Placement of baclofen pump catheter through a C1–2 puncture: technical note

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Intrathecal baclofen has been suggested as an effective and safe treatment for intractable spasticity and dystonia. Techniques of lumbar and intraventricular catheter placement have been previously described. The purpose of this study was to describe a technique to implant catheters for intrathecal baclofen infusion through C1–2 puncture.

Four of 5 consecutively treated patients underwent successful placement of catheters for intrathecal baclofen. There were no instances of infection, CSF leak, or catheter migration seen during a follow-up period of at least 6 months; furthermore, there were no occurrences of vertebral artery or spinal cord injury. All patients had an effective stabilization or reduction of their upper-extremity, lower-extremity, or trunk tone. There were no cases of worsening hypertonia.

The authors’ preliminary experience with C1–2 puncture for placement of the intrathecal baclofen catheter seems to indicate that this is a safe and efficacious technique. Lessons learned from the failed attempt at C1–2 puncture will be delineated.

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2 with spastic diplegia and 2 with spastic quadripareisis/quadriplegia. Three of the 4 patients had cerebral palsy, and 1 patient had anoxic encephalopathy. No patient experienced infection, CSF leak, or catheter migration at 6-month follow-up (range 6–9 months). Each patient had stable to improved tone in the upper extremities, lower extremities, and trunk at most recent follow-up.

Case 1
This 14-year-old boy had cerebral palsy, spastic diplegia, and progressive neuromuscular scoliosis. He underwent scoliosis surgery at an outside hospital and presented to our emergency department 6 months after his spine surgery with symptoms of baclofen withdrawal. Spine radiographs demonstrated loosening of the caudal end of his spinal instrumentation and a subtle fracture of the baclofen catheter that coursed in the vicinity of the failed spinal instrumentation at the level of the spinous process in the lower lumbar region. A dye study and CT myelogram suggested extravasation of dye at the level of the fractured catheter. Because of the presence of a bony fusion in the lower lumbar spine, a revision of the intrathecal baclofen catheter to a C1–2 entry site was considered. After discussion with our colleagues from physical medicine and rehabilitation, we targeted the catheter tip placement to be at the mid- to lower thoracic spine, where the patient’s previous catheter was placed; we were able to place the catheter tip at the level of C-7 before encountering resistance. At 9 months after surgery, the patient maintained stable tone in the upper extremities, lower extremities, and trunk despite the more rostral location of the catheter tip. There was no hypotonia of the upper extremities or trunk. In fact, the patient had improved ability to ambulate with assistance.

Case 3
This 5-year-old girl had a seizure disorder. She had an episode of status epilepticus and suffered an anoxic brain injury. The anoxic encephalopathy led to spastic quadripareisis. She was thought to be a good candidate for baclofen pump placement. A C1–2 entry site was considered, with the catheter tip targeted for the mid- to lower cervical spine. We were able to place the catheter tip at C2–3 before encountering resistance. At 6 months after surgery, the patient had a remarkable decrease in the tone of her upper and lower extremities. She is now able to bring her left arm and hand to her mouth.

Case 4
This 9-year-old boy had a history of cerebral palsy and spastic quadriplegia. Because he presented with spastic quadripareisis, we considered a C1–2 entry into the thecal sac, with the catheter tip ideally at the mid- to lower cervical spine. We were able to place the catheter tip at C6–7, our intended target spinal level. At 6 months after surgery, the patient had improved upper-extremity and trunk tone; however, residual lower-extremity hypertonia remains. The baclofen pump dosage continued to be adjusted at most recent follow-up.

Case 5
This 13-year-old boy presented with cerebral palsy, spastic diplegia, and neuromuscular scoliosis. A C1–2 entry for the baclofen catheter, with the tip at the mid- to lower thoracic region, was contemplated because there was the possibility of his having to undergo scoliosis surgery in the near future. We wanted to decrease the risk of iatrogenic injury to the catheter with scoliosis surgery. We were able to place the catheter at C5–6 before encountering uneasy levels of resistance with passage of the baclofen catheter in the subarachnoid space. At 6 months after surgery, the patient had benefited from the intrathecal baclofen therapy, demonstrating much improved tone in the lower extremities. Upper-extremity and trunk tone remain stable; there is no hypotonia.

