Nonhemorrhagic Cord Contusion After Percutaneous Fiducial Placement: Case Report and Surgical Recommendations

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Abstract

Study Design: Single case report and extensive literature review.

Objectives: To present the first such report of cervical cord contusion after the percutaneous placement of gold-seed fiducials. The pathomechanics and surgical recommendations are reviewed.

Background: Spinal cord injuries are well documented in the medical literature. These injuries range from cord contusion to transection and result primarily from trauma. A single case report of a patient who was found to have a nonhemorrhagic cervical spinal cord contusion after percutaneous fiducial implantation is presented.

Methods: Single case report.

Results: The patient underwent percutaneous placement of fiducials for stereotactic radiosurgery for a nerve sheath tumor. Postoperatively she had primarily sensory complaints; no motor deficits were detected on neurological examination. Neuroimaging studies demonstrated nonhemorrhagic cervical cord contusion. She was treated conservatively and had complete resolution of her symptoms.

Conclusions: The likely mechanism for the contusion was neck hyperextension during thrusting maneuvers during fiducial implantation. This is yet another report of normal intraoperative-evoked potentials with postoperative neurological sequelae. A dedicated team approach involving ancillary staff, anesthesiologists, and surgeons should be utilized to avert this potentially devastating complication.

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Key Words: Spinal cord injuries; Contusion; Fiducials; Radiosurgery; Cyberknife; Nerve sheath tumor; Spondylosis

INTRODUCTION

Injury to the spinal cord frequently results from minor or major trauma; however, iatrogenic cases are increasingly being reported in the literature (1,2,6,7). Cervical spondylosis is often associated with these injuries (1–3). Spinal cord contusion can potentially have disquieting outcomes, depending upon size and location. Even more devastating for the patients and surgeons alike are cases that result in long-term neurological symptoms. We

report on the first case of cord contusion after the percutaneous implantation of fiducials for stereotactic radiosurgery. The proposed biomechanics, imaging modalities, and therapeutic options available for these patients are discussed.

CASE REPORT

History and Physical Examination

A previously healthy 48-year-old woman was seen in neurosurgical consultation for intermittent left arm pain and dysesthesia of her left fourth and fifth digits. Her symptoms had been present for several weeks. Her medical and surgical history was noncontributory. There was no family history of neurocutaneous disorders. No

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upper or lower extremity motor weakness was appreciated on examination, and she had normal reflexes. There was a slight diminution of sensory perception of light touch and pinprick in the left C8 dermatome. No suspicious cutaneous lesions were found on gross inspection and palpation.

Laboratory and Imaging

Routine serum chemistries and cell counts were normal. Incidentally noted on sagittal magnetic resonance imaging (MRI) were multilevel spondylotic changes at the C5-C6 and C6-C7 levels (Figure 1A). High-resolution postcontrast imaging revealed a dumbbell-shaped heterogeneously enhancing 1.9-cm x 1.2-cm mass in the left neural foramen at C7-T1 level (Figure 1B and C). A putative diagnosis of a C8 nerve sheath tumor was made. No other lesions were seen on screening neuraxis imaging.

Therapeutic Interventions

The patient, a graphic artist, was offered surgical resection of the aforementioned lesion; however, she opted for radiosurgical treatment. She was scheduled to undergo fractionated stereotactic radiosurgery totaling 21 Gy in 5 fractions using the CyberKnife system (Accuray Inc, Sunnyvale, CA). In accordance with the system's planning protocol, she was taken to the operating theater for percutaneous placement of gold fiducials (Alpha-Omega Services, Inc, Bellflower, CA) in a noncoplanar fashion. Under general anesthesia and after being placed in the prone position, 9 fiducials were implanted in the lamina or facets via separate stab sites using anterior/posterior and lateral fluoroscopic guidance. There were no reported significant bursts of electromyogram activity during the case. No neurotonic discharges were sustained for longer than 5 seconds.

