Anatomic study of the optical radiation and its relationship in the temporal lobe: definition of a secure approach for amigdalohipocampectomy in epilepsy surgery

Estudio anatómico de la radiación óptica y su relación en el lóbulo temporal: definición de un abordaje seguro para amigdalohipocampectomía en cirugía de la epilepsia

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Resumen

Introducción/Objetivos: El lóbulo temporal anterior tiene importantes estructuras subcorticales, especialmente fibras blancas que llevan la información visual. La comprensión de esta región anatómica, importantes para la práctica microquirúrgica, se basa en técnicas de disección de fibras. Ellos proporcionan perspectiva tridimensional de esta región y añaden un enfoque quirúrgico exitoso para el tratamiento de las lesiones temporales mesiales. El propósito de este trabajo es el estudio de la anatomía de la pared lateral del ventrículo lateral con el fin de determinar una zona libre de la radiación óptica. **Métodos**: Se diseccionaron diez hemisferios cerebrales, preparados de acuerdo con técnicas de Klingler. Se utilizan espátulas de madera con puntas de diferentes tamaños. La radiación óptica fue delimitada y las medidas se tomaron a partir de esta estructura para el polo temporal, que se utiliza como punto de referencia. **Resultados**: Abordajes para el cuerno temporal superior a 27 mm más allá del polo temporal pueden cruzar asa de Meyer y determinar un perjuicio a la radiación óptica con los consiguientes déficits en los campos visuales. **Conclusión**: La determinación de la zona de libre de fibras de radiación óptica es factible. En este trabajo se podría inferir que el área libre de la radiación óptica se encuentra en la región anterioinferior del lóbulo temporal a una distancia de hasta 2,7 centímetros desde el polo temporal y permite el acceso a el hipocampo y la amígdala durante la cirugía de la epilepsia. Resecciones más grandes que estas medidas permiten aclarar de una lesión a la radiación óptica con los consiguientes déficits en los campos visuales.

Palabras clave: Disección de fibras, asa de Meyer, anatomía microquirúrgica, lóbulo temporal, cirugía de la epilepsia.

Abstract

Introduction/Objective: The anterior temporal lobe has important subcortical structures, especially white fibers that lead visual information. Understanding this anatomical region, important for microsurgical practice, is based on fibers dissection techniques. They provide three-dimensional perspective for this region and add a successful surgical approach for the treatment of mesial temporal lesions. The purpose of this paper is to study the anatomy of the lateral wall of the lateral ventricle in order to determine a free area of the optical radiation. **Methods**: Ten cerebral hemispheres were dissected, prepared according to Klingler´s techniques. Wooden spatulas with tips of various sizes were used. The optical radiation was delimited and measures were taken from this structure to the temporal pole, used as a reference point. **Results**: Approaches to the temporal horn larger than 27 mm beyond the temporal pole can cross Meyer´s loop and determine injury to the optical radiation with consequent postoperatively deficits in visual fields. **Conclusion**: The determination of free area of optical radiation fibers is feasible. In this work we could infer that free area of optical radiation is located in the anterioinferior region of the temporal lobe at a distance of up to 2.7 centimeters from the temporal pole and allows access to the hippocampus and amygdala during epilepsy surgery. Larger resections than these measures can possibly determine injury to the optical radiation with consequent deficits in visual fields.

Key words: Fiber dissection, Meyer´s loop, microsurgical anatomy, temporal lobe, epilepsy surgery.

Introduction

The temporal lobe epilepsy (TLE) is considered the main cause of complex partial seizures refractory to conservative treatment in adulthood, with a lower incidence in children, representing 10 to 20% of all causes of epilepsy at this age[1]. The mesial temporal sclerosis (MTS) is the pathological substrate of TLE. Surgical treatment, as the prospective and randomized study of Wiebe et al., in 2001[2] can be considered the first-line treatment for MTS.

