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Patterns of neurovascular compression in patients with classic trigeminal neuralgia: A high-resolution MRI-based study

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ABSTRACT

Purpose: To describe the anatomical characteristics and patterns of neurovascular compression in patients suffering classic trigeminal neuralgia (CTN), using high-resolution magnetic resonance imaging (MRI).
Materials and methods: The analysis of the anatomy of the trigeminal nerve, brain stem and the vascular structures related to this nerve was made in 100 consecutive patients treated with a Gamma Knife radiosurgery for CTN between December 1999 and September 2004. MRI studies (T1, T1 enhanced and T2-SPIR) with axial, coronal and sagital simultaneous visualization were dynamically assessed using the software GammaPlan™. Three-dimensional reconstructions were also developed in some representative cases.
Results: In 93 patients (93%), there were one or several vascular structures in contact, either, with the trigeminal nerve, or close to its origin in the pons. The superior cerebellar artery was involved in 71 cases (76%). Other vessels identified were the antero-inferior cerebellar artery, the basilar artery, the vertebral artery, and some venous structures. Vascular compression was found anywhere along the trigeminal nerve. The mean distance between the nerve compression and the origin of the nerve in the brainstem was 3.76 ± 2.9 mm (range 0–9.8 mm). In 39 patients (42%), the vascular compression was located proximally and in 42 (45%) the compression was located distally. Nerve dislocation or distortion by the vessel was observed in 30 cases (32%).
Conclusions: The findings of this study are similar to those reported in surgical and autopsy series. This non-invasive MRI-based approach could be useful for diagnostic and therapeutic decisions in CTN, and it could help to understand its pathogenesis.

1. Introduction

The existence of neurovascular compression (NVC, known as neurovascular contact or neurovascular conflict) between a blood vessel and the trigeminal nerve (TN) has been proposed as a possible etiology of classic trigeminal neuralgia; however, the exact pathogenic mechanism remains not completely understood [1–3].

Magnetic Resonance Imaging (MRI) has been used successfully in patients with trigeminal neuralgia to study the anatomy of the trigeminal nerve, the brain stem, and its vascular relationships, being this technique nowadays well validated for these purposes [4–15].

The aim of this study is to analyze retrospectively on high-resolution MRI the anatomy of the trigeminal nerve, the brainstem and their neurovascular contacts in 100 consecutive patients with classic trigeminal neuralgia studied with high-resolution MRI and treated with Gamma Knife radiosurgery. Emphasis was done on the different patterns of neurovascular compression and their relative frequencies.

2. Materials and methods

Between December 1999 and September 2004 one hundred consecutive patients with classic trigeminal neuralgia were treated with Gamma Knife radiosurgery (Elekta Instruments AB, Stockholm, Sweden). In all cases, the treatment was based on high-resolution MRI.

MRI studies were acquired with a Philips (Best, the Netherlands), Model: Intera 1.5 T, obtaining axial slices parallel to the orbito-meatal plane. Sequences obtained were T1-weighted, T1-weighted

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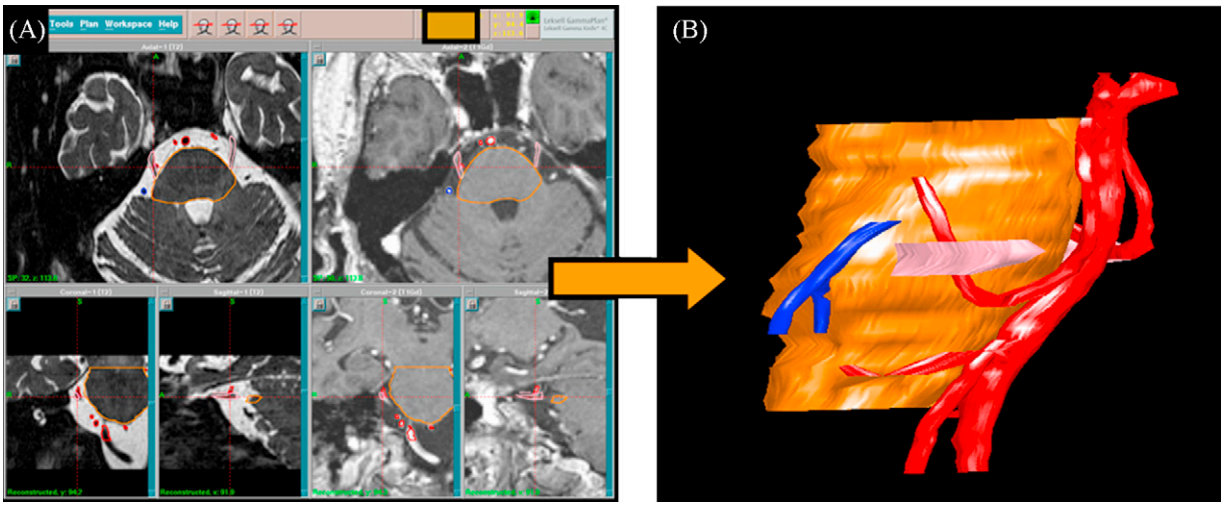

Fig. 1. (A) Multiplanar (axial, coronal and sagital) dynamic display of the MRI (T2-SPIR and T1 enhanced). (A) Delimiting the structures of interest and (B) acquisition of a 3D model.

enhanced and T2-weighted selected partial inversion recovery (T2-SPIR).

