The use of intrathecal baclofen pump implants in children and adolescents: safety and complications in 200 consecutive cases

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Object. The authors investigated the efficacy of intrathecal baclofen therapy, analyzing the complications and risk factors in 200 consecutive patients who received pump implants.

Methods. The patient population included 200 patients (mean age 13.7 ± 5.68 years). The follow-up duration varied from 13.07 to 87.50 months (mean 50.71 months).

Results. The mean Ashworth Scale, Barry-Albright Dystonia Scale, clonus, and spasm scores decreased postoperatively. Overall, 31% of patients experienced complications as follows: 11% had cerebrospinal fluid leakage, 7% had catheter-related problems, 7.5% suffered infections; 5.5% of patients had more than one complication.

Conclusions. The authors found that the onset of at least one complication is statistically more likely in patients with Ashworth Scale scores higher than 3 and an age of 10 years or younger. A reduction in the incidence of infection from 10 to 4.8% by the end of the study period appears to be correlated with the switch in technique to subfascial instead of subcutaneous pump implantation and the adoption of a new preoperative prophylaxis protocol in the last 51 patients.

KEY WORDS • adolescents • baclofen • cerebral palsy complication • pediatric neurosurgery

Cerebral palsy occurs in 1.5 to 2.5 children per 1000 live births in industrialized countries and is associated with movement disorders such as spasticity, athetosis, and dystonia; these disorders may appear individually or together in the same person. In June 1996 the US Food and Drug Administration approved the use of ITB for the treatment of movement disorders. According to the National Institutes of Health, spasticity is a movement disorder characterized by an increase in muscle tone and an exaggeration of tendon reflexes resulting from hyperexcitability of the reflex arc and as one of the symptoms of upper motoneuron syndrome. In the most recent literature on the subject, the primary function of baclofen use in this context has been to reduce spasticity. The rationale for treating spasticity with ITB includes improvement of the patient’s posture and easing the task of caregivers. In 1991, Narayan et al. conducted preliminary studies of the efficacy of ITB treatment for dystonia, and in 1996 Albright described baclofen use in patients with cerebral palsy. Results of more recent studies by Albright and colleagues have supported the use of ITB to treat dystonia. Fahn and associates defined dystonia as a disorder of muscle tone, and therefore of movement, characterized by involuntary and protracted contractions that frequently cause repetitive twisting movements. These movements are often painful and force the individual to adopt abnormal or strange postures. In 2000 the AACPDM reviewed 14 studies related to the efficacy of ITB therapy for spastic and dystonic cerebral palsy according to evidence-based medicine criteria. Of these 14 studies, only four met the AACPDM criteria for Level 1 and 2 evidence. The overall results demonstrated a high rate of efficacy for ITB in the treatment of spasticity and dystonia. One feature that differentiates ITB therapy from surgical treatment is that it is reversible; if the patient is dissatisfied, the device can be removed and treatment stopped. As discussed in the literature, the main complications associated with ITB include CSF leakage, infection, and intrathecal catheter malfunction. In the present study we considered only these three serious complications; analysis of these is particularly complex as the causes can be multifactorial.

Abbreviations used in this paper: AACPDM = American Academy for Cerebral Palsy and Developmental Medicine; CSF = cerebrospinal fluid; GMFCS = Gross Motor Function Classification System; ITB = intrathecal baclofen; OR = odds ratio.
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Clinical Material and Methods

Our review included the first 200 consecutive patients implanted with a SynchroMed pump (Medtronic, Inc.) for the intrathecal administration of baclofen between September 1998 and November 2004 in our Pediatric Orthopedic Department at the “V. Buzzi” Children’s Hospital in Milan. There were 124 male (62%) and 76 female (38%) patients, and at the time of baclofen pump implantation the patients ranged in age from 2.5 and 18.9 years (mean ± standard deviation, 13.7 ± 5.68 years). Of these, 175 patients (87.5%) were affected by varying degrees of cerebral palsy according to the five levels of the GMFCS,21,22 and 25 patients (12.5%) were affected by other pathological processes characterized by spasticity and/or dystonia such as hereditary spastic paraplegia, multiple sclerosis, and traumatic injury.18 One year after pump implantation, two patients died of causes unrelated to ITB therapy. Study enrollment ended in November 2004 to allow for a minimum 1-year follow-up period. The follow-up ranged from 13.07 to 87.50 months (mean 50.71 months). A baclofen bolus was used in 153 patients to evaluate the effect of the drug in the individual patient before pump implantation but, as will be discussed, when it was not used (in 47 patients) there was no increased risk of patient or parent dissatisfaction with the final result.