Surgery for TLE consists on removal of mesial temporal structures including the hippocampus and amygdala. There are three ways to access these structures (transsylvian, subtemporal and transtemporal), each one with advantages and disadvantages related to the areas of language, cognitive processing and subcortical fibers, especially the optical radiation[1,3]. Regarding transtemporal access to mesial temporal structures, it is possible to inflict injury to subcortical white fibers mainly represented by the fibers of the optical radiation passing through the roof and lateral wall of the temporal horn of the lateral ventricle.

Visual field defects, characterized by superior homonymous quadrantopsia, reported in 50% of cases[4-9] are one of the most important complications. The anatomical relationship of the fibers of the optical radiation in the temporal lobe, specifically in the temporal horn is not properly visualized on conventional dissections and sectional anatomical studies[10-13]. In this sense, the dissection of white fibers of the optical radiation allows an appropriate anatomical study with a three-dimensional perspective of their projection in the temporal lobe and their relationship to adjacent anatomical structures.

The studies of subcortical white fibers have been standardized since the work of Klingler et al[12]. It is an important method to understand the three-dimensional structure of the white fibers of the brain. The three-dimensional structure of the brain achieved by white fibers dissection provides a better understanding of its anatomy.

The purpose of this paper is to study the anatomy of the lateral wall of the lateral ventricle in order to determine a free area of the optical radiation, which is safe for surgical resection of the hippocampus and amygdala, thus avoiding visual field defects.

Materials and Methods

Ten normal cerebral hemispheres were dissected according to Klingler's technique[12]. These specimens were assigned by the Department of Morphology, Faculty of Medical Sciences of Santa Casa de São Paulo. They were submitted to a freezing process during a period of 30 days approximately. The dissection was performed in an artisanal way, with wooden spatulas of different sizes and thicknesses, with support of a loupe for image magnification.

The dissection was performed from the surface to the depth; from the lateral surface of the temporal lobe to the mesial aspect. The ultimate goal was the exposure of the optical radiation at the lateral wall of the temporal horn.

The structures identified during dissection were named and photographed. The optical radiation was delimited and measures were taken from this structure to the temporal pole, used as a reference point.

Results

Surface structures were identified as important reference points for the start of the dissection, including superior, middle and inferior temporal gyri, sylvian fissure and central sulci. The cerebral cortex of the lateral surface was delaminated and was separated from subcortical white matter. Subsequently, the arched white fibers were displayed as shown in Figure 1. Following dissection, from surface to depth, temporal horn of the lateral wall was exposed. At this point, the optical radiation was identified. These fibers surround the roof of the lateral ventricle at its most anterior portion and determine an inferoposterior trajectory to reach the lateral ventricular wall. The anterior portion of the optic radiation represents the Meyer's loop (Figure 2).

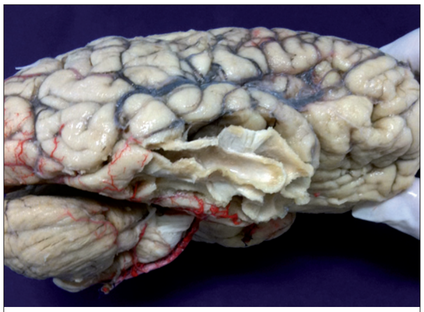
Figure 1. Subcortical white fibers after delamination of the cortex of the middle and inferior temporal gyri.

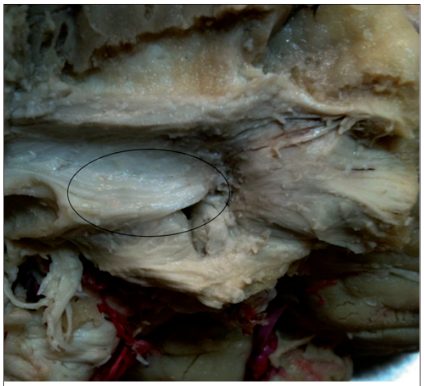
Figure 2. Lateral wall of the lateral ventricle with visualization of the optic radiation and its anterior portion, the Meyer's loop.