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**TABLE 1. Demographic, clinical, and operative data for 5 patients who underwent attempted C1–2 puncture for placement of the intrathecal baclofen catheter**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age at Op (yrs)</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Etiology</th>
<th>Procedure</th>
<th>FU (mos)</th>
<th>Complications</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>M</td>
<td>Spastic diplegia</td>
<td>Cerebral palsy</td>
<td>Revision; lumbar changed to C1–2 entry w/ catheter tip at C7</td>
<td>9</td>
<td>None</td>
<td>Stable tone in UEs, LEs, &amp; trunk</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>M</td>
<td>Spastic quadriplegia</td>
<td>Cerebral palsy</td>
<td>New 20-ml pump placement; lumbar entry</td>
<td>8</td>
<td>Failed C1–2 puncture</td>
<td>Baclofen catheter injury during subsequent scoliosis surgery</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>F</td>
<td>Spastic quadripareisis</td>
<td>Anoxic encephalopathy secondary to status epilepticus</td>
<td>New 20-ml pump placement; C1–2 entry w/ catheter tip at C2–3</td>
<td>6</td>
<td>None</td>
<td>Significant decrease in tone; most notable in Lt UEs &amp; LEs (Ashworth scores 4 preop &amp; 2–3 postop)</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>M</td>
<td>Spastic quadriplegia</td>
<td>Cerebral palsy</td>
<td>New 20-ml pump placement; C1–2 entry w/ catheter tip at C6–7</td>
<td>6</td>
<td>None</td>
<td>Improving trunk &amp; UEs (Ashworth score 1); residual LE hypertonia</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>M</td>
<td>Spastic diplegia</td>
<td>Cerebral palsy</td>
<td>Revision; lumbar changed to C1–2 entry w/ catheter tip at C5–6</td>
<td>6</td>
<td>None</td>
<td>Much improved LE tone</td>
</tr>
</tbody>
</table>

FU = follow-up; LE = lower extremity; UE = upper extremity.
Case 2

For this technique, it is essential to keep the patient’s head in a midline neutral position such that true lateral and true anteroposterior views of the upper cervical spine may be obtained with fluoroscopy during C1–2 puncture. We abandoned this technique in an 11-year-old boy (case 2) with cerebral palsy and spastic quadriplegia. After being brought to the operating room and placed under general anesthesia, his severe laterocollis did not remit and prevented adequate fluoroscopic visualization. Despite the lack of satisfactory fluoroscopic images, we were ill-advised in proceeding with several C1–2 puncture attempts with a 22-gauge finder spinal needle over the course of 30 minutes. Fortunately, there was no overt vertebral artery injury, nor spinal cord injury. This portion of the procedure was abandoned for a traditional lumbar entry of the baclofen catheter into the thecal sac. We aimed to place the catheter tip in the mid- to lower cervical spine but were only able to reach the lower thoracic spine before encountering resistance in the subarachnoid space.

Operative Technique

Parents or guardians provide consent for C1–2 puncture. A discussion of the risks of the procedure, namely vertebral artery injury and spinal cord injury, is undertaken. Furthermore, we make sure that parents or guardians understand that neurovascular injury in the upper cervical spine may beget stroke, coma, or death.

Patients are kept in a supine position, and the skin is prepared from the mastoid and retromastoid region down to the abdominal wall. A horseshoe Mayfield head holder maybe used, but we prefer to simply use a gel donut to maintain head position. Rigid fixation in a 3-pin Mayfield head holder is unnecessary. Our preference is to use the right side, as most patients already have a left-sided gastrostomy tube in place.

A longitudinal 2-cm skin incision is centered approximately 1 fingerbreadth (or 1 cm) below and 1 fingerbreadth (or 1 cm) behind the mastoid tip (Fig. 1). Dissection is carried down to the fascia of the sternocleidomastoid muscle. Lateral fluoroscopy is initially used to guide a 22-gauge spinal needle toward the posterior third of the spinal canal between C-1 and C-2, just inside the spinolaminar line (Fig. 2). This initial puncture has been performed by the senior author (A.J.). After the spinal needle has been advanced 4–5 cm, anteroposterior fluoroscopy is used to guide the tip of the needle toward the midline (Fig. 3). Once the target has been reached, the stylet is withdrawn to check for CSF return.

