Conus medullaris nerve root avulsions

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The association of avulsive lesions and pain has been well established in avulsions of the brachial plexus from the cervical spinal cord, but avulsive lesions of the conus medullaris have not previously been recognized or documented by direct observation. Six patients with intractable lower-extremity pain due to avulsion of nerve roots from the conus medullaris were treated by thoracolumbar laminectomy and dorsal root entry zone (DREZ) lesions. Patients with avulsion of lumbosacral roots from the conus medullaris have a characteristic clinical presentation. They are usually young men who, as a result of a motorcycle accident, have suffered multiple pelvic or long-bone fractures or traumatic amputation of part of the lower extremity. Early in their course there is pain not directly attributable to the injured part. The pain is described as intense and burning, with episodic radiation and electric shock-like sensations in the injured or phantom limb. If the leg is intact, there is usually a dermatomal pattern to the distribution of the pain and neurological deficit. A myelogram often reveals a traumatic pseudomeningocele similar to those seen in the cervical region after avulsion of the brachial plexus. Surgical exploration of the conus medullaris usually reveals the extent of nerve root avulsion, and an appropriate DREZ operation can be performed.

KEY WORDS • dorsal root entry zone • conus medullaris • nerve root avulsion • pseudomeningocele

AVULSION of the brachial plexus following trauma is a common and well-recognized clinical syndrome. However, avulsion of the lumbosacral roots from the conus medullaris has not previously been recognized. We report the cases of six patients with spinal and pelvic trauma who developed intractable lower-extremity pain due to avulsion of the nerve roots from the conus medullaris (Fig. 1). We describe their clinical history, neurological evaluation, and management. Five of the six patients were successfully treated with dorsal root entry zone (DREZ) lesions. All six patients presented with intractable burning and shooting pains in a lower extremity. One patient had a gunshot wound of the abdomen with direct injury of the lumbar spine, and the other five patients had sustained severe pelvic trauma in motor-vehicle accidents (four were riding motorcycles and the fifth was riding a snowmobile).

Case Reports

Case 1

This 32-year-old man was in good health until he sustained a traumatic hemipelvectomy in a motorcycle accident 5 years before his present admission to Duke Hospital. During his recovery he became aware of a painful phantom limb and required large doses of narcotic analgesics for pain control. Examination revealed no right lower extremity and multiple surgical scars over the right lower abdomen and pelvis. Neurological examination showed decreased sensation in all modalities over a portion of the right side of the pelvis and the amputation stump. Two trigger points on the abdominal wall elicited pain in the phantom limb.

A thoracolumbar laminectomy was performed. Dissection of the conus medullaris disclosed avulsion of the right dorsal roots from L-1 to S-2 (Table 1). Eleven unilateral DREZ lesions were placed between L-2 and S-3. The patient had an uneventful postoperative recovery with marked improvement of his phantom limb pain, but returned 4 years later because the pain had gradually increased. He underwent reoperation, at which 15 DREZ lesions were placed, beginning more cephalad and overlapping the same section of the conus medullaris from L-1 to L-4. He remains pain-free 1 year after the second operation.

Case 2

This 19-year-old man was using illicit drugs but was otherwise in good health until 1 year before his present
hospitalization. At that time, he had a motorcycle accident and sustained a fracture-dislocation of the pelvis, bilateral ankle fractures, and a right compound-comminuted tibial-fibular fracture which became infected and necessitated a below-the-knee amputation. From the time of the accident he suffered pain in the right foot which he characterized as crushing and tingling sensations; the pain extended into the right thigh and was unchanged by the amputation. Before his present admission, a tibial neurolysis and lumbar sympathectomy were used to treat the pain without success. On admission he was taking large doses of narcotics for pain relief.

