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Original Research Article

Usefulness of intraoperative monitoring of oculomotor and abducens nerves during surgical treatment of the cavernous sinus meningiomas

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ABSTRACT

Purpose: We analyzed the usefulness and prognostic value of intraoperative monitoring for identification of the oculomotor (III) and the abducens (VI) nerve in patients with cavernous sinus meningiomas.
Material/methods: 43 patients diagnosed with cavernous sinus meningiomas were divided according to their topography. Function of the nerves was scored on original clinical and neurophysiological scales.
Results: The percentage of nerves identified correctly with the monitoring was significantly higher (91% vs. 53% for nerve III and 70% vs. 23% for nerve VI, $p < 0.001$). The fractions of nerves III and VI identified correctly by means of the monitoring were significantly higher in the case of tumors with intra- and extracavernous location (89% vs. 32%, $p < 0.01$) and intracavernous tumors (80% vs. 20%, $p < 0.05$), respectively. The quality of post-resection recording correlated with functional status of both the nerves determined 9 months after the surgery ($R = 0.51$, $p < 0.001$ for nerve III and $R = 0.57$, $p < 0.01$ for nerve VI). Even a trace or pathological response to the post-resection stimulation was associated with improved functional status (90% vs. 50%, $p < 0.05$ for nerve III and 93% vs. 38%, $p < 0.01$ for nerve VI).
Conclusions: Neurophysiological monitoring of ocular motor nerves enables their intraoperative identification during resections of the cavernous sinus meningiomas. Intraoperative monitoring of nerve III is particularly important in the case of tumors with extra- and intracavernous location, and the monitoring of nerve VI in the case of intracavernous tumors. The outcome of the post-resection monitoring has prognostic value with regard to the clinical status of the nerves on long-term follow-up.

1. Introduction

Progress in surgical technique resulted in increased radicality of skull base procedures. One example is surgical treatment of meningiomas located in the cavernous sinus and its surroundings. However, these procedures are still associated with the risk of injury to cranial nerves related to the cavernous sinus. Intraoperative neurophysiological monitoring, supporting visual identification of ocular motor nerves, constitutes one way of preventing such complications [1–4]. While the usefulness of the neurophysiological monitoring in facial nerve sparing was unambiguously confirmed in the case of resections of the cerebellopontine angle tumors, there is no similar evidence with regard to tumors located in the cavernous sinus. Most of the sparse papers dealing with the problem in question [5,6] centered around the description of the methodology of monitoring itself. Moreover, the few available opinions in this matter are highly inconclusive [4,7,8]. For example, Weisz et al. [8] claimed that intraoperative monitoring is not associated with additional benefits due to specific anatomical relationships between the ocular motor nerves and tumor. However, Sekiya et al. [4] showed that the intraoperative monitoring facilitates identification of oculomotor (III) nerve, especially if the tumor alters normal anatomical relationships within the cavernous sinus. The results of this latter study might be confounded by the lack of statistical analysis [4].

The aim of this prospective study was to use statistical analysis in order to objectively verify the usefulness of neurophysiological monitoring for intraoperative identification of nerve III and abducens (VI) nerve. Moreover, having access to a relatively large (as for this type of tumors) sample of 43 operated patients, we

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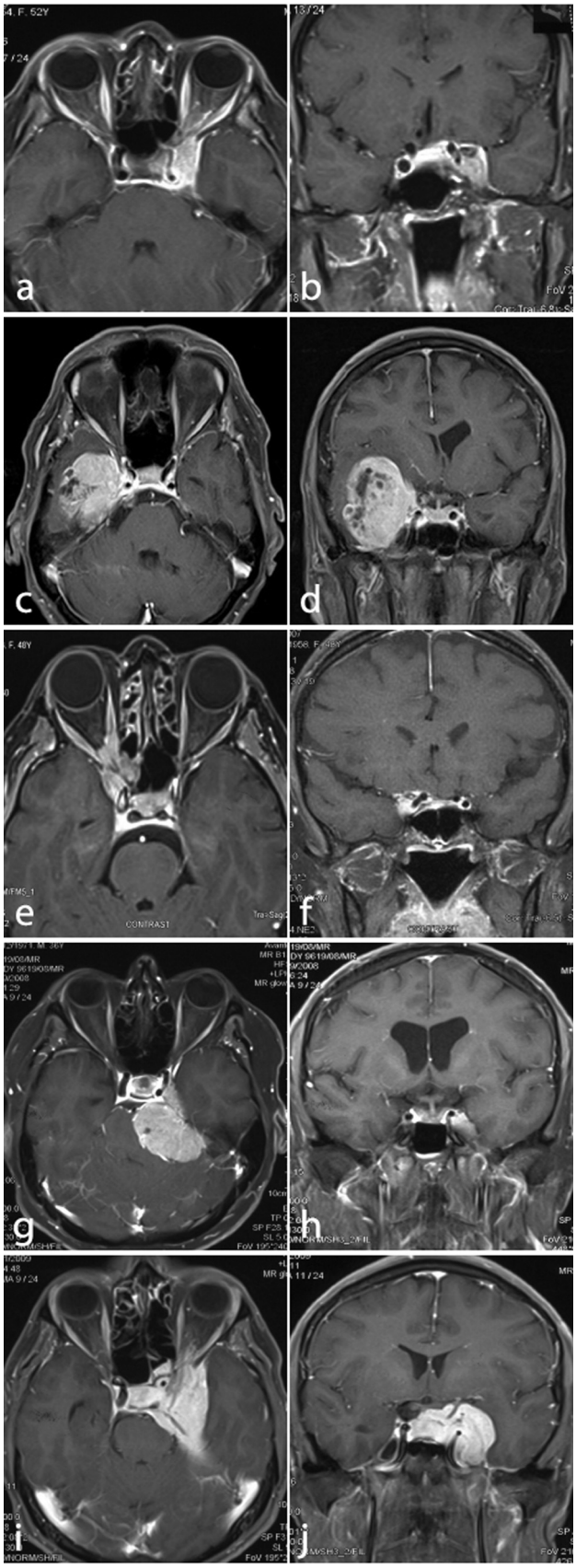

