a meningeal branch of the ascending pharyngeal artery, and an emissary vein of the basilar plexus course through the HC. The venous plexus is an essential component in its passage in this canal. Small variations in HC dimensions may be critical and clinically significant because of their delicate neurovascular structures.[13]

Frequently, patients with BI type B have a bone malformation in the foramen magnum region, notably hypoplasia of clivus and occipital condyles, which correspond to the basioccipital and exoccipital, respectively.[6,11,14] The presence of tongue motricity disorders and their implications for swallowing and speech are often present in the clinical picture of these patients.[1,7,10,15-19] Although the literature shows data on the dimensions of HC in healthy individuals,[12,13,20-25] there is still no evidence on the possible implications of BI type B on the dimensions of HC.

The present study aims to evaluate the cross-sectional dimensions (caliber) of the HC by MRI, comparing participants with and without BI type B.

METODOLOGIA

This was a case-control study, which was conducted after approval by the institution's research ethics committee (informed consent exemption and approval number: 12525519.5.0000.8069).

Amostra

Retrospective examinations were from a private radiology service, performed in the routine of outpatient clinical care. The study included MRI of participants older than 18 years, regardless of sex.

The case group consisted of 36 patients diagnosed with BI from November 2012 to December 2015. This sample was recruited through an electronic search in the service's own Radiological Information System, using the terms “basilar impression” and “basilar invagination” included in MRI radiological reports. No patient in this group had atlantoaxial dislocation associated (BI type A).

We consecutively and randomly selected the control group from a database composed of 92 participants pre-established in a previous case-control study.[11] This group is composed of 31 MRI examinations of individuals without craniovertebral junction anomalies according to the radiological reports.

Aquisição De Imagem E Craniometria

The exams were performed in a 0.35-T open-field magnetic resonance equipment (Magnetom C!, Siemens Medical Solutions, Erlangen, Germany). We used the T1-sequence isotropic 3-dimensional gradient echo volumetric pulse sequence (named by the manufacturer magnetization-prepared rapid gradient-echo), performed in the sagittal plane. Only the sequence without intravenous contrast was analyzed.

The imaging parameters were: section thickness, 0.9e1.1 mm; field of view (FOV) 270 mm; phase FOV 81.3%; base resolution 256; phase and slice resolution 100%; number of acquisitions, 1; TE 6.5 seconds; RT 18 seconds; flip angle 30. Low

field limitations were compensated for by a long acquisition time of about 7 minutes, 50 seconds to obtain a comparable signal/noise ratio, according to radiologists' visual criteria, to that usually obtained within 4e5 minutes in a 1.5-T MRI at the same image resolution parameters.

The MRI scans were stored in Digital Imaging and Communications in Medicine (DICOM) format. The study performed the craniometry using the Osirix visualization and image processing software (V.3.9.2), installed on a Macintosh computer platform (Apple Inc., Cupertino, CA). The internal diameter (ID) and external diameter (ED) measurements of the HC (right and left) were measured in the coronal plane. Firstly, the occipital condyles and the internal and external ostia of the HC were located, which in the coronal plane present medial (ID) and lateral (ED) "horseshoe" morphology. The measurement of the highest ID and ED was used as a reference to the cortical layer internal surface of the bone (Figure 1).

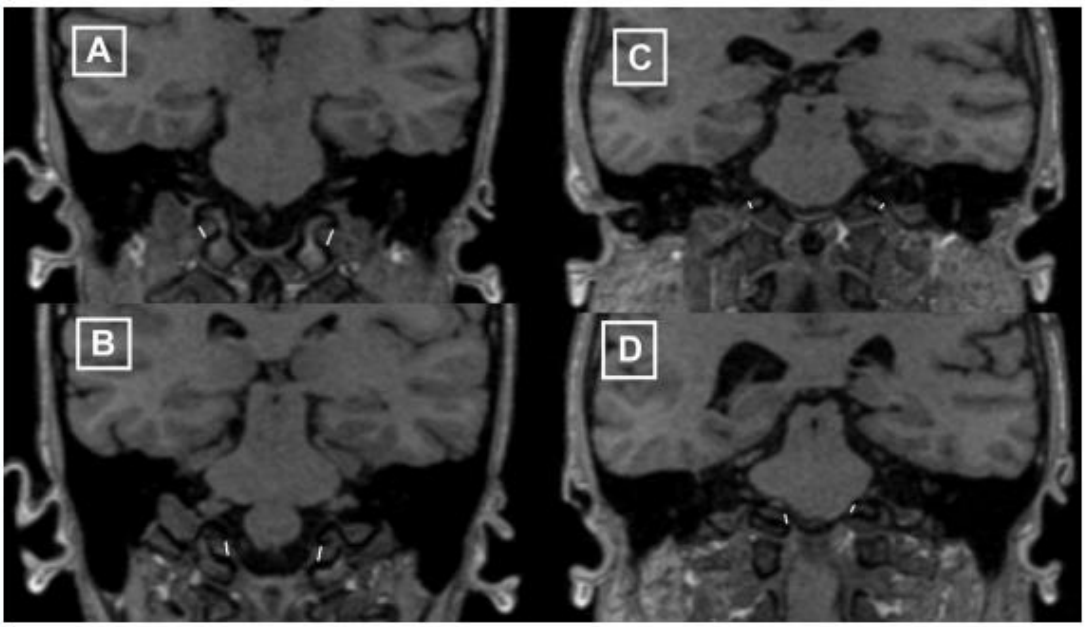

Figure 1. A coronal magnetic resonance image (T1 magnetization-prepared rapid gradient-echo) showing the external diameter (**A**) and internal diameter (**B**) of the hypoglossal canal (HC) in a control patient. (**C**) The external diameter and (**D**) the internal diameter of the HC in a patient with BI of type B.