Physical examination showed decreased rectal tone, absence of the right foot and lower leg, and a decubitus ulcer over the sacrum. Neurological examination revealed decreased pinprick sensation to the inguinal ligament on the right and on the plantar surface of the left foot. Deep reflexes were absent at the knees bilaterally and at the left ankle. A thoracolumbar myelogram showed pseudomeningoceles of L-5 and S-1 on the right (Fig. 2). A thoracolumbar laminectomy was performed, and examination of the conus revealed that five roots were avulsed from L-3 to S-2. A series of 45 DREZ lesions were placed on the side of the avulsed dorsal roots (Table 1). The patient had an uneventful postoperative recovery with complete resolution of his pain syndrome. He left the hospital on a course of non-narcotic analgesics and remains pain-free 3 years following his operation.
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TABLE 1
Summary of clinical findings and operative treatment in six cases of spinal nerve root avulsion

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Cause of Trauma</th>
<th>Injury</th>
<th>Level of Avulsion</th>
<th>Neurological Findings</th>
<th>Myelographic Defect</th>
<th>Pain Distribution</th>
<th>Radiofrequency DREZ Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32, M</td>
<td>motorcycle accident</td>
<td>traumatic hemipel-vectomy</td>
<td>L1-S2 on rt</td>
<td>sensory: T12-L1</td>
<td>study not done</td>
<td>phantom lt knee, foot, posterior calf</td>
<td>1st op: 11 lesions L2-S3, 2nd op: 15 lesions L1-4</td>
</tr>
<tr>
<td>2</td>
<td>19, M</td>
<td>motorcycle accident</td>
<td>pelvic fracture-dislocation, compound-comminuted fracture of tibia &amp; fibula</td>
<td>L3-S2 on rt</td>
<td>sensory: L-1; motor: L-2</td>
<td>pseudomeningoceles of L-5 &amp; S-1 on rt</td>
<td>rt foot &amp; lateral aspect of leg</td>
<td>45 lesions L3-S2</td>
</tr>
<tr>
<td>3</td>
<td>39, M</td>
<td>gunshot wound</td>
<td>high-velocity bullet through L-3</td>
<td>L2-S3 bilat</td>
<td>sensory: T-12 with sacral sparing</td>
<td>study not done</td>
<td>rt foot &amp; leg to knee, lt foot</td>
<td>1st op: 97 lesions L2-S2 on rt; 2nd op: 124 lesions L1-S2 on lt</td>
</tr>
<tr>
<td>4</td>
<td>28, M</td>
<td>motorcycle accident</td>
<td>pelvic fracture, L-1 &amp; L-4 vertebral body fractures</td>
<td>L2-5 on rt</td>
<td>sensory: L-2 (rt), L-4 (lt); motor: L-1 (rt), L-4 (lt)</td>
<td>block at L-1</td>
<td>rt knee</td>
<td>38 lesions L1-5</td>
</tr>
<tr>
<td>5</td>
<td>55, M</td>
<td>snowmobile accident</td>
<td>pelvic &amp; rib fractures, ruptured spleen &amp; bladder, urethral tear</td>
<td>L4-S4 on rt</td>
<td>sensory: L-4 (rt)</td>
<td>pseudomeningoceles of L-5 &amp; S-1 on rt</td>
<td>rt leg below knee</td>
<td>17 lesions L3-S2</td>
</tr>
<tr>
<td>6</td>
<td>30, M</td>
<td>motorcycle accident</td>
<td>traumatic hemipel-vectomy</td>
<td>L2-S1 on lt</td>
<td>sensory: T-12</td>
<td>pseudomeningoceles of S-1 on lt</td>
<td>phantom lt leg &amp; foot</td>
<td>38 lesions L2-S3</td>
</tr>
</tbody>
</table>

* DREZ = dorsal root entry zone.

**Case 3**
This 39-year-old man suffered from hypertension and obesity. Four years before his present admission he sustained a large-caliber high-velocity gunshot wound. The bullet traversed his abdomen and penetrated the L-3 vertebral body. He was rendered immediately paraplegic with the simultaneous onset of burning pain in both legs. He gradually regained bowel and bladder continence. After receiving the gunshot wound he underwent a decompressive laminectomy and eight abdominal operations. He described the pain as a cramping sensation in both feet, worse on the right. He was dependent on large doses of parenteral narcotics.

