Therapeutic value of spinal cord stimulation in irritable bowel syndrome: a randomized crossover pilot study

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Lind G, Winter J, Linderoth B, Hellström PM. Therapeutic value of spinal cord stimulation in irritable bowel syndrome: a randomized crossover pilot study. Am J Physiol Regul Integr Comp Physiol 308: R887–R894, 2015. First published March 18, 2015; doi:10.1152/ajpregu.00022.2015.—Irritable bowel syndrome (IBS) is characterized by abdominal pain and changed bowel habits. Spinal cord stimulation (SCS) has been used for treatment of chronic pain syndromes. Animal studies have shown SCS to reduce the reaction to colonic balloon distension, known to be increased in IBS patients. To elucidate the potential for SCS as treatment for IBS, a pilot study was performed. Ten IBS patients (age 26–56 yr) were recruited. A SCS system with a four-polar electrode was implanted at the T5-T8 level. After a 2-wk run-in, a randomized, crossover design SCS during 6 wk was compared with no stimulation, with an ensuing stimulation period for 12 wk; total study period 28 wk. Patients recorded pain level, pain attacks, diarrheas, and global quality of life in a diary. At end of the study patients could choose to retain their SCS system or have it removed. Nine patients completed the whole trial. During stimulation periods the median pain scores were significantly reduced from visual analogue scale (VAS) 7 (4–8) to 3 (2.5–7) and to 4 (2–6) during early and late stimulation periods, respectively (P < 0.03–0.04). Pain attacks were numerically reduced. A few patients reported reduced number of diarrheas. After study termination, six patients chose to retain their SCS system. To conclude, SCS is a minimally invasive treatment option for pain in IBS. With SCS the pain level was reduced though with merely a trend for number of attacks and diarrheas. The efficacy of SCS in IBS pain indicates a possible usefulness in other painful bowel disorders.

spinal cord stimulation; irritable bowel syndrome; abdominal pain; diarrhea

Irritable bowel syndrome (IBS) is characterized by chronic recurrent abdominal pain or discomfort concurrent with altered bowel habits as described by the Rome III criteria (2). The cause of IBS is considered to be multifactorial. Stressful life events commonly precede the onset of IBS symptoms (31). As well, the risk of developing IBS during the first year after gastroenteritis is 10-fold higher than for the general population (30).

Patients with IBS seem to have an altered intestinal motility and sensitivity. Balloon distension of the distal colon in patients with IBS causes pain at considerably lower inflation volumes than in controls (29). IBS patients also have lower thresholds for perception and discomfort to distension in the rectum as well as in the esophagus (33), indicating a generally increased visceral sensitivity. Furthermore, in IBS a low-grade inflammation in the gut mucosa, with an increase of mast cells, has been observed (24). Numerous treatment options are available for IBS but show suboptimal clinical results (8). A search for new therapeutic strategies and treatment modalities is thus warranted.

Spinal cord stimulation (SCS) has evolved to a useful, cost-efficient, minimally invasive, and reversible therapy for different forms of chronic pain. Controlled trials suggest effectiveness of SCS for pain in the complex regional pain syndrome, lumbosacral rhizopathy, limb ischemia, and angina pectoris (22). Application of SCS is usually perceived by the patient as paresthesia or a “tingling sensation,” as a precondtion for a pain-relieving effect, since the electrode has to be positioned so that resulting paresthesia cover the painful region. Using a remote control, the patients can turn stimulation on and off at their own discretion. An SCS-system and illustrative X-ray image are shown in Fig. 1.