In the immediate postoperative period, the patient complained of right groin pain and a buzzing sensation in her right lower extremity, particularly the heel. She also complained of a sensation of a vise-like apparatus squeezing her right calf. On examination, no weakness was appreciated with hip flexion, knee extension, or plantar and dorsiflexion of bilateral lower extremities. Straight-leg raising was negative bilaterally. No abnormalities were detected with handgrip, elbow flexion and extension, and shoulder abduction. Joint position sensation was normal in the lower extremities. Vibratory

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Figure 1. (A) Sagittal T2-weighted preoperative image without any visible lesions in the cord substance. (B) Sagittal T1-weighted postgadolinium image demonstrates the foraminal expansion by the neural sheath lesion (arrow). There is marked enhancement of the lesion. (C) Axial T2-weighted image shows the isointense-to heterogenous-appearing lesion. Again, the lesion enhances vividly after contrast administration.

sensation was slightly diminished in the right lower extremity. The patient was normoreflexic; Hoffman and Babinski signs were not elicited. Rectal examination and venous Doppler of the lower extremities were unremarkable.

On the postoperative MRI, she was noted to have a 2-mm x 3-mm focus of hyperintensity in the cord substance at the level of the C6-C7 disk space (Figure 2A and B). There was no appreciable expansion of the cord, and there was no loss of signal on diffusion-weighted imaging to suggest hemorrhage. Repeat computerized tomography imaging did not reveal any violation of the spinal canal (Figure 2C).

The patient was placed on a treatment of dexamethasone 4 mg orally every 6 hours that was tapered over 1 week. At the 5-month follow-up examination (Figure 3), she had minimal numbness along the dorsolateral aspect of the right lower extremity and had not experienced any further neurologic decline.

DISCUSSION

Consequential complications resulting from percutaneous spinal procedures can result in disabling and untoward long-term sequelae. These injuries range from intra- and extramedullary hematoma to such insults as contusion (1). Spinal cord contusion is frequently reported in the literature as a result of trauma; however, iatrogenic cases are not commonly cited (1,6,7). These injuries are usually discovered in the immediate postoperative period; however, they may go unnoticed for a protracted period.

Patients, as in this case, present with new neurologic complaints. Depending on the location and size of the lesion, there may be subtle or overt findings. A thorough neurologic examination is warranted in these cases. Sensory abnormalities can have equally disabling consequences as motor findings (1,3). Pathological analyses of the ultrastructural spinal cord changes after contusion have been outlined in animal models and aid in providing insight into outcomes related to human cases (3).

The indications and operative techniques for fiducial placement for frameless image-guided radiosurgery have been eloquently described elsewhere (4,5). We routinely

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Figure 2. (A) Sagittal T2-weighted image demonstrates the focus of hyperintensity at the level of the C6-C7 disk interspace. Note also the disk bulge/degeneration at the C5-C6 and C6-C7 levels. (B) Axial T2-weighted image demarcates the hyperintense focus of the contusion. There is not any significant expansion of the spinal cord substance. (C) Axial computerized tomography image at the level of the C6-C7 levels demonstrates the implanted fiducial at the spinolaminar junction on the left. The fiducial is contained and does not breach the anterior cortex.

Figure 3. Sagittal T2-weighted scan shows marked diminution in the size of the nonhemorrhagic contusion (arrowhead). Note the C5-C6 disk abuts, but does not efface, the thecal sac.

use both anterior/posterior and lateral real-time fluoroscopy for these cases. Briefly, in a step-by-step fashion, we advance a Jamshidi needle toward the target spinal elements under both anterior/posterior and lateral fluoroscopic guidance. Once the target has been reached, the stylet is removed and the fiducials are deployed within the bony elements. Obese patients and those with broad shoulders add a diagnostic challenge when visualizing skeletal landmarks intraoperatively. Of paramount importance in these cases is intraoperative monitoring consisting of both electromyogram and motor-evoked and/or somatosensory-evoked potentials (6). In patients with disconcerting spondylosis or frank spinal cord compromise, we obtain baseline-evoked potentials prior to placing patients in the final operative position. Lesser and colleagues (7) reported their experience with postoperative deficits in the presence of normal somatosensory-evoked potentials.

