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Neuroanatomical study

Transcortical selective amygdalohippocampectomy technique through the middle temporal gyrus revisited: An anatomical study laboratory investigation

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ABSTRACT

The anterior temporal lobectomy (ATL) and selective amygdalohippocampectomy (SelAH) have been used for surgical treatment of mesial temporal lobe epilepsy. We examined the comprehensive white matter tract anatomy of the temporal lobe to gain an insight into the trans-middle temporal gyrus, a lateral approach which has been commonly used. The transmiddle temporal gyrus approach was performed in a stepwise manner on cadaveric human heads to examine the traversing white matter pathways through it and the structures located in the temporal horn. We reviewed the literature to compare the trans-middle temporal gyrus approach with other SelAH techniques based on surgical outcomes. There does not appear to be a significant difference in seizure outcome between SelAH and ATL. However, the SelAH provides a better neuropsychological outcomes than the ATL in selected patients. Each SelAH approach has individual advantages and disadvantages. Based on our anatomical study, in the transcortical amygdalohippocampectomy technique through the middle temporal gyrus the white matter pathways to be encountered. In the temporal horn, the collateral eminence, hippocampus, lateral ventricular sulcus, choroidal fissure, inferior choroidal point, choroid plexus, fimbria of the fornix, and amygdala are exposed. The subpial dissection is performed along the lateral ventricular sulcus from the collateral eminence on lateral side and from the choroidal fissure on medial side by microdissector for *en bloc* resection of the hippocampus proper. The trans-middle temporal gyrus approach is commonly used in treatment of mesial temporal lobe epilepsy patients. A better anatomical and functional understanding of the structures of the temporal lobe is crucial for safer and more accurate surgery.

1. Introduction

One-third of epilepsy patients are living with medically refractory epilepsy due to hipoocampal sclerosis. Multiple studies have demonstrated that epilepsy surgery has more successful outcomes than medical treatments on appropriately selected patients [1]. The most critical issue in temporal lobe surgery is the removal of epileptogenic focus without causing any new neurological deficit on patient.

The anterior temporal lobectomy (ATL) has been described first for treatment of the epilepsy patients. With advent of the neuroimaging technology led to devise the selective amygdalohippocampectomy techniques for treatment of mesial temporal lobe epilepsy (MTLE) patients. The surgical approaches for selective amygdalohippocampectomy (SelAH) has been classified as an anterior, which is the transsylvian, a lateral, which is the transcortical and subtemporal, and a posterior [2], which is the posterior interhemispheric and the paramedian supracerebellar infratentorial [3,4]. The lateral transcortical approach has been described by Paulo Niemeyer in 1958 as an alternative to the classical ATL method has still been widely used [5–7]. Later, a trajectory through

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the superior temporal gyrus has been described as the transcortical approach [8].

Herein, we revisited the trans-middle temporal gyrus approach to evaluate its surgical technique with the internal anatomy of the temporal lobe. We also compared the trans-middle temporal gyrus approach with other SelAH and ATL approaches based on clinical data obtained from literature and neurofunctional anatomy of the white matter pathways of the temporal lobe to relate between surgical outcomes and these approaches. To best of our knowledge, this study is the most comprehensive combination of the surgical technique with the temporal lobe white matter anatomy in trans-middle temporal gyrus approach.

2. Materials and methods

2.1. Anatomical study

Three formalin-fixed and silicone injected human heads were examined. The heads were frozen to perform the fiber dissection technique at −16 °C for 2 weeks [9,10]. The heads were positioned using Mayfield head holders in a manner that replicate the actual surgical setting. The trans-middle temporal gyrus approach was performed in a stepwise manner. Each structure from skin to temporal horn of the lateral ventricle including gray matter, white matter and vessels were exposed under ×6 to ×40 magnifications using Leica surgical microscope (Leica Microsystems, Wetzlar, Germany). Photographs were obtained with E CANON EOS 550 D (Canon Inc., Ohta-ku, Tokyo, Japan) of all dissection stages.

2.2. Clinical study

A comprehensive clinical examination and preoperative tests, which are magnetic resonance imaging (MRI), electroencephalography (EEG), long-term EEG-video monitoring to obtain electrophysiological data, computer tomography, and neuropsychological assessment were applied to all patients. The surgical procedures were performed under general anesthesia. Preoperative, intraoperative and postoperative images were obtained from a selected patient. We also notes the affected fiber tracts of the temporal lobe according to amygdalohippocampectomy procedures in Table 1.