The physiological mechanisms underlying the pain-relieving effect of SCS are only partially understood (9, 21). In a series of studies SCS was applied in rats subjected to colorectal distension (10). Data show that the visceromotor response to distension was substantially diminished by SCS. Sensitization of the rat colon with acetic acid markedly enhanced the response to balloon distension. This reaction was completely normalized by SCS (10). Similarly, after trinitrobenezensulfonic acid-induced colonic hypersensitivity, SCS was found to be significantly effective to ameliorate symptoms when applied 1 mo later when the mucosa showed no signs of inflammation (11). Based on these data, Krames and Moussad (19) reported the case of a patient with treatment refractory diarrhea-dominant irritable bowel syndrome (IBS-D) in whom a quadripolar electrode was implanted at the upper level of the T8 vertebral body. On stimulation, both pain and the number of diarrheal episodes were reduced. Apart from IBS, case series of abdominal pain (chronic pancreatitis and pain secondary to abdominal surgery) have shown to be effectively treated with SCS (13, 16, 18). The combination of animal data and the successful trial in a single patient inspired us to conduct a controlled clinical pilot study. The fact that effective SCS necessarily produces sensations precludes blinded trials; instead a randomized crossover design using on-and-off periods was employed to minimize placebo responses.

The primary aim of our study was to investigate if the typical abdominal pain of IBS was ameliorated by SCS. Secondary aims were to evaluate effects of SCS on diarrhea or constipation, quality of life (QoL), and side effects, as well as tolerability to SCS as validated by the patient’s preference to keep the stimulation equipment after the study period. The investigation was carried out as an exploratory investigation with a limited entry of 10 selected subjects.
MATERIALS AND METHODS

Patients. Eligible patients were selected from a database. Inclusion criteria were age 18–60 yr of age, fulfillment of the Rome III criteria (2), episodic abdominal pain exceeding 4 on a 0–10 visual analogue scale (VAS) scale (12), and stable symptoms for the past 2 years. A thorough clinical workup was done, including routine blood, endocrine, and electrolyte status, hepatic enzyme screening, and lactose tolerance test, tissue transglutaminase serology, as well as colonoscopy or barium enema. Patients with significant somatic (fibromyalgia, urinary tract, or gynecological symptoms, neurological disease) and psychiatric comorbidity were excluded. None of the included patients took any medication because this treatment had previously failed. Patients were given both oral and written information about the study. Eligible patients were then referred to the implanting neurosurgeon for further information about the implantation process. The selected patient’s mean age was 29.7 (range 18–46) yr; 7 women and 3 men, 6 of which with diarrhea-predominant (IBS-D) subtype of IBS with >3 loose bowel movements a day, and 4 of the mixed subtype (IBS-M) with interchanging bowel habits of constipation and diarrhea.

Implantation was performed immediately after surgical electrode implantation. The electrode was advanced to the midthoracic level, aiming for a final tip position around T6-T8, and intraoperative stimulation yielded paresthesia covering the abdomen (with or without paresthesia in the legs). The electrode was connected to an impulse generator (Itrel-3, Medtronic) implanted subcutaneously in the upper left quadrant of the abdomen. In search of the ideal implantation level and stimulation parameters, we used the patients report of paresthesia over the lower abdomen as a successful implantation. The stimulation frequency was set at 50 Hz with other parameters (electrode pole combinations, pulse amplitude 1.3–3.3 V, and pulse width 200–500 μs) set to produce adequate paresthesia covering the usual region of pain with comfortable intensity. Suitable parameters were selected and set shortly after implantation when the patient was mobilized. Stimulation was thereafter turned off. During the subsequent ongoing trial, reprogramming of the stimulation parameters was allowed if necessary to uphold optimal stimulation. Randomization was done by envelope draw by independent person immediately after surgical electrode implantation.

According to the study protocol, stimulation was not permitted during the first 2 wk after surgery as a run-in period. Thereafter, patients were randomized by envelope draw to either of two programming schedules: one starting with SCS for a 6-wk period (early start) (Fig. 2A), and another with the initial 6 wk without SCS (delayed start) (Fig. 2B). During the stimulation-ON periods patients were requested to use SCS for at least 8–12 h at an intensity yielding comfortable paresthesia. If pain attacks appeared, patients were encouraged to increase the stimulation intensity until relief was achieved. After 6 wk, patients without stimulation were crossed over to stimulation and vice versa. After another 6 wk both programs included continued stimulation for an additional 12 wk up to a total study period of 26 wk including the run-in period. After a consecutive 2-wk period without stimulation the trial was terminated. During the whole study period patients recorded in a daily diary: 1) number of pain attacks, 2) number of diarrhea episodes, 3) average pain level for the day, and 4) assessment of average QoL. For the latter two items patients were instructed to use a numeric 0–10 VAS.