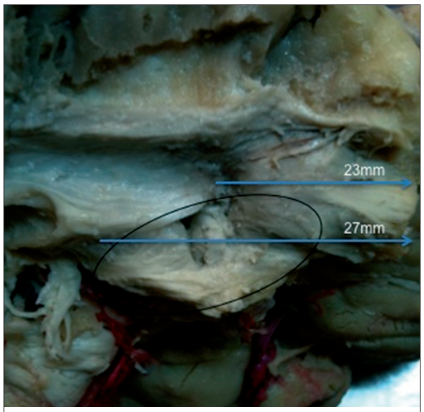

Figure 3. Average distance from the temporal pole to the initial portion of the Meyer's loop and to the lower portion of the optic radiation. Free area of optical radiation (ellipse) is exposed at the antero-inferior portion of the temporal lobe.

As seen in the anteroinferior portion of the temporal lobe (Figure 3), a free area of optical radiation can be identified. The amygdale and the head of the hippocampus were displayed on the floor of the temporal horn. Above these structures an opening on the roof of the temporal horn can be visualized, allowing access to the lateral ventricle.

Taking the temporal pole as a reference, the average distance to the initial portion of the Meyer's loop at the roof of the temporal horn was 23 millimeters. The distance from the temporal pole to the lower portion of the optical radiation in the ventricular wall was 27 millimeters (Figure 3).

Discussion

Strategies for surgical approach to the temporal mesial structures for TLE treatment consist of two types of resections: anterior temporal lobectomy (ATL) and selective amigdalohipocampectomy (SelAH)[14,15]. The ATL is the en-bloc resection of the anterior portion of the temporal lobe to an extension up to 5 centimeters at the non-dominant hemisphere and up to 3.5 centimeters at the dominant hemisphere, but this approach can be considered agressive e can determine injury to eloquent areas[14]. The SelAH can be performed through transtemporal approach, with the advantage of lesser cerebral cortex resections.

Despite the different types of resection already established, there is no consensus concerning the various approaches regarding the seizure control, cognitive impact and quality of life. Till now, no strategy may be considered the standard procedure, when compared to another[1,2,14,16]. This paper proposes an important tool to choose the best approach to deal with temporal epilepsy treatment.

The dissection of the white fibers described by Klingler[12] is not frequently used in training neurosurgeons. Besides, there are few works[4,10,17-20] concerning the structure of microsurgical white fibers in order to refine the knowledge of these anatomical structures and their applicability in practice microsurgery. The dissection of the white fibers provides a better understanding of their anatomy. In this respect, the dissection of the white fibers was important in determining the three-dimensional internal structures of the brain, even before the development of the microtome and the histological sectional techniques[20].

In the 17th century, Thomas Willis (1621-1675) and Nicholau Steno (1638-1686)[21] introduced the anatomical study of brain and its internal structure, especially the subcortical white fibers, followed by the French anatomist Raymond Vieussens (1641-1715), who in 1685 published one of the first atlas of brain anatomy (Neurographia Universalis)[22]. Other anatomists have written clear descriptions of the internal brain structure. In 1810, Johann Christian Reil (1759-1813)[23] was the first to describe the optical radiation using dissection techniques of the white fibers. In 1855, an Italian anatomist, Bartholomeo Panizza[24] (1785-1867), demonstrated the entire visual pathway, from the retina to the occipital cortex. In 1872, in Vienna, Theodor H. Meynert[25] (1833-1892), professor of Neurology and Psychiatry, introduced the latest concepts of association and projection fibers. He also contributed to a detailed description of the optical radiation.