Physical examination was notable for obesity, bibasilar rales and rhonchi, and mildly decreased rectal tone. Neurological examination revealed flaccid paraplegia except for 1/5 to 2/5 strength in the psosas and adductor muscles. Sensory examination showed loss of all modalities to the T-12 vertebral level except for some preserved pinprick sensation on the perineum. A thoracolumbar reexploration and laminectomy was carried out. Microsurgical dissection of the conus revealed root avulsions from L-2 to S-3 on the right, and 97 DREZ lesions were placed only on the right. He had good relief of his right-sided pain and a reduced narcotic intake postoperatively. However, he began to complain of increasing left-sided pain and returned 1 month later to have 124 DREZ lesions placed on the left. After his second operation the patient underwent detoxification for his narcotics dependence and has remained pain-free for 3 years since his second operation (Table 2).

**Case 4**
This 28-year-old man had been in good health until 5½ years before his present admission. He was involved in a motorcycle accident and sustained a pelvic fracture as well as compression fractures of L-1 and L-4. After the accident he had a flaccid paraplegia and noted a burning pain in his right knee. He had had several nerve blocks and a dorsal column stimulator placed without any pain relief. He was dependent on narcotics.

Physical examination was normal except for his neurological findings. Neurological examination revealed a flaccid right lower extremity. His left thigh had good strength in the quadriceps and hamstrings. He had an L-2 sensory level on the right and an L-4 sensory level on the left to all modalities (Table 1). He had no deep tendon reflexes in either lower extremity. There was no response to plantar stimulation. A thoracolumbar myelogram revealed a complete block at the site of his L-1 compression fracture. The patient underwent a thoracolumbar laminectomy, and 38 DREZ lesions were placed in the right conus medullaris where he was noted to have root avulsions from L-2 to L-5. The patient’s postoperative course was uneventful and he has good pain relief without narcotic analgesics during 2½ years of follow-up monitoring.

**Case 5**
This 55-year-old man was in good health until 7 years before the present admission, when he sustained multiple injuries including pelvic fracture with associated bladder rupture and urethral injury in a snowmobile accident. Immediately after the accident he had...
FIG. 3. Case 6. Left: Lumbar myelogram, anteroposterior view, showing a large pseudomeningocele of S-1. Right: Computerized tomography scan of the pseudomeningocele shown (left). Note the absence of nerve roots in the meningocele sac.

bowel and bladder incontinence and paresis of his right leg. He also noted burning pain in the right buttock and right leg. Since then he has had several unsuccessful treatments for pain, including lumbar sympathectomy, sacroiliac fusion, dorsal column stimulation, and peripheral nerve blocks.

Physical examination was notable for a reducible right inguinal hernia (recurrent) and trophic changes in the skin of the right leg. Neurological examination revealed a right third nerve palsy, right foot drop, decreased sensation to pinprick in the L5-S2 dermatomes on the right, hyperpathia in the right L-4 dermatome, and absence of the patellar and Achilles tendon reflexes bilaterally. Rectal tone was decreased. A thoracolumbar myelogram showed pseudomeningoceles of L-5 and S-1 on the right (Table 1). A thoracolumbar laminectomy was performed, and dissection of the conus revealed avulsion of the roots from L-4 to S-4 on the right. Seventeen DREZ lesions were made in the conus on the side of the avulsed roots. The patient had an uncomplicated recovery and good pain relief after the DREZ operation. He has been pain-free for 1½ years.

Case 6

This 30-year-old man suffered a traumatic hemipelvectomy in a motorcycle accident 13 years before his present admission. He began to experience severe burning pain in the phantom left leg immediately after the accident. Reconstructive surgery of the left side of the pelvis and stump did not relieve the pain. Examination revealed loss of the left leg and identified trigger points that elicited burning pain in the phantom leg and foot. Thoracolumbar myelography and computerized tomography (CT) revealed a large traumatic myelocele involving the left S-1 nerve root (Table 1 and Fig. 3).

