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Tools and techniques

Preoperative navigated transcranial magnetic stimulation and tractography in transparietal approach to the trigone of the lateral ventricle

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ABSTRACT

Objective: Eloquent neural structures including white matter tracts surround the trigone of the lateral ventricle. Surgical resection of trigonal tumors via the transparietal approach may cause neurological deterioration depending on the trajectory.

Methods: The authors retrospectively reviewed patients with trigonal tumors that underwent combined preoperative navigated transcranial magnetic stimulation (nTMS) and optic radiation tractography to guide a transparietal approach towards the trigone.

Results: Five patients underwent preoperative nTMS motor mapping, rTMS language mapping, nTMS-derived corticospinal tract tractography, and optic radiation tractography. The information was used to select the optimal trajectory for a transparietal approach and for intraoperative neuronavigation. Four patients underwent surgical resection. None of them experienced a new permanent deficit.

Conclusion: Combination of preoperative nTMS and optic radiation tractography facilitates the identification of the optimal parietal trajectory towards the trigone. It allows for sparing of visual and motor pathways as well as cortical language areas.

1. Introduction

The lateral ventricle of the ventricular system resembles a C-shape structure made up of an anterior (frontal), a posterior (occipital) and an inferior (temporal) horn. The trigone of the lateral ventricle is at the junction of the posterior and inferior horns. This area represents the floor of the atrium of the lateral ventricle [1,2].

Tumors located within the trigone, such as intraventricular meningiomas or choroid plexus papillomas, are rare [3,4]. Parenchymal tumors located adjacent to the trigrone like gliomas and metastases are much more frequent [5]. Selection of the optimal surgical trajectory can be challenging. Depending on tumor entity, size, location and extension, and size of the ventricles, various surgical approaches have been proposed including the supracerebellar, transtentorial, transcollateral sulcus approach [6,7], the contralateral transfalcine, transprecuneus approach [8,9], and the distal Sylvian, lateral transtemporal, or subtemporal approaches [1,2]. Every approach inherits specific benefits and risks. The transparietal approach is another option to approach the trigone (Fig. 1). The cortical incision is performed within or in proximity of the intraparietal sulcus (IPS) or nearby sulci. This approach is referred to as transsulcal, intraparietal, or parietal intrasulcal approach. Transsulcal dissection was described by Yasargil with the intention to minimize damage of white matter tracts by using the shortest possible distance to deep seated tumors [10]. The IPS separates the medially located superior parietal and laterally located inferior parietal lobes (IPL). The parietal transsulcal approach has been used to operate on both vascular malformations and cerebral neoplasms. This approach allows avoidance of the visual pathway, speech areas, and sensorimotor areas. However, the reach of the transparietal approach to the trigone is long and incautious dissection and retractor placement may cause significant

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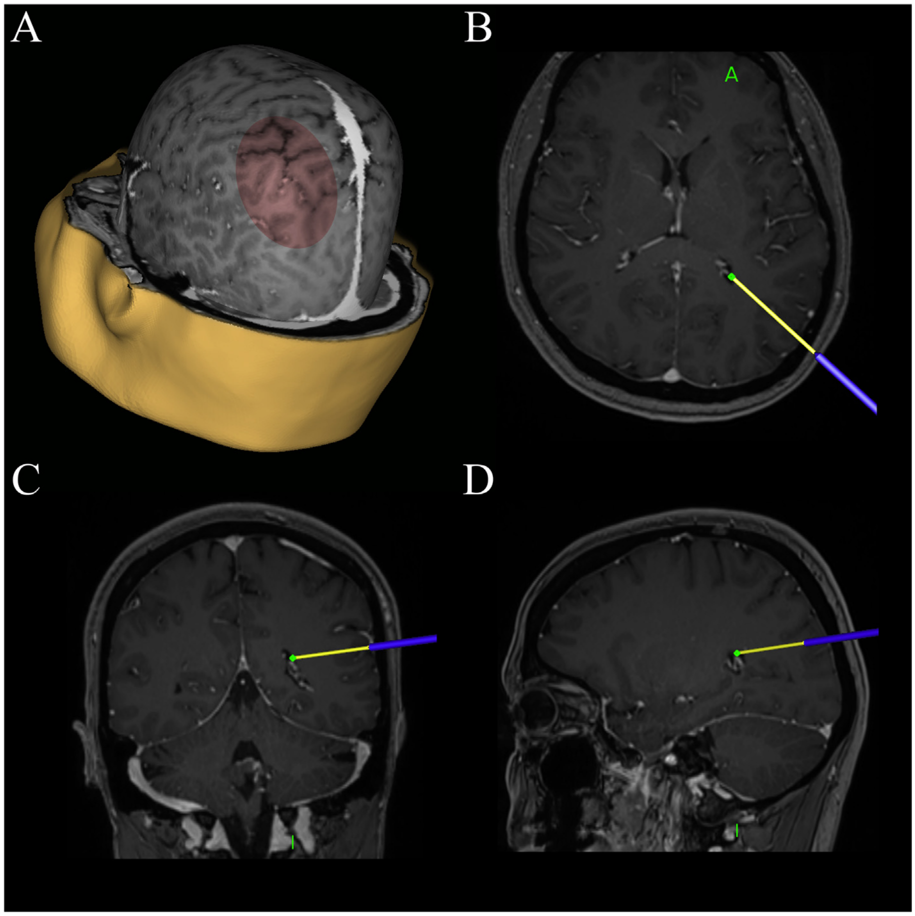