T1-weighted acquisition protocol was 3D Turbo field echo T1, time of acquisition: 7 min 13 s, FOV 270, Rectangular FOV 80%, Matrix 256, spatial resolution 1.05 mm × 1.42 mm × 1.3 mm, 100 slices, 1.3 mm in thickness, TR (ms)/TE/Angle 20/4.6/25°.

T2-SPIR acquisition protocol was 3D Turbo spin echo T2 with Flow compensation SPIR FAT Suppression, time of acquisition: 9 min 3 s, FOV 270, Rectangular FOV 50%, Matrix 512 spatial resolution 0.53 mm × 0.84 mm × 1.0 mm, 50 slices, 1 MM thickness, TR (ms)/TE 3000/180.

Stereotactic co-registered images were analyzed with GammaPlan™ software, version 5.34 software (Elekta Instruments AB, Stockholm, Sweden). Imaging visualization was done in the workstation in a dynamic manner, with multiplanar and multisequence display at once on the screen (Figs. 1–5). In complex and illustrative cases, 3D models were built.

T2-SPIR sequence was initially used for a general anatomic approach, identifying the brainstem, the trigeminal nerve, and all the "vascular-like structures" close to the nerve and, then, T1-weighted and T1-weighted enhanced sequences were used for vessel confirmation.

Arteries and veins were differentiated analyzing their anatomical characteristics following each structure dynamically on the screen.

To generate 3D reconstructions, all significant structures (brain stem, trigeminal nerve, arteries and veins) were outlined on the axial T2-SPIR slices (Fig. 1A). Each structure was outlined separately as a partial volume with a specific color, and then, all these volumes were displayed together, generating the 3D model (Fig. 1B). No MRI angiography was employed.

The 3D model can be displayed on the screen also dynamically, this way; it can be rotated in any direction and studied from any perspective.

NVC was defined as the existence of a vessel in contact with TN, according with two of the criteria described by Masur et al. [9]: 1- simple contact; 2- contact with nerve dislocation. If a layer of cerebrospinal fluid was identified between the nerve and a vessel, the neurovascular contact was not considered. Another criterion used was a contact between the vessel and the brain stem close to the nerve origin in the pons without a direct contact with the nerve itself.

Nerve dislocation or distortion was defined as a nerve angulation or displacement by the vessel at level of contact.

Multiple vascular contacts were considered if two or more vessels contacted the nerve.

The location of NVC was classified in 2 categories: proximal: when distance between NVC and brain stem surface was less than 3 mm [16] or when there was direct contact with the brain stem surface (but not with the nerve itself), and distal: when this distance was 3 mm or more.

The frequency of each type of neurovascular contact was calculated using as a denominator the number of patients having a vascular contact with the nerve.

To compare 2 × 2 contingency tables the two-sided Fisher's exact test was used. A p value ≤ 0.05 was considered significant.

3. Results

Among the 100 patients studied, in 93 (93%), a neurovascular contact was found on MRI in the symptomatic side. Conversely, on the contralateral asymptomatic side, only 55 cases (55%) had a neurovascular contact ($p < 0.0001$).

3.1. Neurovascular compression characteristics (symptomatic side)

The mean distance between the nerve compression and the origin of the nerve in the brainstem was 3.76 ± 2.9 mm (range 0–9.8 mm). This vascular compression was located anywhere along the trigeminal nerve (juxtapontine, midcisternal or juxtapetrous). In 39 patients (42%) the vessel contacted the nerve in the first 3 mm of the nerve from its origin in the pons, and in 42 (45%), it was distal than 3 mm. In seven cases (7.5%) multiple contacts were found. In five patients (5%), there was an obvious contact between the vessel and the brain stem close to the trigeminal nerve origin, but not with the nerve itself, these cases were considered as proximal neurovascular contacts, i.e., in Fig. 4B, the brainstem is compressed and grooved by the vertebral artery without any vessel contacting the trigeminal nerve. The superior cerebellar artery (in two patients), the antero-inferior cerebellar artery (in one case) and a vein (in one case) were also identified.

Nerve dislocation or distortion by the vessel was observed in 30 cases (32%) on the symptomatic side, on the contrary, on the asymptomatic side there was always a simple contact ($p < 0.0001$).