After the introduction of the microtome and histological preparation techniques, dissection of the white fibers was neglected, because it was complicated in its execution and time consuming for its preparation. In 1935, Joseph Klingler (1888-1963), proposed a major contribution to the art of dissection of the white fibers, through a fixation and freezing brain process, called the Klingler's technique[12]. In 1956 he published an atlas containing detailed description of subcortical white fibers, using photographs of dissected specimens[12].

The white fiber tracts in the brain are divided into three groups: association fibers that connect different cortical regions within the same hemisphere as the U-shape fibers, or arched fibers; commissural fibers that are responsible for the connection of the two hemispheres, for instance, the corpus callosum and the anterior commissure; and finally, projection fibers that establish connection between cortical and other CNS structures at different levels, such as the basal ganglia, brain stem and spinal cord, as well as other distant cortical regions[4].

In this sense, the optical radiation can be considered as projection fibers, which leads visual information from the thalamus (lateral geniculate body) to the occipital cortex around the calcarine sulci. This set of fibers is called geniculo-calcarine tract and consists of three bands, based on experimental and clinical studies[10,18,19,20].

This group of fibers must be viewed as a three-dimensional structure that maintains an intimate relationship with the temporal horn of the lateral ventricle. The anterior band, called Meyer's loop, crosses the roof of the temporal horn, extends for a variable distance within the temporal lobe and converge in sagitale stratum, on the lateral wall of the temporal horn at the depth of the middle temporal gyrus[20].

In stratum sagitale, the fibers of Meyer's loop determine an inferior trajectory compared to the fibers of the central band that crosses the roof of the temporal horn. This set of fibers leads central visual field information. Finally, the posterior fibers cross the lateral wall of the atrium and protrude superiorly to the upper lip of occipital cortex around the calcarine sulci. These fibers lead inferior visual field information[4].

In the present study, a correlation was found regarding other studies for the determination of the optical radiation and its anatomical relationship with adjacent structures[4,10,18]. In order to access mesial temporal structures, there is a reduced chance of injury of the optical pathways through the middle temporal gyrus and middle temporal sulcus, approaching them through an average distance of 23 millimeters from the temporal pole. At this point, the Meyer's loop determines a direction on the lateral wall of the temporal horn and not only on its roof. According to measurements taken in this study, resections larger than 23 millimeters posteriorly from the temporal pole may determine injury to the Meyer's loop.

Conclusion

The anterior temporal lobe has important subcortical structures, especially white fibers that lead visual information. Understanding this anatomical region, important for microsurgical practice, is based on fibers dissection techniques. They provide three-dimensional perspective for this region and add a successful surgical approach for the treatment of mesial temporal lesions. It may reduce the maximum functional inherent complications when handling this region.
The determination of free area of optical radiation fibers is feasible. Its location is given in the anterioinferior temporal lobe at a distance of up to 2.7 centimeters from the temporal pole and allows secure access to the hippocampus and amygdala during epilepsy surgery.
Larger resections than these measures can determine injury to the optical radiation with consequent deficits in visual fields.