Fig. 1. Potential trajectory for a transparietal approach to the trigone. Panel A illustrates the entry zone on a pseudo-3D-model. Panel B, C, and D illustrate the trajectory in 2D.

brain injury including speech disturbance, particularly, when the lesion is located within the dominant hemisphere [1,2,11–14]. While this approach can be purely based on neuroanatomical landmarks [15,16], neuronavigation is routinely used these days [17,18].

Here, we retrospectively reviewed patients with trigonal tumors undergoing preoperative nTMS and tractography to select the optimal trajectory for a transparietal approach to the trigone of the lateral ventricle.

2. Methods

We retrospectively reviewed all consecutive patients that underwent nTMS and tractography for presurgical workup of a trigonal tumor between January 2014 and September 2016. For the present analysis, the following criteria were defined: left-sided trigonal lesion in right handed patients or right-sided trigonal lesion in left-handed patients, preoperative nTMS motor mapping, preoperative rTMS language mapping, nTMS-based corticospinal tract tractography, optic radiation tractography, export of nTMS datasets and tractography to neuronavigation, preoperative identification of an optimal trajectory towards the trigone via neuronavigation-based planning modell, scheduling of surgery guided by neuronavigation under general anesthesia.

2.1. Data collection

Data collection on patients undergoing nTMS and tractography was prospective. Neurological condition was assessed preoperatively, at hospital discharge (approximately one week after surgery), and at follow-up visit in the outpatient clinic. The Medical Research Council scale (MRC) grade 0–5 was applied to report motor strength of the limbs [19]. Diagnosis was confirmed by histopathology.

2.2. Preoperative MRI

Preoperative MRI scans were performed on a 1.5 or 3 T scanner (Magnetom Skyra 3.0 T; Magnetom Symphony-TIM 1.5 T, Siemens, Erlangen, Germany). Patients underwent contrast-enhanced T1-weighted MRI for intraoperative neuronavigation (MP RAGE in axial plane: TR = 1.9; TE = 3.52; FLIP-angle 15; slice thickness 1 mm). For diffusion tensor imaging (DTI) fiber tracking, diffusion weighted imaging was acquired (TR = 5.6; TE = 100; FLIP-Angle 90; slice spacing 3.6; slice thickness 3 mm).

2.3. Navigated transcranial magnetic stimulation (nTMS)

The eXimia NBS system with NEXSPEECH® was used to perform nTMS motor and language mapping. All mappings were performed by the first and second authors (P. H., S. S.), both experienced operators. Motor mapping was conducted according to Picht et al. [20,21]. For nTMS language mapping, a protocol published by Krieg et al. was followed [22–26]. Briefly, patients underwent baseline assessment using an object-naming task performed twice (inter-picture interval 2500 ms, display time of presented object 700 ms) recorded on a video camera. Correctly and fluently