Neurology, Psychiatry and Brain Research 28 (2018) 7–12

Contents lists available at ScienceDirect

Neurology, Psychiatry and Brain Research

journal homepage: www.elsevier.com/locate/npbr

The importance of intraoperative neurophysiological monitoring for resection of lumbosacral plexus tumors

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ARTICLE INFO

Keywords:
Lumbosacral plexus/intraoperative procedures
Peripheral nervous system neoplasms/surgery
Nerve sheath neoplasms
Peripheral nervous system/surgery
Monitoring
Intraoperative
Intraoperative neurophysiological monitoring
Neurosurgery/methods

ABSTRACT

Lumbosacral plexus tumors (LSPT) are rare lesions whose clinical presentation can be very nonspeci/fic, and which are usually identifiable through imaging exams. In order to facilitate complete tumor resection without loss of neurological function multimodal intraoperative neurophysiological monitoring (MINM) has been employed, although the literature is still scarce and non-systematic. In this paper we aim to briefly review the lumbosacral plexus' anatomy and describe the strategy adopted for intraoperative monitoring in the treatment of six patients with benign LSPT operated in the last 6 years. In our sudy, all patients improved pain, and none developed motor or sensitive deficit on postoperative period. We consider intraoperative monitoring critical during surgical resection, as a tool for preventing neurological deficit, and improving outcomes, that are particularly important given anatomical and functional significance of lumbosacral plexus tumors.

1. Introduction

Lumbosacral plexus tumors (LSPT) are a rare group of neoplastic lesions, notably those arising in the intimacy of the psoas major muscle, at lumbosacral trunk or deep in the presacral area and since they can involve the retroperitoneum or the pelvis, and lead to compression of the bladder and the rectum and invasion of the lumbosacral spine, their management is sometimes extremely dificult (Arrabal-Polo et al., 2013; Avila Herrera, González Domínguez, Hernández Ordóñez, & Gutiérrez Aceves, 2010; Bergey, Villavicencio, Goldstein, & Regan, 2004; Celli, 2002; Dafford, Kim, Reid, & Kline, 2007; Datta et al., 2004; Guedes-Corrêa, Basílio-de-Oliveira, Santos, Amorim, & Megall, 2008; Viswanathan et al., 2009; Mastoraki et al., 2013; Moro, Kikuchi, Konno, & Yaginuma, 2003; Strauss, Qureshi, Hayes, & Thomas, 2011). The clinical presentation of these tumors can be very nonspecific, with patients complaining vaguely of abdominal or pelvic pain, constipation, and sciatica, with different somatosensory alterations, such as numbness in the lower extremities or in the perineal region (Dafford et al., 2007; Viswanathan et al., 2009). These masses are usually identifiable through imaging exams, such as US, CT, and MRI (Benjamin, Oermann, Thomas, Distaso, & Sandhu, 2016; Nishio et al., 1999; Hayasaka, Tanaka, Soeda, Huppert, & Claussen, 1999). Nevertheless, to date, even though some images are very characteristic, it is still not possible achieve absolute assurance about the nature of this type of expansive lesion from the image alone.

Upon their detection, the surgical indications for resection are based on a series of factors such as clinical evolution, presence of pain and neurological deficits, compression of neighboring viscera, suspicion of malignancy. Other factors related to lesion per se can also advocate for the excision of the mass: tumor size, rapid growth, vascularization, aspects of the tumor margins, signs of soft tissue invasion, evidence of necrosis, hemorrhagic or cystic changes, calcifications, and involvement of bone structures such as vertebral column and pelvic ring (Benjamin et al., 2016; Dafford et al., 2007; Viswanathan et al., 2009; Nishio et al., 1999).

Multimodal intraoperative neurophysiological monitoring (MINM) has been employed in some centers in order to ease complete tumor resection without loss of neurological function even though the evidence in the literature is still scarce and non-systematic (Boah & Perin, 2016; Nishio et al., 1999; O'Toole, Eichholz, & Fessler, 2006; Uribe, Arredondo, Dakwar, & Vale, 2010). It has also been reportedly utilized in minimally invasive approaches to lumbar plexus but not sacral lesions (Benjamin et al., 2016; Boah & Perin, 2016).

In a series of 17 LPST (11 in the lumbar plexus; 6 in the sacral plexus) surgically treated in our service between 2005 and 2017, we could employ MINM-assisted resection for the last 6 cases. We aim to describe the strategy adopted for the treatment of a consecutive series of 6 non-neurofibromatosis patients with benign LSPT operated by the senior author in the last 6 years. Besides, we describe briefly the anatomy of the lumbosacral plexus.

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https://doi.org/10.1016/j.npbr.2018.01.050
Received 27 October 2017; Received in revised form 5 January 2018; Accepted 11 January 2018
Available online 26 February 2018

2. Anatomy of the lumbar and sacral plexus

The ventral branches of the spinal nerves from T12 to S4 are involved in the formation of the lumbosacral plexus (Aumüller et al., 2009). These branches, before reaching their territory of innervation, exchange nerve fibers with the ventral branches of the higher or lower spinal nerves, making a true interchange and entanglement of nerve fibers, and giving rise to the lumbosacral plexus (Gabrielli & Vargas, 2010).

The fibers of the lumbosacral plexus are intended for the nerve supply of the wall of the abdomen, the pelvic floor, and the lower limbs. The lumbosacral plexus can be divided into two portions, lumbar plexus and sacral plexus.

