Ependymomas are the most common spinal cord tumor in adults, but not in pediatric populations. Although these tumors may appear anywhere along the spinal axis, they are most commonly encountered in the lumbosacral region, followed by the cervical and thoracic region. Mobile cauda equina tumors are uncommon, a unique pathological finding reported almost exclusively as schwannomas. However, ependymoma was the first mobile spinal tumor described in the literature; a report in Military Medicine from 1958 by Captain William W. Ayres of the US Navy describes a cauda equina ependymoma mobilized by a Valsalva maneuver initiated by the patient himself. Surgical approaches to these entities are often complicated by discrepancies in tumor location between preoperative imaging and intraoperative findings. Migration of these tumors can lead to extended laminectomies and associated surgical morbidities. We report a unique case of cauda equina ependymoma in a pediatric patient that migrated rostrally from its primary site upon durotomy, but could be moved back into full operative view with a Valsalva maneuver. To our knowledge, this is the first case of a spinal ependymoma mobilized intraoperatively with the intentional use of a Valsalva maneuver under anesthesia.

Case Report

History and Presentation. This previously healthy 11-year-old boy presented in February 2006 with an unusual 4-month history of severe and recurrent bitemporal headache associated with nausea and vomiting, intermittent back pain and stiffness, and toe walking during bouts of pain. His examination was unremarkable except for relatively diminished right ankle jerk response (hyporeflexic) and some decreased range of motion around the lumbar spine.

Magnetic resonance imaging showed 2 nonenhancing intraspinal lesions, 1 very small round mass dorsal to the conus measuring a few millimeters in diameter, and a larger elliptical intraspinal mass slightly off-center on the right side at S1–2 measuring 1 cm in diameter (Fig. 1). No intracranial lesions were noted on preoperative MR imaging to suggest drop metastases. The lesions were believed to be either myxopapillary ependymomas or atypical schwannomas on imaging, and resection was deemed optimal.

Operative Course. The patient underwent resection of the tumors under general anesthesia in the prone po-
sition. Following S1–2 laminectomies, transdural ultrasoundography was used to identify the lesion and a midline durotomy was performed. We initially observed the thecal sac, lower filum terminale, and sacral roots, but no tumor. The anesthesiologist was asked to initiate a Valsalva maneuver in the patient and a whitish yellow elliptical tumor entered the field as it moved caudally (Video 1).

**Video 1.** Clip obtained through the operating microscope showing an exposure through a sacral laminectomy of the resection of an intradural ependymoma. Upon opening the dura, the tumor was not observed. The anesthesiologist was asked to induce a Valsalva maneuver, and the tumor then moved into the operative field and was resected. Click here to view with Windows Media Player.

The tumor had no obvious attachment to the filum terminale. It was grasped and removed as a single specimen (Fig. 2). An L-1 laminectomy and midline durotomy were performed to resect the smaller and more cephalad tumor. A fleshy intradural mass was observed on the dorsal aspect of the conus as it blended into the filum terminale. The mass had the same consistency as the lower intradural mass. A radical resection was performed in a piecemeal fashion using microscissors and disectors.

**Pathological Characteristics.** The larger tumor at S1–2 was noted to have extensive coagulative necrosis and rare mitotic figures. The smaller tumor at L-1 was observed to have focal clear cell and tanycytic differentiation. Both tumors were confirmed to be ependymomas without myxopapillary features.

**Postoperative Course.** Postoperative MR imaging confirmed total resection of the tumors, as well as continued absence of any intracranial lesions to suggest drop metastases (Fig. 3). The patient awoke neurologically intact, and follow-up at 2 months revealed a normal examination with full motor strength and normal gait. He was treated with 54 Gy of focal radiation to the lumbosacral spine and remains neurologically intact without radiographic evidence of tumor recurrence 3 years postoperatively.