Processamento Estatístico

The Kolmogorov-Smirnov test (with Lilliefors adjustment) was used to assess the normality of the variables and the Levine test was used to verify the homogeneity of the variances. The Student t test compared the variables between groups. Analyses were performed within the 95% confidence interval. Statistical treatment was performed using version 20 of the SPSS software (IBM, Armonk, NY)) program.

RESULTADOS

The case and control groups had an age of 50.7 18.6 years (17 men), and 42.9 18.3 years (15 men), respectively. None of the evaluated parameters presented a significant difference concerning sex (P > 0.05). In the comparison between groups, the diameters of the HC showed a significant bilateral reduction in the group with BI (Table 1).

Results show that, on each side, the HC diameters were significantly narrower in the BI type B group (Figure 1) when compared to the control group (Figure 1) (P < 0.001). This reduction was most pronounced in the ID in comparison with the ED (P < 0.001).

Table 1. Comparison of Hypoglossal Canal Diameters Between the BI and Control Groups

Diameter	BI Group	Control Group
External (right side)	3.3 ± 0.9 mm	4.7 ± 0.8 mm
External (left side)	3.1 ± 0.9 mm	4.6 ± 0.9 mm
Internal (right side)	2.8 ± 0.7 mm	4.4 ± 0.9 mm
Internal (left side)	2.7 ± 0.7 mm	4.3 ± 0.8 mm

DISCUSSÃO

This study aimed to evaluate the cross-sectional dimensions of the HC by MRI, comparing participants with and without BI type B. We found that the HC diameters were significantly narrower in the BI type B group. This reduction was stronger in the ID in comparison with the ED diameter.

Although there are descriptions in the literature about bone malformation of the foramen magnum in patients with BI type B,[6,11,14] such as occipital condyle hypoplasia, we found no study with objective assessment of magnitude of these alterations on the caliber of HC in patients with BI and neither the comparison of this phenomenon with healthy individuals with computed tomography (CT), MRI, or by macroscopic anatomy analysis in skulls.

To the best of our knowledge, this is the first MRI study to investigate whether there is a relationship between HC dimensions and BI of type B. The comparison of the ED and ID between groups showed a canal narrowing in the BI group that probably is related to the underdevelopment of the exo-occipital in these patients. It is in this portion of the occipital bone that the occipital condyles are found, structures that frequently present hypoplasia in patients with BI of type B.[9] The mean values of HC presented in the BI group were also lower compared with those reported in the literature on populations without a diagnosis of craniovertebral junction abnormalities.[12,20-24]

We can use either MRI or CT in anatomical measurements of the HC. Although we have not compared these 2 techniques, is well known that CT better depicts bone margins and may be superior to MRI on estimating stenosis of the hypoglossal canal.

The clinical repercussions of BI are varied and derive from the compression of nerve structures and/or disturbances in cerebrospinal fluid circulation. According to the pathological process presented by the patient, the presence of dysphagia and dysarthria has been described in more than one-third of patients,[1,7,10,16-19] which may show improvement after surgical decompression of the posterior fossa. Symptom regression suggests that the brainstem compression could cause

impairment of the hypoglossal nerve nucleus, and decompression surgery would play a vital role in the rehabilitation of this nerve. However, the severity of the canal narrowing may play an essential role in the clinical presentation of the hypoglossal nerve in patients with BI, once some patients do not show an improvement of symptoms after surgery.[18]

The evidence obtained in the present study suggests that hypoglossal nerve disorders in patients with BI type B[1,15] may also be related to a significant “traction” of this nerve into the HC pathway. This could be intensified by the posterior force vector exerted by the odontoid in the brainstem. Literature data showing the permanence of hypoglossal nerve dysfunction in some patients even after surgery to treat odontoid compression[26-28] could generate reflections on a possible relationship between HC stenosis and prognosis of manifestations of the hypoglossal nerve in BI, mainly patients with severe hypoplasia of clivus and occipital condyles.

Differentiating the cause of neurologic disorders related to the function of the hypoglossal nerve is a challenging task in patients with BI. They can occur by both central and peripheral mechanisms. When there is radiologic evidence of HC stenosis, we must consider a peripheral cause directly on the nerve. In the case of a patient with other symptoms of brainstem damage, this clinical picture suggests that there is, at least in part, a central cause regarding the abnormalities related to hypoglossal nerve function.

Future prospective studies could explore whether there is any correlation between HC diameter stenosis and clinical manifestations of hypoglossal nerve dysfunction. One possibility would be to compare the postoperative clinical outcome in the 2 BI subtypes with signs and symptoms of the hypoglossal nerve, a group related exclusively to atlantoaxial dislocation (BI type A without occipital condyle hypoplasia) and another BI type B group, which may provide data related to the etiological factors of hypoglossal nerve dysfunction in BI. We hypothesized that these manifestations might be related not only to direct brainstem compression, but also to HC stenosis.

DECLARAÇÃO DE CONTRIBUIÇÃO DE AUTORIA

Beatriz B. Vasconcelos: Conceptualization, Validation, Writing - original draft, Writing - review & editing, Visualization, Supervision.

José J.C. Nascimento: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization, Supervision.

Marcelo M. Valença: Writing - original draft, Writing - review & editing, Visualization, Supervision.

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CONFLITO DE INTERESSES

The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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