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THE LIGAMENT OF BARKOW IS A SOLID STRUCTURE IN HUMAN FETUSES

O LIGAMENTO DE BARKOW É UMA ESTRUTURA INDIVIDUALIZADA EM FETOS HUMANOS

EL LIGAMENTO DE BARKOW ES UNA ESTRUCTURA INDIVIDUALIZADA EN FETOS HUMANOS

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ABSTRACT

Objective: The present study aims to dissect and identify the Barkow ligament (LB) in fetal specimens and describe its anatomical characteristics to contribute to its knowledge in the pediatric population and the clinical and surgical application of conditions associated with the Craniovertebral Junction (CVJ).). Methods: This work evaluated 19 human fetuses aged 28-38 weeks. Of these, six specimens constituted the final sample and were studied through detailed dissections using coronal sections in an anterior approach up to the region described by the LB. Results: In all specimens, a thin fibrous band was found, horizontal and anterior to the axis tooth, with bilateral fixation on the occipital condyles, corroborating the results found for describing LB in adults. Conclusion: The LB is a congenital ligament that resists the extension of the atlantooccipital joint and may play a role in the stability of the CVJ. ***Level of Evidence III; Diagnostic Study.***

Keywords: Ligaments; Spine; Atlanto-Occipital Joint; Anatomy; Fetus.

RESUMO

Objetivo: O presente estudo tem como objetivo dissecar e identificar o ligamento de Barkow (LB) em espécimes fetais, e descrever suas caraterísticas anatômicas visando contribuir para o seu conhecimento em população pediátrica e na aplicação clínica e cirúrgica das condições associadas à Junção Craniovertebral (JCV). Métodos: Esse trabalho avaliou 19 fetos humanos de 28-38 semanas de vida. Destes, 6 espécimes constituíram a amostra final e foram estudados através de dissecções minuciosas utilizando secções coronais, em uma abordagem anterior, até a região de descrição do LB. Resultados: Em todos os espécimes foi encontrada uma delgada banda fibrosa, de disposição horizontal e anterior ao dente do áxis, com fixação bilateral nos côndilos occipitais, corroborando com os resultados encontrados para a descrição do LB em adultos. Conclusão: O LB é um ligamento congênito, que resiste a extensão da articulação atlantoccipital, e que pode ter papel na estabilidade da JCV. ***Nível de Evidência III; Estudo diagnóstico.***

Descritores: *Ligamentos; Coluna Vertebral; Articulação Atlantoccipital; Anatomia; Feto.*

RESUMEN

Objetivo: El presente estudio tiene como objetivo diseccionar e identificar el ligamento de Barkow (LB) en especímenes fetales, y describir sus características anatómicas con el fin de contribuir a su conocimiento en la población pediátrica y en la aplicación clínica y quirúrgica de las condiciones asociadas a la unión craneovertebral. (UCV).). Métodos: Este trabajo evaluó 19 fetos humanos de entre 28 y 38 semanas. De estos, 6 ejemplares constituyeron la muestra final y fueron estudiados mediante disecciones detalladas mediante cortes coronales, en abordaje anterior, hasta la región descrita por el LB. Resultados: En todos los ejemplares se encontró una delgada banda fibrosa, horizontal y anterior al diente axis, con fijación bilateral en los cóndilos occipitales, corroborando los resultados encontrados para la descripción de LB en adultos. Conclusión: El LB es un ligamento congénito, que resiste la extensión de la articulación atlantooccipital, y que puede desempeñar un papel en la estabilidad de la UCV. ***Nivel de Evidencia III; Estudio Diagnóstico.***

Descriptores: *Ligamentos; Columna Vertebral; Articulación Atlantooccipital; Anatomía; Feto.*

INTRODUCTION

In adults, Barkow's ligament (LB) consists of a horizontal ligamentous band located anterior to the axis tooth that attaches to the anterior surface of the occipital condyles, anterior to the attachment of the alar ligaments, and connects the tip of the axis tooth to the occipital condyles.[1,2] The LB makes up the group of ligamentous structures of the craniovertebral junction (CVJ) together with the transverse ligament of the atlas, the alar ligaments, the atlantoccipital, atalantoaxial and tectorial membranes, which perform stability functions in this region.[2,3]