2.1. Lumbar plexus

The lumbar plexus is formed by the ventral branches of the spinal nerves from T12 to L4 (Gray & Goss, 1988). The ventral branches of the first three lumbar nerve contribute integrally to the formation of the lumbar plexus, as well as most of the fourth lumbar nerve and, eventually, the twelfth thoracic nerve.

The major portion of the lumbar plexus is located in the posterior wall of the abdomen, disposed dorsally to the fibers of the psoas major muscle and ventrally to the transverse processes of the lumbar vertebrae (Gray & Goss, 1988). Only its terminal branches emerge in between the fibers of the psoas major muscle (Latarjet & Liard, 1996).

The group of fibers from the first lumbar nerve, along with the fibers from the twelfth thoracic nerve, is divided into an upper and a lower branch. The superior branch forms the iliohypogastric and ilioinguinal nerves, while the inferior branch joins some nerve fibers from the second lumbar nerve to form the genitofemoral nerve. The fibers from the second, third and fourth lumbar nerves separate into an anterior and a posterior division. The group of fibers from the anterior division together forms the obturator nerve and the posterior divisions of the second and third lumbar nerves divide once again, giving rise to the lateral cutaneous nerve of the thigh. For the formation of the femoral nerve, there is an interchange of nerve fibers from the posterior divisions from the second, third, and fourth lumbar nerves (Gray & Goss, 1988).

2.2. Sacral plexus

The sacral plexus includes the contribution of the ventral branches of the lumbar nerves L4 and L5 which, fused, form the lumbosacral trunk. The latter joins the sacral nerves from S1 to S4, originating the sacral plexus. The branches of the nerves that constitute this plexus are further divided in anterior and posterior.

Regarding its topography, the sacral plexus is located near the posterolateral wall of the pelvis, between the piriformis muscle and the internal iliac vessels (Gray & Goss, 1988). Subsequently, its fibers emerge through the major sciatic foramen towards the gluteal region. The former is divided into two foramina, the suprapiriformis and the infrapiriformis. This division is determined by the piriformis muscle that crosses and divides the larger sciatic foramen (Aumüller et al., 2009).

3. Multimodal intraoperative neurophysiological monitoring

In the last years, we have been able to count on the availability of MINM in our division for plexus surgery. We have used this technique in the last 6 surgical cases of LSPT. In none of the cases, we use the so-called minimally invasive techniques because we considered the lesions very complex and large-sized. Also, the tumors were in the ischiorectal fossa in half of the cases, what would hamper minimally invasive approaches (Avila Herrera et al., 2010; Benjamin et al., 2016; Mastoraki et al., 2013; Nishio et al., 1999).

According to the protocol defined together with the clinical neurophysiology team, the MNIM consisted of 4 studies, and was applied using the same method in all patients of our series:

a) Multimodal Motor evoked potential (MEP): to evaluate the motor pathways from the cortex to the muscles.
b) Somatosensory evoked potential (SSEP): to evaluate the posterior column of the spine with peripheral stimulation and cortical recordings.
c) Electromyography (EMG) without stimuli: also called “free-running EMG”, continuously evaluates neurological function and helps to monitor any changes provoked by traction, stretching or mechanical displacement.
d) EMG with stimuli: assesses the Motor Action Potentials (MAP), and so assists mapping neural structures such as nerve roots, cranial and peripheral nerves through direct stimulation.

4. Methods and clinical material

This is a retrospective study on a series of 6 patients with LSPT submitted to intraoperative neurophysiologic monitoring, among a group of 17 patients with this tumors operated by the senior author at the Division of Neurosurgery of Gaffrée e Guinle University Hospital, Federal University of Rio de Janeiro State, between January of 2005 and April 2017. After approval of the local ethics committee, this patient’s charts were revised and all relevant data were collected.

All patients were referred to our service with an established diagnosis of LSPT and they had already undergone complementary investigation, with MRI and electroneuromyography (ENMG) exams. All of the tumors had round edges and were well circumscribed, and none showed adjacent structures invasion. The Table 1 resumes other MRI findings for each case. In Fig. 1 a coronal and sagittal view of T1 contrast enhanced MRI of one our patients with a bulky schwannoma between the uterus and the sacrum is shown.

Most patients were female (66%), with ages ranging from 32 to 49. All patients underwent complete clinical and neurological examination. They were graded with regards to motor function and pain, according to the scale of the British Medical Research Council (MRC scale) and Visual Analogic Scale (VAS), respectively. Only one patient in our series presented with motor deficit. She had marked paresis in the right lower limb (MRC grade M2 for thigh flexion and leg extension). Thereafter, of the 6 patients in the series, 5 (83%) had no sensorimotor deficits at the time of their surgeries. All patients had severe pain, with VAS ranging from 6 to 9. Individual case demographic and baseline clinical presentation are described on Table 2.

After our evaluation, complementary imaging studies were ordered, specifically for vascular evaluation of cases (Celli, 2002; Dafford et al., 2007; Moro et al., 2003). They corresponded to sacral plexus tumors with important relation to the internal and external iliac arteries, veins, and their branches.

All cases were discussed with the general surgery team and the possible surgical approaches for each case were evaluated and discussed.

Table 1
Individual Case MRI Findings.

Case	Localization	Laterality	Max. Diameter (cm)	Contrast Enhancement
1	Lumbosacral trunk	Right	4	Homogenous
2	Lumbosacral trunk	Right	4,5	Homogenous
3	L3–L4	Left	7	Heterogenous
4	L2-L3-L4	Left	4,5	Homogenous
5	Lumbosacral trunk and S1	Right	5,5	Heterogenous
6	S2–S3	Right	5	Heterogenous