3. Results

3.1. Anatomical study

The lateral temporal surface has three gyri and two sulci; the superior, middle and inferior gyri and superior and inferior sulci. The vascular structures to be encountered on the surface are the vein of Labbe and the cortical branches of the middle cerebral artery (Fig. 2A). The vein of Labbe on lateral surface connects the superficial sylvian and middle temporal veins to the transverse sinus, and this vein should be preserved [11]. The blood supply of the temporal lobe is provided by the temporopolar, anterior, middle, and posterior temporal areas [12], which are the branches of middle cerebral and posterior cerebral arteries.

After passing through the middle temporal gyrus, the short association fibers, which interconnect neighbor gyri, are encountered first (Fig. 2B). The fibers located deeper to the short association fibers are the long association fibers, which interconnect distant areas in the same hemisphere [9]. The first long association fiber tract to be encountered in middle temporal gyrus is the arcuate fasciculus (AF) (Fig. 2C). The AF has a ventral and a dorsal segments [13]. The AF ventral segment in the middle one third of the middle temporal gyrus, and the AF dorsal segment in the posterior one third of the middle temporal gyrus are situated. Progressingly deeper to the AF, the inferior fronto-occipital fasciculus (IFOF) is encountered. The IFOF and the occipital extension of the anterior commissure, which is situated a deeper to the IFOF, travels through the superior and middle temporal gyri. Finally, the optic radiation fibers in the superior and middle temporal gyri and then tapetal fibers in the lateral wall of the temporal horn of the lateral ventricle are encountered before entering into the temporal horn of the lateral ventricle (Fig. 2D, E). After opening the ependymal layer of the lateral wall of the temporal horn of the lateral ventricle, the collateral eminence, hippocampus, lateral ventricular sulcus, choroidal fissure, inferior choroidal point, choroid plexus, fimbria of the fornix, and amygdala are exposed (Fig. 3A, B). *The collateral eminence* situated lateral to the hippocampus covers the base of the temporal horn of the lateral ventricle. The collateral eminence is the indentation of the collateral sulcus and the most medial area for neocortical removal. *The hippocampus* can be easily identified between the collateral eminence laterally and choroidal fissure medially. *The lateral ventricular sulcus* separates the hippocampus proper from the collateral eminence, extending anteriorly toward the amygdala–hippocampal junction. The hippocampus sits over the parahippocampal gyrus and has the head, body and tail parts. The anterior portion of the hippocampal head blends into the amygdala. The medial border of the hippocampus is *the choroidal fissure*, and the inferior choroidal point is the at the most anterior and inferior point of the choroidal fissure. *The inferior choroidal point* is situated medial to the head of hippocampus and posterior to the uncus. The anterior choroidal artery passes through the inferior choroidal point to enter into the temporal horn of the lateral ventricle (Fig. 3B, C). The opening of the choroidal fissure exposes the crural and ambient cisterns (Fig. 3D). *The fimbria of the fornix* located just medial to and above the dentate gyrus covers medial

Table 1
Comparison of damaged structures in surgical techniques

Structure of interest	Anterior temporal lobectomy	Transsylvian amygdalohippocampectomy	Transcortical through middle temporal gyrus SelAH
IFOF	+Neurocognitive defects (picture naming, object recognition, naming of sounds and recognition of speech) [15,16]	+Neurocognitive defects(picture naming, object recognition, naming of sounds and recognition of speech) [15,16]	+Neurocognitive defects (picture naming, object recognition, naming of sounds and recognition of speech) [15,16]
ILF	+Object identification and recognition, language [9]	–	–
MLF	+Language and attention disorders [9]	–	–
Uncinate fasciculus	+Neurocognitive defects (recognizing faces, actions, objects and emotion) [17,18]	+Neurocognitive defects (recognizing faces, actions, objects and emotion) [17,18]	–
Optic radiation	–	+Upper contralateral quadrantanopia [20,21]	+Upper contralateral quadrantanopia [20,21]
Arteries	–	+Vassospasm [50]	–

IFOF = inferior fronto-occipital fasciculus, ILF = inferior longitudinal fasciculus, MLF = middle longitudinal fasciculus, SelAH = selective amygdalohippocampectomy.