We modified our surgical technique for pump implantation in March 2003. Instead of placing the device in a subcutaneous pocket in the last 51 patients, we positioned it in a subfascial pocket to the external oblique and straight abdominal muscles.7,17 We also modified the preoperative prophylaxis procedure. Each patient received antibiotic therapy for 48 hours preoperatively, his or her skin was washed with antibacterial soap, and the back and abdomen were further treated with iodopovidone the evening before the operation and again immediately before entering the operating room.

All patient information was registered in a database, which included the following: personal details, diagnosis, medical history, GMFCS score,21,22 walking class (Class 1, nonambulatory; Class 2, walking only for exercise; Class 3, walking at home; and Class 4, unrestricted walking in the community),16 use of aids, pump model, position of pump, type of catheter, bolus dose, mean Ashworth score21,22 and Barry–Albright Scale scores,4 whether the patient had clonus or spasms, explanation surgeries, and any serious complications. We defined serious complications as those not related to the use of baclofen and requiring physician intervention. Using these data we compared the following factors: patient age at pump implantation (patients ≤ 10 years compared with those > 10 years); patient weight (≤ 20 kg compared with > 20 kg); the presence of dystonia; the presence of spasticity (moderate, mean preoperative Ashworth scale score for upper and lower limbs ≤ 3 compared with severe, Ashworth scale score > 3); whether a preoperative baclofen test had been performed; whether the implant was subcutaneous or subfascial; whether the patient had cerebral palsy rather than another pathological disorder; and the patient’s ability to walk (Class 1 or 2 compared with Class 3 or 4). Within each of these categories, the 200 patients were further divided into two groups in two-by-two contingency tables for OR analysis to calculate the increased risk of total complications, infection, CSF leakage, problems linked to catheter malfunction, or other complications. Odds ratio analyses were then performed to assess whether there was an increase in risk at the onset of complications according to combinations of different parameters.

Results

In reviewing our results, at first we can see that patients at GMFCS Level V (73 patients) represent the largest group with the lowest mean age, most impairment (highest Ashworth Scale scores and the presence of dystonia), and highest incidence of complications (13.0%; Table 1). Overall, the mean preoperative and postoperative Ashworth Scale scores in our patients changed from a mean of 3.36 ± 0.85 to 2.26 ± 0.64, Barry–Albright Dystonia Scale scores changed from a mean of 22.63 ± 5.46 to 16.73 ± 4.54, clonus scores changed from a mean of 1.48 ± 1.16 to 0.57 ± 0.8, and spasm scores from 1.10 ± 0.83 to 0.51 ± 0.61.

Complications and Pump Explantation

A total of 214 pumps were placed in the 200 patients studied. Eleven of the pumps had to be replaced due to battery depletion, and three pumps had to be reimplanted following infection (two of these were in the same patient). Twenty-four pumps (12%) were removed as follows: eight pumps (3.7%) were removed (in four male and four female patients) at the request of the patient or his or her family; one pump (0.5%) was removed due to severe CSF leakage

| TABLE 1 |
| Personal and clinical details of patients stratified by GMFCS level* |