Surgical exploration of the conus medullaris revealed extensive arachnoidal scarring around the conus medullaris with avulsions of the five dorsal nerve roots (L2-S1) on the left side. Thirty-eight DREZ lesions were made in the left side of the conus medullaris from L-2 through S-3. Initially the patient had good relief of the pain in the left phantom limb, but he injured his back 4 months later and the pain in the phantom leg returned. He began to use narcotics for relief. Recently he has entered a drug rehabilitation program, but still experiences the original burning phantom limb pain.

Summary of Cases

Clinical Results

We believe that these patients represent a recognizable clinical entity. All were men; five of six sustained pelvic fractures in a motor-vehicle accident, usually as motorcycle riders hit by a car. All six suffered from a deafferentation pain syndrome of the lower extremity. This persistent pain problem has resulted in narcotic dependence. Three of the six patients had a traumatic lumbosacral pseudomeningocele (Table 1 and Figs. 2 and 3). A CT scan following metrizamide myelography revealed distortion of the thecal sac at the site of the pseudomeningocele and distortion and displacement of the conus medullaris (Fig. 3 right).

Surgical Technique

The following is a brief description of the surgical procedure used in this group of patients. A standard laminectomy was performed from T-11 to L-2. The conus medullaris was exposed and examined under the operating microscope, and the area of the avulsed roots identified. The avulsive injury may involve only one or two roots; however, in most cases several dorsal roots were avulsed. Multiple DREZ lesions were produced.
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### Table 2

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases</th>
<th>No. With Pain</th>
<th>Levels of Myelographic Deficit</th>
<th>Treatment</th>
<th>Follow-Up Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alker, et al., 1967</td>
<td>2</td>
<td>0</td>
<td>Case 1: L-5, Case 2: L-5-S2</td>
<td>Case 1: lumbar exploration, Case 2: none</td>
<td>no change in neurol exam</td>
</tr>
<tr>
<td>Assmann &amp; Steube, 1982</td>
<td>1</td>
<td>0</td>
<td>L-5 &amp; S-1</td>
<td>none</td>
<td>not available</td>
</tr>
<tr>
<td>Barberá, et al., 1977</td>
<td>1</td>
<td>1</td>
<td>multiple lumbar roots, no precise level reported</td>
<td>exploratory laminectomy</td>
<td>improved neurologically</td>
</tr>
<tr>
<td>Barnett &amp; Connolly, 1975</td>
<td>1</td>
<td>1</td>
<td>L-5 &amp; S-1</td>
<td>lumbar sympathectomy, dorsal column stimulation</td>
<td>pain reduced after dorsal column stimulation</td>
</tr>
<tr>
<td>Carlson &amp; Hoffman, 1971</td>
<td>1</td>
<td>0</td>
<td>L-5 &amp; S-1</td>
<td>none</td>
<td>not available</td>
</tr>
<tr>
<td>Eisenberg, et al., 1972</td>
<td>1</td>
<td>1</td>
<td>L-5 &amp; S-1</td>
<td>C1–2 percutaneous cordotomy</td>
<td>pain improved, hemiparesis after cordotomy</td>
</tr>
<tr>
<td>Finney &amp; Wulfmann, 1960</td>
<td>1</td>
<td>1</td>
<td>L-4</td>
<td>None</td>
<td>not available</td>
</tr>
<tr>
<td>Goodell, 1966</td>
<td>3</td>
<td>0</td>
<td>Case 1: none, Case 2: L-5-S1, Case 3: L-5-S1</td>
<td>exploratory laminectomy</td>
<td>no change in neurol exam</td>
</tr>
<tr>
<td>Harris, et al., 1973</td>
<td>4</td>
<td>2</td>
<td>Case 1: L-5, Case 2: L-3, Case 3: L-4 &amp; L-5, Case 4: L-2, L-3, &amp; L-5</td>
<td>none</td>
<td>2 cases with persistent pain 6 yrs after injury</td>
</tr>
<tr>
<td>McLennan, et al., 1973</td>
<td>1</td>
<td>0</td>
<td>L-4 &amp; L-5</td>
<td>none</td>
<td>gradual improvement</td>
</tr>
<tr>
<td>Moossy, et al., 1987</td>
<td>6</td>
<td>6</td>
<td>see Table 1</td>
<td>dorsal root entry zone lesions</td>
<td>see Clinical Results</td>
</tr>
<tr>
<td>Nosik, 1955</td>
<td>1</td>
<td>0</td>
<td>L-4</td>
<td>bed rest</td>
<td>headache improved</td>
</tr>
<tr>
<td>Padberg, 1977 and Padberg &amp; Coene, 1975</td>
<td>2</td>
<td>0</td>
<td>both at S-2</td>
<td>none</td>
<td>neurologically normal</td>
</tr>
<tr>
<td>Payne &amp; Thomson, 1969</td>
<td>1</td>
<td>1</td>
<td>L-5, S-1, &amp; S-2</td>
<td>C7–T1 open cordotomy</td>
<td>mild leg weakness, pain relieved immediately postop</td>
</tr>
<tr>
<td>Privat, et al., 1983</td>
<td>3</td>
<td>3</td>
<td>lumbar exploration</td>
<td>Lumbar exploration</td>
<td>some improvement but persistent pain in 2 of 3 cases</td>
</tr>
</tbody>
</table>