When the 22-gauge spinal needle has been confirmed fluoroscopically, and with the flash of CSF, a 14-gauge Tuohy needle is passed parallel to the finder needle under fluoroscopic control to recapitulate the finder needle’s trajectory and destination. This second puncture of the thecal sac is usually performed by a fellow or resident, under the close supervision of the senior author. Once CSF is observed from the Tuohy needle, the spinal needle is withdrawn. The bevel of the Tuohy needle is then turned caudally, and the intrathecal catheter (Ascenda; Medtronic, Inc.) is advanced to the desired cervical or thoracic level.

The guidewire is removed from the intrathecal catheter,
and we look for spontaneous drips of CSF from the end of the catheter. Using the anchor dispenser tool, we secure the catheter to the fascia and muscle with a bi-wing anchor and 2-0 sutures (TiCron; Medtronic, Inc.). The catheter is covered with a betadine-soaked gauze. With the catheter in place, the patient’s head is turned to the contralateral side to facilitate the shunt passer later in the procedure.

We then turn our attention to creating a subfascial pocket via a transverse subcostal incision for the baclofen pump in most cases. Occasionally, a subcutaneous pocket is used. The intrathecal catheter is tunneled from the retromastoid incision to the abdominal incision over the thoracic cage with a shunt passer, similar to passing the distal catheter of a ventriculoperitoneal shunt (Fig. 4). The intrathecal catheter is juxtaposed to the stem with a pump connector. The catheter is then snapped onto the side port of the baclofen pump (SynchoMed II; Medtronic, Inc.). CSF is aspirated from the distal end of the catheter to confirm patency of the system and spontaneous flow. Intrathecal vancomycin and gentamycin are then injected into the side port.

Extraneous catheter is coiled behind the baclofen pump, and the pump is inserted into the abdominal pocket. One liter of bacitracin irrigation is used to irrigate both wounds, and 1 g of vancomycin powder is sprinkled into the wounds. The incisions are then closed in a standard fashion.

Using this technique, there were no complications associated with C1–2 puncture, such as vertebral artery injury or spinal cord injury. Likewise, there were no catheter-related complications, such as infection, CSF leak, and catheter migration, with at least 6 months of follow-up. All patients had stable to improved tone in the upper extremities, lower extremities, and trunk; there was no case of worsening spasticity during the follow-up period.

Discussion

The most common technique for placing an intrathecal baclofen pump catheter involves insertion through the lumbar interlaminar spaces. However, high complication rates have been reported with lumbar placement of intrathecal catheters. These complications include surgical site infection with a wound in the diaper region of the patient, and a CSF leak with a durotomy in the most gravity-dependent area of the thecal sac. In certain situations, such as in patients with a history of neuromuscular scoliosis and long-segment spinal fusion, introducing the catheter into the lumbar region may be technically challenging, or it may require disruption of the fusion mass and spinal instrumentation.

Alternative surgical techniques for placement of baclofen catheters, such as intraventricular insertion or insertion of intrathecal catheters in the cervical or thoracic region through open dissection and small laminotomy, may be even more technically demanding and invasive. Minimally invasive percutaneous placement of a baclofen catheter through a fused lumbar spine has also been described. However, this technique also requires drilling and disruption of the fusion mass; advanced image guidance (i.e., cone-beam CT), which might not be available at many institutions; and patient transport between the operating room and interventional radiology suite while under general anesthesia. Therefore, introducing the intrathecal catheter through a transfascial/transmuscular route at the C1–2 interlaminar space, without soft-tissue dissection, bone resection, and image guidance that is more sophisticated than readily available intraoperative fluoroscopy, may be an acceptable option.

Farhat et al. used a similar 14-gauge 9-cm Tuohy needle to place 27 cervical drains through a lateral C1–2 puncture. They used a technique similar to ours, using biplanar fluoroscopy to confirm safe placement. There were no procedural complications related to the lateral C1–2 puncture; the authors specifically pointed out that there were no infections.