<table>
<thead>
<tr>
<th>GMFCS Level</th>
<th>No. of Patients (%)</th>
<th>Age (yrs)†</th>
<th>Preop Ashworth Scale</th>
<th>Dystonia</th>
<th>Subfascial Tech Used</th>
<th>No. of Patients w/ Complications (%)</th>
<th>Total Complications</th>
<th>No. of Dissatisfied Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2 (1.0)</td>
<td>14.97 ± 0.58</td>
<td>2.50 ± 0.00</td>
<td>No</td>
<td>Yes</td>
<td>1 (0.5)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>4 (2.0)</td>
<td>17.17 ± 0.32</td>
<td>2.75 ± 0.96</td>
<td>No</td>
<td>Yes</td>
<td>1 (0.5)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>33 (16.5)</td>
<td>15.04 ± 4.77</td>
<td>2.67 ± 0.69</td>
<td>No</td>
<td>Yes</td>
<td>9 (4.5)</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>IV</td>
<td>63 (31.5)</td>
<td>13.41 ± 5.08</td>
<td>3.49 ± 0.61</td>
<td>Yes</td>
<td>Yes</td>
<td>19 (9.5)</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>73 (36.5)</td>
<td>12.20 ± 5.21</td>
<td>3.68 ± 0.80</td>
<td>Yes</td>
<td>Yes</td>
<td>26 (13.0)</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>No CP</td>
<td>25 (12.5)</td>
<td>16.35 ± 8.36</td>
<td>3.14 ± 1.08</td>
<td>No</td>
<td>Yes</td>
<td>6 (3.0)</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>200 (100)</td>
<td>13.70 ± 5.68</td>
<td>3.36 ± 0.85</td>
<td>No</td>
<td>Yes</td>
<td>62 (31.0)</td>
<td>80</td>
<td>8</td>
</tr>
</tbody>
</table>

* Bac = baclofen; CP = cerebral palsy; NA = not applicable; tech = technique.† Values are expressed as the means ± the standard deviations.

which did not resolve despite being treated; and 15 pumps (7%) were removed because of infection. Of the patients who underwent implantation because of infection, two requested reimplantation. At least one complication was present in 62 patients (31%) with a total of 75 complications that could be single or associated (Table 2). There was an incidence of one complication every 11.3 years of treatment, calculated by dividing the total months of follow-up by the total number of complications.\(^\text{10}\) Infection developed in 20 patients (10%) and, as previously mentioned, in 15 of these this led to pump explantation; in four patients the pump was moved to the opposite abdominal quadrant, and in one patient the infection was resolved after treatment with antibiotic agents. Complications of CSF leakage arose in 34 patients (17%). In 13 of these patients, complications were treated with one or more venous patches. One patient underwent neurosurgical exploration of the dura mater, which resolved the complication, but in one patient the complication continued despite treatment and the family requested neurosurgical exploration of the dura mater. In 19 patients (9.5%) the complications cleared up spontaneously. Of the patients with complications, 32 (17%) went neurosurgical exploration of the dura mater, which resolved the complication, but in one patient the complication continued despite treatment and the family requested neurosurgical exploration of the dura mater. In 19 patients (9.5%) the complications cleared up spontaneously. Of the patients with complications, 21 (10.5%) suffered from problems associated with the catheter itself such as drawing out, disconnection, or breakage.

**Statistical Analysis**

In our statistical analysis we considered single and associated complications in 62 patients as follows: 15 patients (7.5%) had infections only, 22 patients (11%) had CSF leakage only, 14 patients (7%) had complications associated with the catheter only, and 11 patients (5.5%) had more than one complication. The incidence of complications was fairly uniform over the years with the exception of a reduction in infection (from 10% in 1998–2000 to 4.8% in 2003–2005 [Table 2]). We found that infection was statistically correlated with severe spasticity (OR 2.18, \(p = 0.015\)), especially in patients with cerebral palsy (Ashworth Scale score > 3, OR 0.25, \(p = 0.037\)); there was no correlation in patients without cerebral palsy (\(p = 0.174\)) or those with a subcutaneous implant (OR 11.0, \(p = 0.048\)). We found that complications were no more likely to develop in patients with cerebral palsy than in patients without it; however, patients with Ashworth Scale scores higher than 3 were at a statistically significant increased risk for complications.