by a thermal electrode* which heated the tissue to 75°C for 15 seconds. We estimate that this produces a lesion approximately 2 mm in diameter which would destroy the first five superficial Rexed laminae of the DREZ. Although we prefer the thermal lesion, other neurosurgeons have used the laser to produce DREZ lesions. The number of lesions varies with the extent of the avulsive injury.

**Extent of Sacral Avulsion**

The exact extent of the sacral avulsion is at times difficult to determine by neurological examination or myelography. The same difficulties were experienced in evaluation of patients with brachial plexus avulsion. In the case of the sacral avulsion, a dermatomal pattern related to the pain may be helpful but is not always present. Identification of the avulsed dorsal roots was further complicated by the fact that in this group of patients two patients were paraplegic and three had sustained traumatic amputation of the lower extremity (in one patient complete hemipelvectomy had occurred). A lumbar myelogram was helpful in most of these patients. A traumatic pseudomeningocele involving the lower lumbar or sacral roots raises a suspicion that the patient is suffering from a traumatic dorsal nerve root avulsion. In Case 1, the patient’s complaint was pain in a phantom leg, the result of a traumatic hemipelvectomy. Myelography was not performed. At the time of surgical exploration of the lumbar-sacral cord, extensive dorsal nerve root avulsion was encountered on the side of the trauma from L-1 to S-5, and a unilateral DREZ operation was carried out on that side. In Case 2, there was a partial traumatic amputation of the right leg, but on myelography a traumatic pseudomeningocele was found involving the L-5 and S-1 nerve roots. The avulsions were confirmed later on surgical exploration; however, these two avulsed dorsal roots were initially not seen under the microscope until the intact roots above were carefully moved laterally. Thus, it is possible to miss one or two avulsed roots at the time of surgery if careful inspection of the conus is not carried out. Another complicating factor is the degree of arachnoiditis that may often be associated with these injuries and often obscures the avulsed area. It is important that the surgeon carry out a very careful dissection under the microscope to delineate the area of injury.

