In situ photocoagulation of spinal dural arteriovenous malformations using the Nd:YAG laser

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Spinal dural arteriovenous malformations (AVM's) are the most common type of AVM involving the spinal cord in adults. These lesions usually present with progressive myelopathy, although subarachnoid hemorrhage (SAH) can occur. Treatment strategies have evolved during the last decade, largely as a result of an improved understanding of the lesion angioarchitecture. Typically, these arteriovenous fistulae are fed by radical dural arteries and are found in the dura adjacent to the dorsal nerve root (intervertebral foramen). The lesions drain intrathecally through one or more efferent vessels that penetrate the dura adjacent to the dorsal nerve root and through the coronal venous plexus along the posterior surface of the spinal cord.

Previously, the dilated coronal venous plexus was believed to be the entire AVM, rather than merely the veins draining the malformation, and treatment consisted of microsurgical stripping of these veins through multilevel laminectomies. It is now clear that the preferred treatment of these lesions is direct obliteration of the dural nidus alone or coupled with disconnection from the coronal venous plexus.

The Nd:YAG (neodymium:yttrium-aluminum-garnet) laser, because of its physical characteristics and interaction with biological tissues, was selected as a tool to produce in situ obliteration of spinal dural arteriovenous fistulae in five patients. This type of laser, well known for its ability to produce vessel coagulation, penetrates tissue and scatters, causing thermal effects and vessel coagulation beneath the tissue surface being irradiated. This combination of properties would seem ideally suited for in situ obliteration of spinal dural AVM's. We report our experience using the Nd:YAG laser for the open surgical treatment of spinal dural AVM's in five patients.

Clinical Material and Methods

Case Material

The clinical features, lesion angioarchitecture, and response to surgery of the five patients treated are shown in Table 1. All patients were middle-aged men (range 43 to 65 years). Three of the five patients presented with varying degrees of myelopathy, while two patients (Cases 4 and 5) presented with SAH. Magnetic resonance imaging and/or myelography was performed to suggest the diagnosis, and the lesion angioarchitecture was determined via angiography in all patients. Dural nidus locations ranged from the foramen magnum to the L-3 level. Two of the five patients (Cases 2 and 5) underwent unsuccessful attempts at endovascular embolic therapy before Nd:YAG laser surgery was performed.
Pre- and postoperative neurological function was graded using a simple five-point scale: 1 = normal neurological examination; 2 = abnormal neurological examination but still independently active; 3 = abnormal neurological examination but able to ambulate with a cane; 4 = abnormal neurological examination but able to ambulate with crutches; and 5 = wheelchair-bound or bedridden.

Operative Approach

Surgical exposure of the spine was obtained via laminectomy and/or suboccipital craniectomy. After the dura was opened and tacked, magnification was used to open the arachnoid and expose the one or more intrathecal efferent vessels that penetrated the dura adjacent to the dorsal nerve root and that drained the lesion nidus. These efferent vessels were cauterized and sectioned, thus disconnecting the nidus from the coronal venous plexus. After the eyes of the patient and the surgical team were appropriately protected, the Nd:YAG laser was employed to produce photoacoagulation of the dural nidus and the surrounding dura. Laser energy can be delivered by fiberoptic cables through a variety of differently shaped handpieces. A short, angled probe,* originally designed for use in the oral cavity, was found to be the most suitable for working in the lateral spinal canal. Sapphire-tipped fibers that allow for direct contact between the laser tip and the dura were not found to be effective; therefore, bare fiber handpieces (noncontact) were used in all cases. Laser energy was delivered in the continuous mode with power levels ranging from 8 to 15 W. The laser handpiece was moved back and forth over the dura to "erase" the lesion by coagulation. The laser was defocused (spot size varied) by varying the distance between the dura and the end of the handpiece to produce the desired effect. The handpiece was also positioned in the orifice of the dural root sleeve, allowing for coagulation of the dura in the intervertebral foramen. Care was taken not to coagulate the dorsal spinal root. In situ photoacoagulation of the nidus and the surrounding dura proved to be a simple technical exercise and usually required less than 10 minutes to perform. Following laser photoacoagulation, it was not necessary to resect the dura containing the nidus. Autologous fascia lata grafts were used to repair the dura in each case, this being the preference of the senior author (D.C.); however, sufficient dura remained in each instance to provide a watertight closure by primary repair. Complete obliteration of the spinal dural AVM was confirmed by delayed angiography in each case.

Results

All five dural AVM’s were easily and rapidly obliterated using the Nd:YAG laser, and all patients improved following the procedure (Table 1). Angiography was performed from 1 week (Case 4) to 2 months postcoagulation and confirmed complete and durable obliteration of the lesion in all cases. Figure 1 shows pre- and postoperative angiograms in a patient (Case 2) with a T-9 fistula treated with the Nd:YAG laser. There were no permanent complications related to the surgical exposure or the use of the Nd:YAG laser. One patient (Case 4), however, had a brief transient peripheral facial palsy immediately following surgery. This was believed to be due to injury or occlusion of the stylomastoid branch of the occipital artery during surgical exposure. Another patient (Case 3) developed transient numbness in a T-4 dermatome following surgery. This was thought to be secondary to thermal injury of the T-4 dorsal root caused by the Nd:YAG laser. Table 1 summarizes the pre- and postoperative neurological function grades (determined at long-term follow-up examination) in all patients.

Discussion

The preferred treatment of spinal dural AVM’s is direct obliteration of the dural nidus alone or coupled with disconnection from the coronal venous plexus. 2,4,17 Formerly, surgical stripping of the dilated coronal venous plexus from the posterior cord was recommended. This approach is no longer used because it

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* Nd:YAG laser, Model CL60, and probe, Model SSR18, manufactured by Surgical Laser Technologies, Malvern, Pennsylvania.
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removes only the venous drainage, leaving the fistula nidus intact, and is associated with disabling postoperative posterior column deficits.

More recently, therapeutic endovascular embolization has been advocated as the treatment of choice for these lesions.\(^3\)\(^\text{10,11}\) This approach is attractive because it avoids the discomfort and risks associated with open surgical exposure. In some situations, however, it may not be safe or technically feasible to approach these lesions endovascularly. The long-term durability of apparently successful endovascular treatment has also been questioned. Hall, et al.,\(^10\) studied three patients with apparently successful endovascular treatment as judged by complete lesion obliteration on immediate posttreatment angiography. In two of the three patients symptoms recurred after a period of 2 to 8 months and repeat angiography showed reconstitution of the lesions. Presumably, tiny angiographically occult vascular channels may escape embolic occlusion and later enlarge, or occluded channels may recannulate. Hall, et al., concluded that embolization offers only temporary treatment for many spinal AVM's and that surgical excision provides the only therapeutic means to permanently eliminate flow through the AVM in most patients.

In 1984, Symon, et al.,\(^17\) reported the surgical results in 55 cases of spinal dural AVM's. Neurological improvement or stabilization occurred in 85% of the patients. In 50 of the 55 cases, however, surgery consisted only of clipping the communicating vessel between the dural nidus and the coronal venous plexus. This approach, although far superior to others being used at the time, failed to eliminate the dural fistula.

Currently, most authors advocate disconnection of the nidus from the coronal plexus coupled with excision of the dural nidus.\(^4\)\(^5\)\(^6\)\(^\text{10,14,16}\) We report our experience with in situ photoocoagulation of the dural nidus using the Nd:YAG laser as an alternative to direct excision of the dural nidus. Photocoagulation is a safe, effective, and durable alternative to extensive dural resection. It can be performed in less time than dural excision and avoids the difficulties and complications associated with dural resections in the lateral spinal canal.

References


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