Because the CVJ is the transition region between the occipital bone and the atlas and axis vertebrae, it has important anatomical structures that emerge and immerse themselves in the region, which are crucial to the individual's health.[4] At the same time, the CVJ is the most mobile area of the spine, which makes its functioning even more complex.[5,6] These factors contribute to the wide range of injuries that can affect the CVJ, so the study of its ligamentous structures is essential for the proper management of patients with injuries, especially traumatic ones.[2,7,8]

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It is known that the CVJ is especially more unstable in children and infants due to the biomechanical characteristics of this age group, such as a proportionally larger head, ligamentous laxity, horizontal angulations in the articular facets, immature development of the neck muscles and incomplete ossification of the vertebrae. This added to the anatomical particularities of age, explains the greater risk of injuries to the CVJ and purely ligamentous injuries in this population.[9-11] However, there is a gap in scientific knowledge on this subject in this age group, both about CVJ and LB.[10,12]

The relevance of this knowledge becomes clear when evaluating situations in which lesions occur in the CVJ and, presumably, in the LB. Instability and deformity of the CVJ can result from congenital and developmental alterations, such as genetic syndromes (Down's Syndrome, mucopolysaccharidosis, among others), as well as being acquired or traumatic.[13] Pediatric injuries to the upper cervical spine have a high mortality rate, and this region is the most affected by trauma.[12,14,15]

LB has only been described in adults, and even in this population, knowledge about it is scarce. It is a ligament that resists neck extension and connects the axis tooth to the occipital condyles.[1,2] Because it is a ligament of the CVJ and has a potential influence on the pathological conditions of this region, the LB should be studied in greater detail. This study aims to dissect and identify the LB in fetal specimens and describe its anatomical features to contribute to its knowledge in the pediatric population and the clinical and surgical application of conditions associated with the CVJ.

MATERIALS AND METHODS

The Human Research Ethics Committee authorized all the procedures in this study via Plataforma Brasil (48336921.7.0000.5060). We studied 19 human fetuses aged between 28-38 weeks of intrauterine life and fixed in 4% formalin from the collection of the Department of Morphology at CCS-UFES. Only those within the age range, without signs of a procedure in the craniovertebral region and malformations, were included.

The specimens were analyzed at the Laboratory for Applied Morphology Studies (LEMA) in the Department of Morphology. A cross-section was made at the level of the mandible, separating the upper part of the neck and head. A frontal section was then made through the retropharyngeal space to expose the anterior part of the craniovertebral junction. The long muscles of the head, the anterior rectus of the head, and the lateral rectus of the head were identified and carefully removed. The anterior atlantoccipital membrane was identified and removed through frontal sections (Figure 1, A and B). Next, frontal sections of approximately 1mm in the anterior arch of the atlas and the basilar part of the occipital bone were made to access the region between the foramen magnum and the atlas, immediately anterior to the axis tooth; this allowed analysis of the region where the LB is located.

The entire region was documented using photographs (Figure 1). The LB's anatomical characteristics were assessed, such as location, orientation, size, consistency, color, and insertion regions. The anatomical relationships with adjacent structures were also assessed. The dissection continued with frontal cuts of around 1mm to assess the regions posterior to the LB location.

RESULTS

After cross-sectioning the neck and separating the craniovertebral junction and the head, it was observed that some of the specimens were fixed in formalin with rotation of the head and neck to such an extent that it was impossible to proceed with the dissection using a frontal section with good orientation. For this reason, 14 specimens were excluded from the study, so the final sample consisted of 6 fetuses (Table 1), which complied with the proposed methodology.

The LB was characterized in this sample as a thin, horizontally arranged fibrous band positioned anteriorly to the axis tooth, with

Table 1. Sample data.

Identification number	Gender	Moore age (weeks)	Streeter age (weeks)
6824	M	28 – 30	30 – 31
7016	M	36 – 38	38 – 39
7337	M	32 – 36	32 – 33
7486	F	32 – 36	36 – 37
7709	M	32 – 36	34 – 35
8007	F	32 – 36	37 – 38