Patients younger than 10 years of age were more likely to experience CSF leakage (OR 3.07, \(p = 0.009\)); however, this was not influenced by the presence of dystonia as has been reported in other studies. There were no statistically significant risk factors related to catheter malfunction. In general, the onset of at least one complication is significantly correlated with an age below 10 years (\(p < 0.050\)) and to the presence of severe spasticity both in patients with cerebral palsy and those without. An Ashworth Scale score higher than 3 and having undergone a bolus screening test are very significant (\(p < 0.010\)) in the onset of complications considered singularly. Receiving a preimplantation baclofen bolus, apart from being correlated with the onset of at least one complication (\(p < 0.010\)), does not appear to increase the risk of patient or parent dissatisfaction with the final results of ITB treatment. Even though there is no statistical significance (\(p = 0.121\)) to this observation, all patients whose pumps were removed due to dissatisfaction had received a preoperative baclofen bolus. Patient weight and walking class do not appear to have any statistical correlation with the onset of complications. Based on the results of OR comparisons, we found that patients younger than 10 years with severe spasticity are at a higher risk for CSF leakage (\(p = 0.025\)). Additionally, the risk of infection is higher in children younger than 10 years of age with Ashworth Scale scores higher than 3 (\(p = 0.051\)).

**Discussion**

The aim of this study was to describe the efficacy of ITB therapy, its complications, and risk factors. In 200 consecutive patients, we found the same complications as have been described in the literature.\(^{6,7,10,14,15,19,22}\) In our patients, CSF leakage developed in 11%, catheter malfunction in 7%, and infections in 7.5%. Based on our data, it is not possible to establish the percentage of children with a postoperative CSF leak who also had occult hydrocephalus.\(^\text{3}\) Our most important finding was the reduction in the infection rate during the years. The incidence of infections went from 10% (1998–2000) to 6.9% (2001–2002) to 4.8% (2003–2004–2005). In this last period the subfascial technique was adopted and the presurgical prophylaxis procedure was modified. The results of OR analysis demonstrate a strong association between the use of the subcutaneous technique and lower rates of infection. The infection reduction is statistically correlated to the use of the subfascial pump implantation technique and to the preoperative prophylaxis protocol we adopted during that same period (2003–2005). The use of the bolus test did not have any effect on the risk of dissatisfaction with the final result; however, our data show a correlation between the use of the bolus test and complications. We decided not to use the bolus infusion test prior to pump implantation in accordance with findings about the efficacy of ITB in reducing spasticity of cerebral origin.\(^{3,4,10}\) Moreover, not using the bolus infusion test may reduce the risk of complications related to lumbar injections.

**Conclusions**

As has already been demonstrated in the literature, treat-

<table>
<thead>
<tr>
<th>Time Period</th>
<th>No. of Total Patients</th>
<th>w/ Complications</th>
<th>w/ Infections Only</th>
<th>w/ CSF Leakage Only</th>
<th>w/ Catheter Malfunction Only</th>
<th>&gt;1 Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998–2000</td>
<td>80</td>
<td>31 (38.8)</td>
<td>8 (10.0)</td>
<td>12 (15.0)</td>
<td>6 (7.5)</td>
<td>5 (6.3)</td>
</tr>
<tr>
<td>2001–2002</td>
<td>58</td>
<td>15 (25.9)</td>
<td>4 (6.9)</td>
<td>6 (10.3)</td>
<td>2 (3.4)</td>
<td>3 (5.2)</td>
</tr>
<tr>
<td>2003–2005</td>
<td>62</td>
<td>16 (25.8)</td>
<td>3 (4.8)</td>
<td>4 (6.5)</td>
<td>6 (9.7)</td>
<td>3 (4.8)</td>
</tr>
</tbody>
</table>
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ment with ITB results in a reduction in spasticity. In our study this improvement was confirmed by a reduction in the mean Ashworth Scale, Barry–Albright Dystonia Scale, clonus, and spasm scores after pump implantation. Because of complications, the pump was removed in 24 patients (12%). In 16 patients (8%) this was because of severe complications (CSF leakage and infection), and in eight patients (4%) as a result of patient or parent dissatisfaction. The bolus test was used to evaluate the effect of the drug in the individual patient prior to pump implantation, but we found that when it was not used the risk of dissatisfaction with the final result did not increase. A reduction in the rate of infection was statistically correlated with the use of the subfascial pump implantation technique and with the preoperative prophylaxis protocol we adopted in the last 51 patients. According to our data, the onset of at least one complication appears to be statistically correlated with an Ashworth Scale score greater than 3 and an age of 10 years or younger. Patient weight, ambulatory status, and the presence of dystonia or cerebral palsy were not statistically correlated with the rate of complications.

References


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