Patients were scheduled for outpatient visits, at weeks 2, 8, 14, 26, and 28 after the implantation. Patient compliance was monitored since the impulse generator stores information on the percentage of elapsed time...
with SCS stimulation-ON. At termination of the study, participants were offered to keep the implanted SCS system or have it removed.

All patients underwent a structured follow-up telephone interview between 18 to 78 mo after study termination. At the telephone interview a questionnaire was used to assess their present pain level, medication, use of SCS, side effects, and global satisfaction. Patients were also asked whether they would have participated if they had known the outcome in advance and if they would recommend SCS treatment to someone else with similar gastrointestinal problems.

All patients were evaluated with the hospital anxiety and depression scale (HADS) (36) and a modified version of the gastrointestinal symptom rating scale for IBS (GSRS-IBS) (34).

Statistics. Statistical processing was performed utilizing GraphPad Prism 6 (GraphPad Software, San Diego, CA) employing the Friedman ANOVA multiple comparisons test for the prestimulation period versus the early and late-stimulation periods. Analyses where made for responders to treatment, as well as for all stimulation periods as a full analysis set (FAS). Wilcoxon matched-pairs test was used for individual comparisons. Spearman correlation analysis was used to evaluate correlations between pain intensity, the number of pain attacks, and diarrhea episodes. All parameters are expressed as medians with 25–75 percentiles and range.

RESULTS

Out of a total number of 63 eligible patients, 18 were selected by the gastroenterologist and referred to the neurosurgery team for more specific information about the procedure. Ten of these patients volunteered to participate in the study according to the protocol (Figs. 2 and 3). All patients had a GSRS-IBS scoring between 3 and 5 for different domains before onset of the study. The HADS score was below 7 in six patients, whereas increased anxiety was found in two patients and depression in one. The final position of uppermost pole of the electrode is given in Table 1. One patient chose to leave the study after 10 wk for undisclosed reasons. The remaining nine patients completed the entire study. Six of those reported a satisfactory result with stimulation, whereas three did not. The three patients without benefits from stimulation also chose to have their SCS-system removed after study closeout. The remaining six have continued their stimulation treatment beyond the trial period, with the longest follow-up of 6½ years.

Pain intensity, pain attacks, diarrhea, and quality of life. On comparison, the median pain intensity scores, number of pain attacks, and number of diarrhea episodes were lower during the early and late stimulation periods than during the prestimulation period and nonstimulation periods (Fig. 4). This difference was statistically significant for pain intensity throughout all groups ($P < 0.003$), for both the early ($P < 0.03$) and late ($P < 0.04$) (cf. Fig. 4) stimulation periods, but failed to reach statistical significance for number of pain attacks and diarrhea. When limiting the analysis to pain intensity responders (as described in post hoc experience), this difference became even more evident with a reduction of pain intensity by 25.5% and 25.7% for the early and late stimulation periods than during the prestimulation period ($P < 0.04$) (Fig. 5).

Concerns. Figure 6 shows the overall correlation between the pain intensity and the number of pain attacks ($r = 0.52, P < 0.0001$). Before SCS there was only a borderline significant correlation ($r = 0.64, P < 0.07$), whereas during the stimulation-ON periods, the correlation became markedly significant ($r = 0.64, P < 0.003$) also occurring during the stimulation-OFF periods ($r = 0.43, P < 0.003$). This indicates an association between the rated pain intensity and number of pain attacks. However, there was no correlation between the IBS pain intensity or number of pain attacks versus number of

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Fig. 3. Flow chart of the study protocol. Group A started with spinal cord stimulation upon onset of the study period. Group B had delayed start by 6 wk until crossover. The diagram also shows the number of patients available for each step.