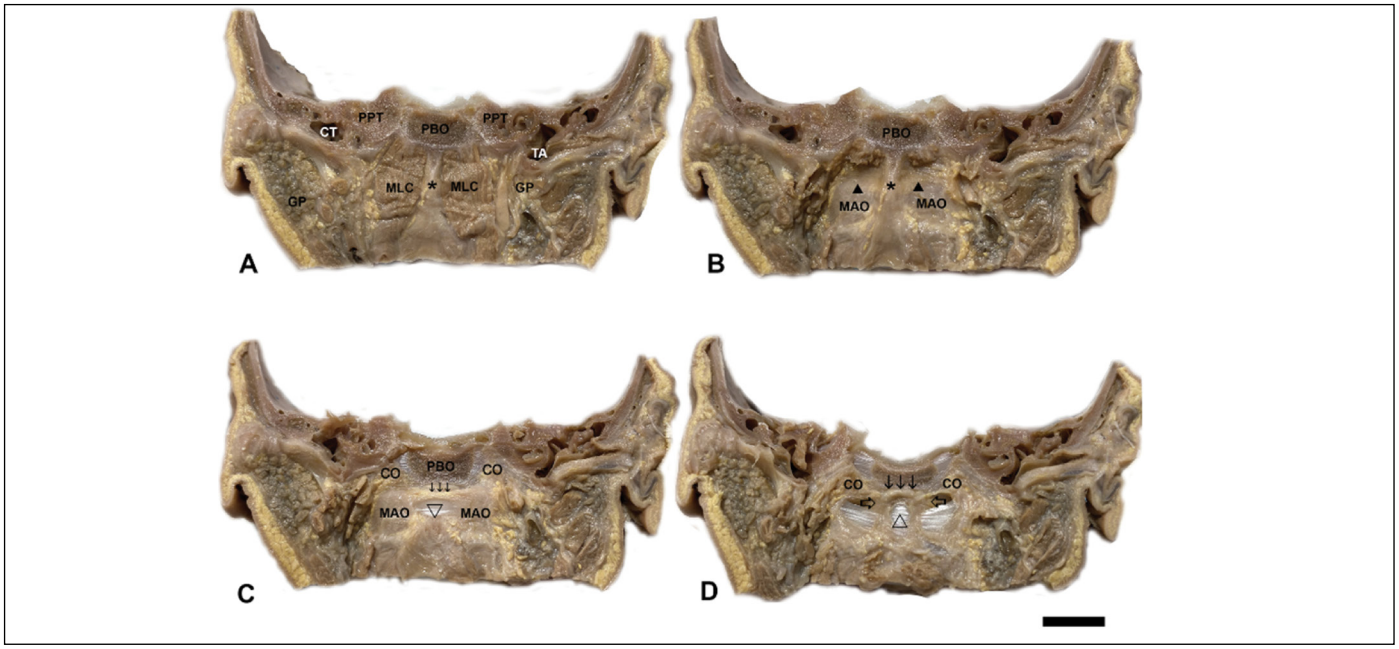

Figure 1. Pissection of Barkow's ligament from the frontal section through the retropharyngeal space. A-D are the dissection steps: *) Anterior tubercle of the atlas; MLC) Long head muscle; GP) Parotid gland; PBO) Basilar part of the occipital bone; PPT) Petrous part of the temporal bone; CT) Tympanic cavity of the temporal bone; TA) Eustachian tube; ▲) Anterior arch of the atlas; MAO) Anterior atlantoccipital membrane; ▽) Section of the anterior arch of the atlas; CO) Occipital condyle; ↓↓↓) Barkow's ligament; △) Tooth of the axis; ⇨) Articular capsule of the atlantoccipital joint.

bilateral attachment to the occipital condyles (Figure 1). It was also possible to identify the attachment of this band to the anterior margin of the foramen magnum and the anterior atlantoccipital membrane in all cases. The latter added complexity to the dissection procedure so that an extension movement was applied to the craniovertebral region to analyze the plane and direction of the fibers of the adjacent structures and determine the structure to be analyzed. There were no anatomical differences between the specimens regarding location, attachment to other ligaments in the region, or other anatomical relationships of this band.

