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Update

Surgical anatomy of the hippocampus

Anatomie chirurgicale de l'hippocampe

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ABSTRACT

Background and purpose. – Hippocampectomy is an efficient procedure for medial temporal lobe epilepsy. Nevertheless, hippocampus anatomy is complex, due to a deep location, and a complex structure. In this didactic paper, we propose a description of the hippocampus that should help neurosurgeons to feel at ease in this region.
Methods. – Embryological data was obtained from the literature, whereas adult anatomy was described after dissecting 8 human hemispheres (with and without vascular injection) and slicing 3 additional ones.
Results. – The hippocampus is C-shaped and made of 2 rolled-up laminae, the cornu Ammonis and the gyrus dentatus. Its ventricular aspect is covered by the choroid plexus of the inferior horn excepted at the head level. Its cisternal aspect faces the mesencephalon from which it is limited by the transverse fissure. Its rostral part (head) curves dorso-caudally to form the uncus, located at the medial aspect of the temporal lobe. Its caudal part (tail) splits into the fimbria and the gyrus fasciolaris that respectively run ventral and dorsal to the corpus callosum, to become the fornix and indusium griseum.
Conclusion. – Consequences of this complex anatomy are presented, and the authors stress the need for a subpial resection. Important landmarks are provided to avoid lesions of the surrounding structures.

Mots clés :
Hippocampe
Anatomie
Chirurgie de l'épilepsie

RÉSUMÉ

État de l'art et objectifs. – L'hippocampectomie est efficace dans le traitement de l'épilepsie temporale mésiale. Néanmoins, la compréhension de l'anatomie de l'hippocampe est difficile en raison d'une situation profonde et d'une structure complexe. Cet article didactique propose une description schématique de l'hippocampe qui devrait aider la pratique neurochirurgicale de cette région.
Méthode. – Les données embryologiques sont issues de la seule littérature, alors que les données anatomiques adultes ont été obtenues après dissection de 8 hémisphères humains injectés ou non et la réalisation de coupes pour 3 autres.
Résultats. – L'hippocampe a une forme de « C » et est constitué de 2 lames enroulées, la corne d'Ammon et le gyrus dentatus. Sa portion ventriculaire est recouverte par le plexus choroïde de la corne ventriculaire inférieure sauf au niveau de la tête. Sa portion cisternale fait face au mésencéphale dont il est séparé par la fissure transverse. Sa partie rostrale (tête) s'incurve dorso-caudalement pour former l'uncus. Sa partie caudale (queue) se divise en fimbria et gyrus fasciolaris qui cheminent respectivement aux faces ventrale et dorsale du corps calleux, pour devenir la jambe du fornix et l'indusium gris.
Conclusion. – Les conséquences pratiques de cette anatomie sont présentées et les auteurs soulignent l'importance de la dissection sous piale et du respect de repères anatomiques lors de la chirurgie de cette région.

1. Introduction

Most of the epileptic patients suffering an hippocampal sclerosis can be efficiently treated by resection of the hippocampus more or less including the surrounding structures, especially amygdaloid

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complex and parahippocampal gyrus: after such a surgery, more than 80% of them are seizure free (Engel Class I) [1–4]. Nevertheless, hippocampus anatomy has the reputation to be very complex and difficult to understand for non-specialized neurosurgeons or neurologists. Hippocampus is indeed a deep structure, hidden between the mesencephalon and medial aspect of the temporal lobe, its main aspect being only visible inside the inferior horn of the lateral ventricle. This anatomical challenge is increased by a complexity in the used terminology, a same structure being differently named in different part of the hippocampus.

The goal of this didactic paper is to provide the reader with a comprehensive and practical anatomy of the hippocampal region and the practical consequences of this anatomy for neurosurgical procedures. We first present a summarized and highly simplified embryological view of this region, in order to give the reader the keys that are mandatory to understand the adult anatomy. We then describe the surface and sectional anatomy of the hippocampus, and finally present influence this anatomy should have in surgical planning. This paper does not aim at a complete description of the hippocampus morphology and function that can be found elsewhere [5,6], nor in an original description of this region. For this reasons, we only used a limited number of specimens, without any attention paid to inter-subjects variability.

2. Material and method

For the description of adult anatomy, 11 human brain hemispheres (5 left and 6 right) were obtained from the body donation program of our laboratory. For surface anatomy, we studied 4 hemispheres (2 right 2 left) that were extracted, fixed in a 10% commercial formalin solution for 3 months and then whitened in a 10% commercial hydrogen peroxide solution. To study hippocampus vascularization, two brains were injected with colored latex: after severing the head, red neoprene latex (neoprene latex #671, E. I. Du Pont de Nemours–Dow Elastomers, Wilmington, DE) was injected into the primitive carotid and vertebral arteries, and blue neoprene latex was injected into the jugular veins. Brain was extracted after latex polymerization and fixed as previously described. Dissections were performed under optical magnification and important steps of the dissections were photographed. Relationships of the hippocampus were studied on these dissections but also slices. One additional right hemisphere was sliced following a coronal plane after being fixed, whereas another brain was sliced after carotid and vertebral injection of a mixture of gelatin and india ink.

Due to the didactic aim of this paper, and to the limited number of subjects that does not allow study of variations, photographs of right specimens were presented in their original orientation, whereas those from left specimens were right-left flipped.