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**Table 1.** Summary of the Distribution of the Number of Patients

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received allocated intervention (n=5)</td>
<td>Received allocated intervention (n=5)</td>
</tr>
<tr>
<td>Did not receive allocated intervention (n=0)</td>
<td>Did not receive allocated intervention (n=4)</td>
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<tr>
<td>Discontinued intervention (n=0)</td>
<td>Discontinued intervention (n=0)</td>
</tr>
<tr>
<td>Excluded from analysis (n=0)</td>
<td>Excluded from analysis (n=0)</td>
</tr>
</tbody>
</table>

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**Table 2.** Summary of the Distribution of the Number of Patients

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<th>Group A</th>
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<tbody>
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</tr>
<tr>
<td>Did not receive allocated intervention (n=0)</td>
<td>Did not receive allocated intervention (n=4)</td>
</tr>
<tr>
<td>Discontinued intervention (n=0)</td>
<td>Discontinued intervention (n=0)</td>
</tr>
<tr>
<td>Excluded from analysis (n=0)</td>
<td>Excluded from analysis (n=0)</td>
</tr>
</tbody>
</table>

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**Table 3.** Summary of the Distribution of the Number of Patients

<table>
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<tr>
<th>Group A</th>
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</thead>
<tbody>
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<td>Received allocated intervention (n=5)</td>
<td>Received allocated intervention (n=5)</td>
</tr>
<tr>
<td>Did not receive allocated intervention (n=0)</td>
<td>Did not receive allocated intervention (n=4)</td>
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<tr>
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<td>Discontinued intervention (n=0)</td>
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<tr>
<td>Excluded from analysis (n=0)</td>
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</tr>
</tbody>
</table>
diarrhea episodes ($r = 0.21$ and $r = 0.19$, respectively), possibly indicating separate mechanisms behind these symptoms. Furthermore, after SCS there was only a weak trend for an increased QoL. At onset of stimulation QoL was estimated to VAS 4.9 $\pm$ 0.8, whereas at 6 wk QoL was 5.5 $\pm$ 1.1 and at the end of the study 6.5 $\pm$ 0.5 using a linear estimate displaying a trend for improvement.

The HADS showed elevated values for anxiety in 3 patients and depression in 1 of 10 patients, yielding no relationship to the response to SCS.

Post hoc experience. Compliance to the study protocol appeared to be excellent in all patients. During periods without stimulation, the pulse generator was set to 0 and the patient was unable to use the SCS. During the stimulation periods the stimulators were turned “on” for an average of 60% of study time and no pulse generator showed a usage below 41%, indicating that no patient used the stimulator $8 \text{ h per day}$.

When limiting analysis to pain intensity responders, the effect of SCS became evident with a reduction of pain intensity by 53 $\pm$ 10.6% (range 18–95%) for the summarized early and late

Table 1. Demographics implantation and spinal cord stimulation parameters of study patients