Theoretical benefits of inserting intrathecal catheters at C1–2 include decreased risk of CSF leak, infection, and iatrogenic injury of the catheter during spine surgery. Because of a small durotomy in the upper cervical thecal sac, the risk of a CSF leak should be lower than it would be in
the more gravity-dependent lumbar region. Furthermore, the retromastoid incision may make it easier to provide wound care than had the incision been made in the lower lumbar spine within the diaper area; the lumbar wound is more likely to be repeatedly contaminated with urine and feces. For a child with neuromuscular scoliosis that is likely to need surgical treatment, insertion at C1–2 may be advantageous by keeping the intrathecal catheter out of harm’s way. Insertion of the intrathecal catheter via a posterior lumbar route invites iatrogenic injury to the catheter during complex spine surgery, such as in case 2.

Any theoretical benefit from C1–2 insertion of baclofen catheters must be balanced against the reported risks of lateral C1–2 puncture. Unique hazards associated with lateral cervical puncture include vertebral artery injury and spinal cord injury. In a survey of 220 neuroradiologists, Robertson and Smith found 68 major complications associated with lateral C1–2 puncture when using a small-gauge needle for cervical myelography. Most of these complications were related to patient positioning—i.e., hyperextension of the neck, especially in the case of congenital or acquired cervical spinal canal stenosis or disc herniation. Twenty-five complications were caused by the C1–2 puncture itself. Of the 25 complications, 21 were caused by injection of contrast medium into the spinal cord or by spinal cord puncture, 3 were caused by arterial injury (2 vertebral artery and 1 posterior inferior cerebellar artery), and 1 was the result of an epidural hematoma. Overall, these numbers corresponded to 0.045% of 55,419 vertebral artery), and 1 was the result of an epidural hematoma.

Injury (2 vertebral artery and 1 posterior inferior cerebellar artery), and 1 was the result of an epidural hematoma. Overall, these numbers corresponded to 0.045% of 55,419

Lessons Learned

In cases of spastic quadripareis or dystonia, in which the catheter tip in the cervical region is desirable, it is more convenient to advance the intrathecal catheter a short distance from the C1–2 entry site than it is to pass it through a much longer distance from a lumbar entry site. Occasionally, arachnoid webs or other intradural structures prevent passage of the intrathecal catheter from the lumbar to cervical zone. These same intradural obstacles may likewise prevent passage of the catheter from a rostral to a caudal direction; this situation occurred in 2 of our cases of spastic diplegia in which the target destination was the thoracic spine, and we were only able to place the catheter to the mid–lower cervical spine. There were no untoward effects on upper-extremity or trunk tone in these patients despite the more rostral location of the catheter tip.

While we did not have occasion to revise a C1–2 baclofen catheter during our follow-up period, we do not anticipate any greater or lesser trials of revision surgery for the intrathecal catheter than we would for other techniques, such as lumbar, intraventricular, or open approaches. Arachnoiditis preventing recannulation of the thecal sac, passage of the intrathecal catheter tip to the desired spinal level, or effective diffusion of intrathecal medication seems like the most difficult challenge.

Obtaining adequate anteroposterior and lateral fluoroscopic images is the single most important step in our technique. Lateral C1–2 puncture failed in 1 of our cases because we were unable to attain true anteroposterior and lateral fluoroscopic images. The spasmodic torticollis in this patient did not diminish even while the patient was under general anesthesia. After this seminal case, our standard work is to proceed with C1–2 puncture only if we are able to obtain acceptable anteroposterior and lateral fluoroscopic images of the C1–2 interspace; otherwise, we opt for a lumbar entry of the thecal sac.

Of note, the patient in case 2 was taken back to the operating room about 3 months after baclofen pump surgery, for a T2–lium posterior instrumented fusion to treat progressive spinal deformity. The senior author inadvertently damaged the extraspinous portion of the baclofen catheter during exposure of the lower lumbar spine with a Kerrison rongeur.

Conclusions

A larger series of patients who have undergone C1–2 puncture for placement of intrathecal baclofen catheters is necessary before this technique can be accepted for widespread use. Selection criteria for proper candidates and indications need to be defined. For now, we simply provide an early report that C1–2 puncture for intrathecal catheter placement seems to be safe and effective and comparable to other catheter insertion techniques.

References


Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: all authors. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: Jea, Aljuboori. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Jea. Statistical analysis: all authors. Administrative/technical/material support: all authors. Study supervision: all authors.

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