The embryologic considerations were obtained from the literature [6–8].

3. General situation

The hippocampus is located between the medial aspect of the temporal lobe and the temporal horn of the ventricle. It is part of the limbic lobe (or rhinencephalon), a complex puzzle of various anatomical structures located at the medial aspect of the hemisphere [9]. The limbic lobe (Fig. 1A) is limited from the surrounding cortex by the limbic fissure, and is divided into 2 concentric circles, the limbic and intralimbic gyri.

The discontinuous limbic fissure includes:

- the cingulate sulcus, between the anterior and middle parts of the cingulate gyrus and the superior frontal gyrus;
- the subparietal sulcus that limits the posterior part of the cingulate gyrus from the precuneus;
- the anterior segment of the calcarine sulcus, running between the isthmus of the cingulate gyrus and the lingual gyrus (or 05);

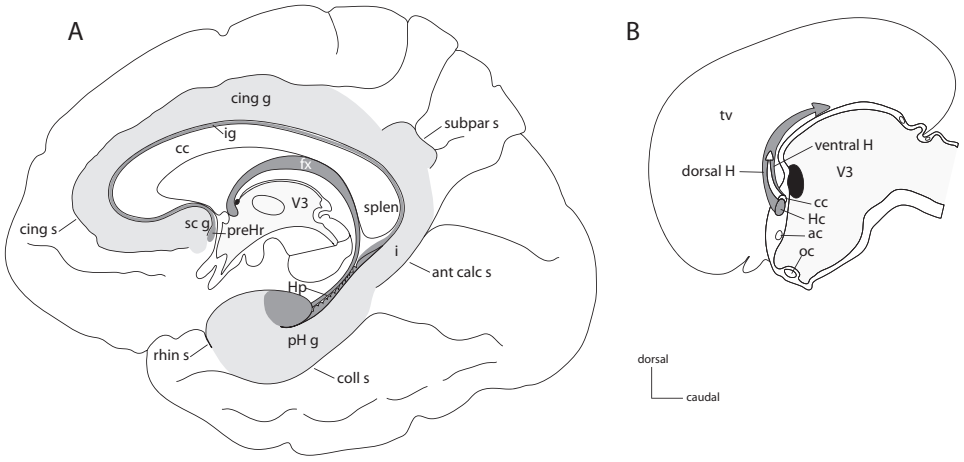

Fig. 1. Development and adult anatomy of the limbic system. A. Gross anatomy of the adult limbic lobe. The limbic fissure that separates the limbic lobe from the surrounding cortex is made of: the cingulate (cing s), subparietal (subpar s), anterior calcarine (ant calc s), collateral (coll s) and rhinal sulci (rhin s). The limbic lobe contains the limbic gyrus [Light grey: subcallosal (sc g), cingulate (cing g), isthmus (i), and parahippocampal gyri (pHg)] and the intralimbic gyrus [Dark grey: prehippocampal rudiment (preHr), indusium griseum (ig), and hippocampus proper (Hp)]. B. Development of the hippocampal and callosal commissures. The optic chiasm (oc), anterior commissure (ac), hippocampal commissure (Hc) and callosal commissure (cc) develop from the commissural plate of the midline telencephalon (telencephalon impar). The hippocampal commissure first develops and follows the rotation of the telencephalic vesicle (tv) towards the temporal lobe. As it develops, the corpus callosum splits the hippocampal commissure in dorsal and ventral parts. The ventral hippocampus gives the adult fornix (A, fx), whereas the dorsal hippocampus involutes as the indusium griseum (A, ig) and prehippocampal rudiment (A, PreHR). Ventral to the splenium (A, splen), the ventral and dorsal hippocampus join to give the hippocampus proper (Hp).
Développement et anatomie adulte du système limbique. A. Anatomie du lobe limbique. La fissure limbique, qui sépare le lobe limbique du cortex avoisinant, est constituée des sulci : cingulaire (cing s), subparietal (subpar s), calcarin antérieur (ant calc s), collatéral (coll s) et rhinal (rhin s). Le lobe limbique contient le gyrus limbique [gris clair : gyri subcalleux (sc g), cingulaire (cing g), isthme cingulaire (i), et parahippocampique (pHg)] et le gyrus intralimbique [gris foncé : rudiment préhippocampique, (preHr), indusium griseum (ig), et hippocampe propre (Hp)]. B. Développement des commissures hippocampique et calleuse. Le chiasma optique (oc), les commissures antérieure (ac), hippocampique (Hc) et calleuse (cc) se développent à partir de la plaque commissurale du télencéphale médian (telencephalon impar). La commissure hippocampique est la première à se développer. Elle suit la rotation des vésicules télencéphaliques (tv) vers le lobe temporal. Le développement du corps calleux induit ensuite la séparation de la commissure hippocampique en deux parties, ventrale et dorsale. L'hippocampe ventral donne le fornix (A, fx), tandis que l'hippocampe dorsal involue pour se transformer en indusium griseum (A, ig) et rudiment préhippocampique (A, PreHR). Ventralement au splénium (A, splen), les parties ventrale et dorsale de l'hippocampe se rejoignent pour former l'hippocampe propre (Hp).