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age at IBS Debut, yr</th>
<th>IBS Subtype</th>
<th>Age at Implant, yr</th>
<th>SCS Parameters (Frequency: 50 Hz for All)</th>
<th>Level of Highest Electrode Pole</th>
<th>Study Group</th>
<th>Opted to Keep SCS</th>
<th>Medical History</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>45</td>
<td>IBS-D</td>
<td>56</td>
<td>Poles: 0 &amp; 1 $\pm$ 2 &amp; 3 $\pm$ PW: 330 $\mu$s A: 2.3 V</td>
<td>T7/8</td>
<td>A</td>
<td>Yes</td>
<td>Appendectomy. Operated for benign adrenal tumor.</td>
</tr>
<tr>
<td>M</td>
<td>31</td>
<td>IBS-D</td>
<td>45</td>
<td>Poles: 1, 2, &amp; 3 $\pm$ PW: 270 $\mu$s A: 3.0 V</td>
<td>T7/8</td>
<td>A</td>
<td>Yes</td>
<td>Appendectomy. Subarachnoidal hemorrhage.</td>
</tr>
<tr>
<td>F</td>
<td>46</td>
<td>IBS-D</td>
<td>50</td>
<td>Poles: 0 &amp; 1 &amp; 2 $\pm$ PW: 420 $\mu$s A: 5.5 V</td>
<td>T6/7</td>
<td>B</td>
<td>Yes</td>
<td>Cholecystectomy. Hysterectomy. Anal fistula.</td>
</tr>
<tr>
<td>F</td>
<td>35</td>
<td>IBS-M</td>
<td>39</td>
<td>Poles: 0 &amp; 2 $\pm$ PW: 390 $\mu$s A: 3.5 V</td>
<td>T7/8</td>
<td>B</td>
<td>Yes</td>
<td>Hysterectomy</td>
</tr>
<tr>
<td>F</td>
<td>26</td>
<td>IBS-D</td>
<td>31</td>
<td>Poles: 0 &amp; 3 $\pm$ 1 $\pm$ PW: 450 $\mu$s A: 8.0 V</td>
<td>T7/8</td>
<td>B</td>
<td>No</td>
<td>Dystrophia myotonica</td>
</tr>
<tr>
<td>M</td>
<td>18</td>
<td>IBS-D</td>
<td>25</td>
<td>Poles: 0 $\pm$ 2 $\pm$ case $\pm$ PW: 270 $\mu$s A: 3.5 V</td>
<td>T7/8</td>
<td>A</td>
<td>No</td>
<td>Asthma</td>
</tr>
<tr>
<td>F</td>
<td>18</td>
<td>IBS-D</td>
<td>29</td>
<td>Poles: 0 &amp; 1 $\pm$ 2 &amp; 3 $\pm$ PW: 240 $\mu$s A: 2.0 V</td>
<td>T5/6</td>
<td>B</td>
<td>Aborted</td>
<td>Previous thoracotomy for benign thoracic tumor.</td>
</tr>
<tr>
<td>F</td>
<td>36</td>
<td>IBS-M</td>
<td>45</td>
<td>Poles: 0 &amp; 1 $\pm$ 2 $\pm$ PW: 420 $\mu$s A: 3.0 V</td>
<td>T7/8</td>
<td>A</td>
<td>Yes</td>
<td>Previous transverse colon tumor, Dukes A</td>
</tr>
<tr>
<td>F</td>
<td>23</td>
<td>IBS-M</td>
<td>26</td>
<td>Poles: 3 $\pm$ case $\pm$ PW: 330 $\mu$s A: 7.5 V</td>
<td>T7/8</td>
<td>B</td>
<td>No</td>
<td>No clinically significant</td>
</tr>
<tr>
<td>F</td>
<td>19</td>
<td>IBS-M</td>
<td>40</td>
<td>Poles: 0 &amp; 3 $\pm$ 1 &amp; 2 $\pm$ PW: 330 $\mu$s A: 3.3 V</td>
<td>T5/6</td>
<td>A</td>
<td>Yes</td>
<td>Appendectomy. Cholecystectomy. Hiatal hernia.</td>
</tr>
</tbody>
</table>

IBS, irritable bowel syndrome (C, constipation; D, diarrhea; M, mixed); SCS, spinal cord stimulation; Poles, electrode poles; PW, pulse width; A, amplitude; $\pm$, positive electrode pole; $\pm$, negative electrode pole; case, stimulator case.
stimulation periods compared with the maximum pain scoring during the prestimulation period.

Reprogramming to uphold adequate paresthesia coverage of the painful area during the trial was necessary for four patients, two of whom required a second reprogramming (a routine in SCS therapy to ascertain adequate paresthesia).

Six patients reported side effects during the trial or at follow-up. Two patients reported a feeling of tiredness during stimulation periods. Another two patients reported sensations of unsteady gait during stimulation probably related to paresthesia in the legs (cf. 22). One patient reported uncomfortably high-intensity stimulation in her legs, pain at the implantation site of the stimulator, and transient headache upon removal of the SCS system.

Follow-up. After study closeout six patients opted to keep their SCS systems. At follow-up after on average 61 mo, three patients who opted to keep the SCS system reported that their SCS was still in use. Two patients experienced over the first 4 years progressively less pain with stimulation therapy, even to an extent that they ceased to use the SCS on a regular basis. However, both patients have chosen to retain the equipment, should the symptoms return in the future. In one patient both pain and diarrheas were eradicated and no longer present.