**Discussion**

We reviewed a group of case reports in which the histories and x-ray results were similar to those of our patients, but an avulsive injury from the conus me-
dullaris was not included. Previous reports have concentrated on the radiographic manifestation of lumbosacral meningoceles\(^1\)\(^-\)\(^9\),\(^12\)-\(^6\),\(^10\)-\(^22\) (Table 2). Most authors reported the association of antecedent pelvic trauma and lumbosacral pseudomeningoceles\(^6\),\(^8\)-\(^12\),\(^20\)-\(^22\) and others connected lumbar pseudomeningoceles with minor trauma.\(^6\)-\(^9\),\(^13\) Some authors emphasized the common association of many types of lower-extremity nerve injury with pelvic trauma.\(^6\),\(^8\),\(^10\),\(^12\)\(^-\)\(^21\) In none of the papers describing lumbosacral meningoceles did the authors identify the conus as the site of neural injury. When pseudomeningoceles are associated with significant spinal or pelvic trauma and the patient also has a chronic deafferentation pain syndrome, we believe that the site of neural injury is in the DREZ of the conus medullaris.

Of the 23 previously reported cases in which the patient's complaint of pain was an important feature,\(^6\),\(^8\),\(^9\),\(^12\),\(^20\),\(^21\) (Table 2), nine had a significant pain syndrome. Several different methods of treatment have been used to ameliorate the pain problems, and the results have varied. None of these patients had an operation that would expose the conus medullaris. Goodell\(^9\) reported three patients, in whom pain was not a prominent complaint, who underwent exploration of the conus medullaris. The surgeon, performing the operation without magnified vision, did not see any damage. He then performed explorations at the site of the pseudomeningoceles and found the nerve roots disrupted at that level. Privat, \(et\ al.\)\(^21\) also found nerve root disruption at the site of the pseudomeningoceles.

In a postmortem study of patients who suffered pelvic fractures and died due to motor-vehicle accidents, Huittinen\(^10\) found a wide variety of injuries to the nerves of the lower extremities, which he examined grossly and by light microscopy. He compiled an exhaustive review of the sites and types of damage sustained along the course of the nerves, but did not examine the conus in most of the patients. There is also no clinical information about the presence or absence of pain. In 1936, Lam\(^11\) prospectively examined 100 consecutive patients admitted to the Henry Ford Hospital for treatment of pelvic fracture. He found nine patients with clinical evidence of nerve damage. Four of his patients had persisting complaints of pain in the legs. This report preceded the regular use of myelography as a diagnostic tool so the presence or absence of pseudomeningoceles remained unknown. The description of the pain which these patients experienced is similar to the pain syndrome seen in our patients.

When we combined our six patients with pain with those previously reported (Table 2), we found that 15 of 29 patients with myelographic signs or direct observation of nerve root avulsion were troubled by a persistent debilitating pain syndrome. We believe that these patients have a common etiology and pathogenesis and therefore represent a distinct clinical entity. All of the patients were male. Fourteen of the 15 had been involved in motor-vehicle accidents with associated pelvic trauma, usually fractures. All had lower-extremity pain which appeared to have a radicular distribution. The area of pain was usually less extensive than the neurological deficit, which often included both motor and sensory loss. Radiographic findings included evidence of old pelvic fracture, myelography often showed pseudomeningoceles of the lower lumbar and sacral roots, and postmyelographic CT showed distortion of the thecal sac. We treated our patients with DREZ lesions of the conus medullaris. Five of the six patients are doing well, with an average of 23 months of follow-up monitoring.

**Addendum**

We have had the opportunity to treat another patient with avulsion of the dorsal roots from the conus medullaris. This patient differs from our others in only one way: she is the first woman we have treated with this problem. The mechanism of injury is similar: she was a pedestrian who was hit by a car. The accident caused such extensive pelvic and lower-extremity injury that hemipelvectomy was necessary. She had a stormy recovery and began to complain of pain in her phantom left knee and foot. She characterized the pain in her foot as a crushing or burning sensation. She came to our service 3 years after her injury.

Myelography did not show a pseudomeningocele, but it was not a complete study because the patient could not tolerate the procedure. Thoracolumbar exploration revealed avulsion of the L2–S2 or S-3 dorsal roots on the left side. There was extensive scarring of the arachnoid. We made 50 DREZ lesions. Postoperatively, the patient had relief of the burning and crushing sensations in the left foot. She did complain of sensing a band-like constriction in her phantom thigh. As yet, there has been no follow-up appointment to assess her long-term results.

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