To help minimize hyperextension of the cervical spine, we now secure the cranium with Mayfield pins. This minimizes excessive forceful extension of the neck during the insertion of the needle in the posterior structures of the vertebrae. We postulate that this patient's cord contusion resulted from the anteriorly directed thrusting maneuvers during fiducial implantation that resulted in hyperextension of the cervical spine. In patients, especially the nonosteoporotic or those whose spines are not destroyed by malignancy, a considerable amount of force can at times be required to drive the Jamshidi needle into the posterior elements. A mallet may be required to achieve the desired insertion depth of the needle to allow for optimal purchase of the fiducials. Moreover, this action may result in quick bursts of neck hyperextension during the procedure. The anterior to posterior diameter of the spinal canal in hyperextension was further compromised by the coexistent stenosis. Inoue and colleagues (8), in their computerized tomography myelographic analysis of normal subjects, determined that the diameter of the cervical cord increases as one progresses caudally. The greatest diameter was found to be at C4-C5. The surgeon should be cognizant of patients with existing cervical spondylosis and minimize neck hyperextension.

Certainly the anesthesiologist should be made aware of patients with concomitant cervical spondylosis, particularly the elderly. Safer methods of securing an airway in these patients are available and should be utilized. These include fiberoptic transnasal or oral intubation; more important, jaw thrust maneuvers should be kept to a bare minimum (11). Other ancillary staff should be cautioned to avoid rapid lateral bending or flexion/extension of the cervical spine when these patients are transferred to and from the operating room table.

It is imperative that imaging modalities be readily available and employed to expeditiously evaluate potential surgical lesions postoperatively. Although nonspecific, computerized tomography scans aid in identifying compressive spinal cord lesions. The ability to visualize the cord substance is certainly inferior to MRI (9,10). MRI, although more expensive than computerized tomography, offers several advantages, including delineating cord contusion from expansile masses, such as hematomas. To the trained eye, intraparenchymal lesions can be readily differentiated from extradural lesions (10,12). Contusions are typically hyperattenuated on T2-weighted images, as was with this patient. Moreover, there is usually no loss of signal on diffusion-weighted sequences (8–10).

Spinal cord contusions can be effectively managed expectantly. A short course of steroids tapered over a few days can be employed and aids in minimizing the inflammatory response to the contusion (1,13). These patients should be reassured that symptomatic spinal cord contusion cases usually abate over time; moreover, surgical intervention is not indicated. Patients with

persistent motor deficits might benefit from a physiatrist-directed rehabilitation program (1,9,12). Novel techniques have been reported using altered neurons transfected into contused spinal cords in animal studies; however, human trials are in their infancy (14). Long-term follow-up consisting of serial neurological examinations and imaging studies done over several weeks to 1 to 2 years, or longer in some cases, is often required to detect patients' improvement or treatment failure.

CONCLUSIONS

It is well documented that patients with coexisting cervical stenosis are prone to cord injury secondary to neck hyperextension either peri- or postoperatively. A team effort should be employed that begins with patient transfer and movement to final surgical positioning. Our anesthesiology colleagues should be forewarned and urged to minimize neck hyperextension during intubation. Intraoperative monitoring and fluoroscopy are added adjuncts in the surgeon's armamentarium; however, these modalities are not without limitations. Patients' body habitus can offer a challenge even to seasoned surgeons when attempting to visualize anatomical landmarks intraoperatively. We recommend that patients with documented cervical spondylosis be counseled about the remote possibility of this injury when they are evaluated preoperatively. As in this case, cord contusions can be managed conservatively and often have favorable outcomes.

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