**Fig. 4.** Box-and-whiskers diagram showing the median, 25–75 percentiles, and range for pain intensity (top; visual analogue scale [VAS]), pain attacks per day (middle), and diarrhea (bottom) during the prestimulation, early, and late spinal cord stimulation periods for all responders (n = 6) to treatment. Significant differences were obtained for pain intensity during both the early and late stimulation periods but not for pain attacks and diarrhea.

Significant differences were obtained for pain intensity during both the early and late stimulation periods but not for pain attacks and diarrhea.

**Fig. 5.** Box-and-whiskers diagram showing the median, 25–75 percentiles, and range for pain intensity (top), pain attacks per day (middle), and diarrhea (bottom) during the whole study period for all included patients (n = 9). There was no difference in pain effects whether the stimulation-OFF period occurred before stimulation-ON period or vice versa.
possible pathological mechanisms, many of which are un-

IBS pain is more multifaceted with numerous underlying
cannot be directly compared neuropathic pain because the
when applied for neuropathic pain (22). However, IBS pain
60–70%, which is in fact comparable to the outcome of SCS
did not. This could be extrapolated to a responder rate of
three
had their stimulators exchanged, at their own request. The fact
the stimulator eventually ceases to function, our patients have
after the trial. As the battery is depleted after about 5 years and
treatment as witnessed by their choice to retain the SCS system
Another patient had her SCS system removed because of safety
concerns in conjunction with an MRI examination at 3 years
from implantation. No early or late complications were associa-
ted with the implantation.

DISCUSSION

The approach of our study was to prospectively evaluate
SCS applied for IBS pain, with a randomized crossover trial
design. Blinding was not possible to accomplish, because
paresthesias are always sensed during SCS. A statistically
significant reduction of perceived pain intensity was observed
during the stimulation periods. Data also showed a progres-
ively increasing pain relief over prolonged study time. In
addition, not only pain intensity but also the number of pain
attacks per day decreased with SCS. There was a trend that
SCS had a positive effect also on other IBS symptoms but
failed to reach statistical significance for the number of pain
attacks and diarrheal episodes per day. This result is possibly
related to the small number of patients included in the study
and the fact that we did not specifically include patients with
IBS-D, but rather patients with a more common IBS profile
with pain as the principal IBS symptom. However, correlation
analysis showed a markedly significant relationship between
pain intensity and number of pain attacks, whereas pain intensity
as well as pain attacks and diarrheal episodes did not. It is
therefore likely that similar mechanisms are involved in pain
intensity and pain attacks, while diarrhea stems from another
source.

A majority of our patients apparently benefited from the
treatment as witnessed by their choice to retain the SCS system
after the trial. As the battery is depleted after about 5 years and
the stimulator eventually ceases to function, our patients have
had their stimulators exchanged, at their own request. The fact
that this procedure will demand repeat surgery clearly supports
that patients found the treatment beneficial. Taken together, six
patients had benefit from the SCS treatment, whereas three
did not. This could be extrapolated to a responder rate of
60–70%, which is in fact comparable to the outcome of SCS
when applied for neuropathic pain (22). However, IBS pain
cannot be directly compared neuropathic pain because the
IBS pain is more multifaceted with numerous underlying
possible pathological mechanisms, many of which are un-
likely to respond to SCS. It should be noted that the
common success rate of IBS patients when studied in
clinical trials is 30–40% at its best (8).

The average pain reduction in our SCS study was found to
be in the range of 25%, which is low compared with standards
for analgesic drugs claiming at least a 30% pain reduction as a
clinically important difference (4). The pain reduction also
seemed surprisingly low compared with the patients’ sponta-
neous comments on the exceptional treatment effect. This
disparity between the pain experience and pain sensation may
be due to the linear monitoring of pain sensations by VAS and
the meaningfulness of a pain relief that patients may experi-
ence. Furthermore, as no wash-out period was interspersed
between the stimulation-ON and stimulation-OFF periods, a
carry-over effect from the stimulation-ON period cannot be
ignored, which may have reduced the therapeutic gain of SCS.
As verified by post hoc experience a meaningful pain relief
was still achieved in the majority of our IBS patients. Therefore, it
appears that the success rate of the SCS treatment could be
more advantageous as an adjunct in the management of IBS in
selected patients.