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References

1. Benifla M, Otsubo H, Ochi A, et al. Temporal lobe surgery for intractable epilepsy in children: an analysis of outcomes in 126 children. Neurosurgery 2006; 59(6): 1203-1214.
2. Wiebe S, Blume WT, Girvin JP, Eliasziw M. Effectiveness and efficiency of surgery for temporal lobe epilepsy study group: A randomized, controlled trial of surgery for temporal-lobe epilepsy. N Engl J Med 2001; 345(5): 311-318.
3. Schramm J, Clusmann H. The Surgery of Epilepsy. Neurosurgery 2008; 62[Suppl 2]: 463-481.
4. Pujari VB, Jimbo H, Dange N, Shah A, Singh S, Goel A. Fiber dissection of de visual pathways: analysis of the relationship of optic radiations to the lateral ventricle: a cadaveric study. Neurology India 2008; 56(2): 133-137.
5. Babb TL, Wilson CL, Crandall PH. Asymmetry and ventral course of the human geniculostriate pathway as determined by hippocampal visual evoked potentials and subsequent visual field defects after temporal lobectomy. Exp Brain Res 1982; 47(3): 317-328.
6. Bender D. Retinotopic organization of macaque pulvinar. J Neurophysiol 1981; 46(3): 672-693.
7. Bjork A, Kugelberg E. Visual field defects after temporal lobectomy. Acta Ophthalmol (Copenh) 1957; 35(3): 210-216.
8. Meyer A. The connections of the occipital lobes and the presents statues of the visual cerebral affections. Trans Assoc Phys 1907; 101: 739-746.
9. Egan RA, Shults W, So N, Burchiel K, Kellogg J, Salinsky M. Visual field deficits in conventional anterior temporal lobectomy *versus* amygdalohippocampectomy. Neurology 2000; 55(12): 1818-1822.
10. Ebeling U, Reulen HJ. Neurosurgical topography of the optic radiations in the temporal lobe. Acta Neurochir (Wien) 1988; 92(1-4): 29-36.
11. Falconer M, Wilson J. Visual field changes following anterior temporal lobectomy: their significance in relation to Meyer's loop of the optic radiation. Brain 1958; 81(1): 1-14.
12. Klingler J. Erleichterung der makroskopischen Praeparation des Gehirns durch den Gefrierprozess. Schweiz Arch Neurol Psychiatry 1935; 36: 247-256.
13. Horton JC, Hoyt WF. The representation of the visual field in human striate cortex: a revision of the classis Holmes map. Arch Ophthalmol 1991; 109(6): 816-824.
14. Clusmann H, Kral T, Gleissner U, et al. Analysis of different types of resection for pediatric patients with temporal lobe epilepsy. Neurosurgery 2004; 54(4): 847-860.
15. Yasargil MG, Teddy PJ, Roth P. Selective amygdalohippocampectomy. Operative anatomy and surgical technique. Adv Tech Stand Neurosurg 1985; 12: 93-123.
16. Tanriverdi T, Dudley RW, Hasan A, et al. Memory outcome after temporal lobe epilepsy surgery: corticoamygdalohippocampectomy *versus* selective amygdalohippocampectomy. J Neurosurg 2010; 113(6): 1164-1175.
17. Smith CG. Serial Dissections of the Human Brain. Baltimore, Urban & Schwarzenberg, 1981.
18. Türe U, Yasargil MG, Pait TG. Is there a superior occipitofrontal fasciculus? A microsurgical anatomic study. Neurosurgery 1997; 40(6): 1226-1232.
19. Wen HT, Rhoton AL Jr, de Oliveira E, et al. Microsurgical anatomy of the temporal lobe: Part 1-Mesial temporal lobe anatomy and its vascular relationships as applied to amygdalohippocampectomy. Neurosurgery 1999; 45(3): 549-592.
20. Peuskens D, van Loon J, Van Calenbergh F, van den Bergh R, Goffin J, Plets C. Anatomy of the anterior temporal lobe and the frontotemporal region demonstrated by fiber dissection. Neurosurgery 2004; 55(5): 1174-1184.
21. Marshall LH, Magoun HW. Discoveries in the Human Brain. Totowa, NJ, Humana Press, 1998, pp 51-52.
22. Vieussens R. Neurographia Universalis. Lyons, Lugduni, Apud Joannem Certe, 1685.
23. Reil JC. Fragmente über die Bildung des kleinen Gehirns im Menschen. Arch Physiol Halle 8: 1-58, 1807-1808.
24. Panizza B. Osservazioni sul nervo ottico. Gior I Reale Inst Lombardo 1855; 7: 237-252.
25. Meynert TH. Vom Gehirne der Saugethiere, in Stricker (ed): Handbuck der Lehre von Geweben des Menschen und der Thiere. Leipzig, Engelmann, 1872, vol II, pp 694-808.

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