Fig. 1. Topographic types of 43 analyzed meningiomas of the cavernous sinus. (a, b) Type A tumor, fibrosus meningioma located inside the left cavernous sinus; (c, d) type B tumor, mixed meningioma of the right large sphenoid wing, infiltrating layers of the lateral wall of the cavernous sinus; (e, f) type C tumor, syncytial meningioma involving the orbital cone, sphenoid sinus and anterior part of the right cavernous sinus; (g, h) type D tumor, psammomatous meningioma involving the apex of the left temporal bone pyramid and superior part of the clivus, penetrating through the Meckel's cavity toward the posterior part of the cavernous sinus; (i, j) type E tumor, psammomatous meningioma of the left cavernous sinus, penetrating toward the sella turcica, ethmoid sinus, medial parts of the temporal lobe, clivus and apex of the temporal bone pyramid.

analyzed the usefulness of this method in various topographic variants of the cavernous sinus tumors. Finally, we verified if the use of intraoperative monitoring influences clinically determined function of the nerves during long-term follow-up.

2. Patients and methods

2.1. Patients

The study included the group of 43 consecutive patients (33 women and 10 men) aged between 22 and 74 years (mean age: 49.8 years), who were diagnosed with meningiomas located in the cavernous sinus or its surroundings. All the patients were treated at the Department of Neurosurgery, Medical University of Silesia in Sosnowiec between 2001 and 2011. Five topographic types of the tumors were identified on the basis of their localization documented on MRI: (1) intracavernous tumors (type A, Fig. 1a and b), (2) extracavernous tumors surrounding the cavernous sinus (type B, Fig. 1c and d), (3) tumors with both extra- and intracavernous location, penetrating into the anterior part of the cavernous sinus (type C, Fig. 1e and f), (4) tumors with both extra- and intracavernous location, penetrating into the posterior part of the cavernous sinus (type D, Fig. 1 g and h), and (5) tumors with both extra- and intracavernous location, invading the entire cavernous sinus (type E, Fig. 1i and j). Functional status of nerves III and VI was determined one day prior to the surgery, at discharge from hospital, and during control visit 9 months after the surgery. The functional impairment of the nerves was graded on a 4-item scale: (I) normal status, (II) discrete paresis or subjectively reported impression of double vision without evident impairment of the eye globe motility, (III) severe paresis, and (IV) palsy. Although none of the patients showed isolated trochlear (IV) nerve palsy, functional deficits of this nerve accompanied disorders of nerve III and VI in some cases.

2.2. Intraoperative monitoring of nerves III and VI

Monitoring was conducted with a 16/32 channel amplifier ISIS (Inomed Medizintechnik, Germany) exporting data to NeuroExplorer software. Recording needle electrodes were applied to muscles innervated by the monitored nerves: levator palpebrae superioris muscle or superior rectus muscle to monitor nerve III, and lateral rectus muscle for the purpose of nerve VI monitoring. A reference electrode was applied to the temporal muscle [9]. We eventually examined two nerves: nerve III located in the cavernous sinus wall, and nerve VI passing through the cavernous sinus. After several unsuccessful attempts we resigned from nerve IV monitoring. This decision was associated with difficulties in clinical interpretation of neurological deficits resulting from functional impairment of this nerve, as well as with problems with proper insertion of recording electrode into a small superior oblique muscle, or with selective stimulation of nerve IV located in close proximity of nerve III in the cavernous sinus wall. The nerves were stimulated with a 1.5–1.8 V direct current delivered via parallel or concentric electrodes. The amplitude of recording was considered as a principal criterion of muscular response. The result of identification was classified using a 4-item scale (from a to d): (a) both visual and electromyographic identification, (b) visual identification without electromyographic response,