Abdominal pain was the only symptom significantly reduced
by SCS in all subcategories with IBS. As for diarrhea fre-
quency, only two of five fully participating IBS-D patients
experienced a clear reduction of diarrhea with stimulation.
Nonetheless, our results suggest that adjunct symptoms of
bowel dysfunction such as diarrhea and constipation are less
responsive to SCS than IBS pain per se.

It is not clear in which way that SCS influences the gut-brain
axis. Krames and Foreman (20) have hypothesized that the
effect is mediated via the spinothalamic tract and the visceral
pain-mediating postsynaptic tract deep in the dorsal columns.
Furthermore, antidromic activation of sensory nerves innervat-
ing the gut may be of importance, as shown in other SCS
experiments (20). In animal studies, Qin et al. (26, 27) has
shown SCS to influence the transmission of visceralreceptor
information in the spinal cord. Qin et al. also performed
extracellular microrecordings of dorsal horn neurons in the rat
L6-S2 spinal segments. These neurons responded to colorectal
distension and could be inhibited by SCS (27).

The first investigations of SCS for gastrointestinal effects
were done by Pescatori et al. (25) who studied colonic motility
in two patients with neurological disease (multiple sclerosis,
spina bifida) and severe constipation. Both patients received
SCS at the T8-9 level similar to our stimulation level. During
stimulation the authors found that the patients’ bowel move-
ments were regularized, which is different from our experi-
ence.

Occasional gastrointestinal effects of SCS as applied for
other indications have been reported as adverse effects (17,
32). In these studies SCS was not used intentionally for
gastrointestinal effects, and the electrodes were implanted
remotely from the gut. Successful SCS treatment of abdominal
pain in mesenteric ischemia has also been documented (1). The
electrode was located at the T6 level and stimulation induced
paresthesia in the abdominal area. The patient was reported
to be relieved still after 1 year. Presently, there are several
publications of studies on SCS applied for different kinds of
abdominal pain with at least 70 patients reported as success-
fully treated (14–16). It is worth noting that these successful
treatments were achieved after careful patient selection and

Fig. 6. Correlations between pain intensity and pain attacks per day during the
prestimulation period. Each data point represents daily pain scoring versus
number of pain attacks during that day. There was a trend for a covariation
between pain intensity and number of daily pain attacks during the prestim-
ulation period. During the stimulation-ON period and the stimulation-OFF
periods correlations were statistically significant.
prior temporary trial stimulation. For IBS specifically, two additional case reports have recently been published confirming that SCS may have beneficial effects in this condition (6, 7). A different type of neurostimulation, selective stimulation of sacral nerves, has also been tried against IBS pain. Reports show a significant reduction of IBS-related symptoms and improved QoL in highly selected IBS patients but with no detectable small bowel motility effect (6, 7) as well as rectal wall relaxation and highly significant reduction of symptoms in IBS-D and IBS-M (5).

The presence of paresthesia on stimulation has been considered a prerequisite for an optimal SCS effect and this precludes blinded designs of clinical SCS trials. Nonetheless, a few studies with stimulation intensities below the threshold for paresthesia have been performed with SCS in angina pectoris and neuropathic pain (3, 35), usually demonstrating a clear effect of SCS at subparesthesiastic intensity, but that a somewhat higher stimulation intensity providing paresthesia is more effective. In our study, one patient chose to stimulate with low intensity and reported a satisfactory effect also with stimulation subthreshold to paresthesia, but was urged to continue with paresthetic stimulation, as intended with the study protocol.

In conclusion, our study suggests that SCS may be an optional treatment modality for IBS pain. It appears that the principal beneficial effect of SCS is amelioration of the IBS-related pain. There is a trend for other symptoms of IBS to be positively influenced. However, these effects have to be further explored in more extensive studies. The high prevalence of IBS motivates larger randomized studies to establish the possible long-term usefulness of SCS in the management of this disorder and its cost benefits.

REFERENCES