**Discussion**

Two aspects of this case are unique to the literature. First, the majority of mobile tumors of the spinal cord are schwannomas; the last reports of mobile ependymomas of the spinal cord reported in the literature are at least 50 years old. Second, intraoperative evaluation and visualization of the tumor’s mobility by use of a Valsalva maneuver under anesthesia has not previously been described for mobile ependymomas. Our literature search

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**Fig. 1.** Preoperative sagittal T2-weighted MR image of the lumbar and sacral spine without contrast enhancement, demonstrating a non-enhancing mass measuring 1 cm at S1–2 (lower arrow) and a smaller nodular mass just distal to the conus (upper arrow).

**Fig. 2.** Intraoperative photographs showing exposure through a midline sacral durotomy. **A:** Nerve roots of the cauda equina are displaced laterally, but the large intradural neoplasm identified on preoperative imaging is not observed. **B:** After a Valsalva maneuver, the white intradural neoplasm, which had migrated rostrally, enters the operative field.
produced a report by Captain William W. Ayres of the US Navy, published in *Military Medicine* in 1958, which we believe is the first to describe a mobile ependymoma. Although the report discusses 18 cases in total, 2 are particularly interesting. Ayres describes 2 neoplasms hidden beneath the nerves of the cauda equina and not immediately visible upon opening the dura. Moreover, he cites 1 “dramatic” case in which the patient strained as a result of pain while under anesthesia and literally “coughed the tumor out” from among the roots of the cauda equina. In another case, he states that the surgeon found the lesion could be easily “popped” from among the roots of the cauda equina. The report suggests no mechanism or pathology to explain the mobility of the tumor.

Wortzman and Botterell last reported a mobile ependymoma in 1963. The mobility of the ependymoma was attributed to the unusual laxity of the filum terminale, and was visualized on myelogram with tilting of the fluoroscopy table. The most recent case of a mobile spinal tumor reported in the literature was a mobile schwannoma by Marin-Sanabria and colleagues in 2007, in which a discrepancy in the tumor’s position was observed between preoperative MR imaging and surgery, resulting in closure of the initial incision and reimaging. The authors of that report note, interestingly, that the patient in their second case had strained significantly at micturition, leading them to suspect the Valsalva maneuver as a cause of the tumor’s migration. Other mechanisms have been proposed in the literature for the mobility of extramedullary tumors, including laxity of the nerve root, postural changes, and thrust of injected radiopaque material during myelography. Regardless, it is often difficult to explain the mechanism behind the discrepancy between preoperative and intraoperative findings in these unique cases.

In our case, intraoperative ultrasonography was used to initially locate the caudal (larger) tumor. However, upon opening the dura at S1–2, we were surprised at the absence of any tumor at that level. It was only when the Valsalva maneuver was initiated by our anesthesiologist that the tumor came into the operative field, moving freely caudally before receding and hiding under the intact lamina rostrally. We believe that the tumor’s unusual mobility resulted from both an acute change in CSF pressure following durotomy and lack of attachment to the filum. Although Pau and colleagues described similar operative visualization of a schwannoma without a Valsalva maneuver in 1982, this is the first report we have noted in the literature since Ayres’ original work of an ependymoma mobilized with Valsalva maneuver and resultant changes in CSF pressure. Visualization by this technique allowed for complete resection of the tumor as a single specimen. Friedman et al. in 2000 demonstrated the use of intraoperative ultrasonography to further localize a migrating schwannoma after the initial durotomy, a case that required extension of the laminectomy. While it was not necessary in this case, it would be prudent to use further imaging should a mobile tumor not be localized either by preoperative imaging or intraoperative changes in CSF pressure using a Valsalva maneuver.

While uncommon, mobile intramedullary neoplasms must be approached with discretion. It has been documented in the literature that unexpected discrepancies in the position of a mobile intramedullary neoplasm can occur between perioperative imaging and intraoperative views. Intraoperative mobility of a tumor can be demonstrated not only by changes in patient position, but also by fluctuations in CSF pressure, as in our case. Therefore, using methods such as a Valsalva maneuver under anesthesia to locate a tumor should be recognized. The possibility of unexpected tumor movement underscores the need for accurate localization to prevent excessive multilevel laminectomy and surgical morbidity.
Disclaimer

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