DISCUSSION

This study provides an anatomical description of a horizontal fibrous band, fixed between the occipital condyles and superiorly on the anterior margin of the foramen magnum and positioned anteriorly to the axis tooth, which is consistent with the description found in the literature for Barkow's ligament in adults. Although the anatomical data corroborates between adults and fetuses,[1] the location and anatomical aspects analyzed in this study raised doubts about whether the structure was an individualized ligament or a deep part of the anterior atlantoccipital membrane. This question was also the subject of discussion by Tubbs et al.[1] when they found fixation of the LB in the anterior atlantocpital membrane in 75% of the specimens. As the proposed methodology involved dissection using millimetric frontal sections, and as the anterior atlantoccipital membrane was removed, the LB remained; it is believed that the latter may be a fibrous band individualized to the atlantoccipital membrane (Figure 1, C and D). Furthermore, applying the extension movement to the CVJ showed that this structure exerts traction on its insertion points, which is the presumed limiting movement conferred on the LB of adults, as well as on the anterior atlantoccipital membrane.[1]

As far as it was possible to find any bibliography on the subject, this study seems to be the only one to have described the anatomy of the LB in fetal specimens. The choice of this sample can be summed up by the existence of a collection of fetuses in the institution, the difficult task of grouping specimens for such a study in a pediatric population, and the similar anatomy that the fetal CVJ has about the adult one from the 14th week of intrauterine life onwards.[16] Thus, these specimens allowed us to establish the methodology and find results that can be compared with anatomical descriptions found in works developed with adult specimens.

The dissections proved particularly challenging: the age and evolutionary state of the anatomical structures led to smaller dimensions and greater fragility in the study by traditional dissection, which led to the establishment of the dissection methodology by millimeter frontal sections. This probably explains the lack of similar studies or studies using fetal specimens to describe LB. Thus, the comparative methods for describing LB were based on existing descriptions in adults. Tubbs et al.[1] described the LB as a horizontal band with insertions on both occipital condyles. They argued that the tooth of the axis acts as a pivot point to resist the extension of the atlantoccipital joint. This study was the main reference found for the LB, with such a description of the ligament in 12 of the 13 adult cadavers in its sample. The present study corroborated these results, however, in all specimens. Although there is no established incidence rate for the LB, as it is a ligament, it is expected to be present in all specimens, which leads us to question why it was not found in 1 of the specimens dissected by Tubbs et al.[1] These researchers state that the LB was not found in any female specimens, which could not be corroborated in this study. One hypothesis is that it was impossible to distinguish the fibrous laminae of the LB from the atlantoccipital membrane, so that they may have been dissected together and removed from the field of study. In this sense, dissecting with millimeter-sized frontal sections proved important in the methodology proposed in this research.

Even in adults, data on LB is scarce. Tuli et al.[2] discuss the anterior ligaments that maintain the stability of the CVJ in two layers - superficial and deep - and only mention the LB among the superficial layer ligaments that may be involved in CVJ instability in situations of occipital condyle fracture. Hall et al.[17] evaluate atlantoccipital dislocation, characterizing it primarily as a ligamentous injury, and also cite the LB as a structure involved in the biomechanics of CVJ by helping to resist neck extension. Other studies that report LB in adults also do so briefly and use the descriptions made by Tubbs et al. and Tuli et al.[3,4,18,19]

The results of this study suggest that the LB is a congenital fibrous band that presumably plays a role in the stability of the CVJ. Some clinical conditions lead to congenital and developmental alterations in the CVJ, which are associated with ligamentous and biomechanical changes, such as Down's syndrome, IVA mucopolysaccharidosis, congenital spondyloepiphyseal dysplasia, Goldenhar syndrome; Klippel-Feil syndrome; osteogenesis imperfecta; and Chiari type I syndrome.[13,20-23] A prevalent complication of Down syndrome is craniovertebral instability due to ligament laxity, which has the potential to cause neurological damage.[13,24] Traumas affect children mainly in the upper cervical region and the CVJ, the latter being more vulnerable and unstable at this age, so these injuries become more severe and have a high morbidity and mortality rate.[12,14,15] Purely ligamentous injuries to the CVJ are even more serious and are, unfortunately, the most likely type of CVJ injury in the pediatric population, which, added to the lack of anatomical knowledge about the region in this age group, constitutes a serious risk for this population.[10,15,25] Thus, understanding that the LB is a limiting structure and part of the guarantee of the stability of the CVJ in the pediatric population and that its description follows that of the LB in adults is important information for clinical and surgical treatment in this population.

The main limitation of this study was the position of the head and neck when the specimens were fixed, which meant that most of the initial sample was excluded. Despite the small sample size, the results were consistent and corroborated those found in the literature in adult specimens.

CONCLUSION

In conclusion, the LB is an individualized, congenital ligament of the CVJ, made up of a horizontal fibrous band located anterior to the axis tooth, with attachment to both occipital condyles, resistant to the extension of the atlantoccipital joint and which may play a role in the stability of the CVJ.

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