Sacral magnetic stimulation in puborectalis paradoxical syndrome

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**Background and Purpose:** Our earlier studies have demonstrated that sacral magnetic stimulation (MS) in the canine model, in healthy volunteers and in constipated subjects affected rectal pressure rise, decline of the rectal neck (anal canal) pressure as well as rectal evacuation. Based on these results, we studied the effect of sacral MS on defecation in patients with puborectalis paradoxical syndrome (PPS). Methods: Eleven subjects (8 women, 3 men; age 36 - 53 years) with PPS were enrolled in the study. The magnetic coil was placed on the back with its center located between L4 and L5. Stimulation parameters were set at 70% of maximum intensity, 40 Hz frequency and 2-second burst length with 2 seconds off. During MS, the rectal neck and gastric (intra-abdominal) pressures were measured. The procedure was performed in the empty and in the full rectum using the balloon expulsion test in the latter. Results: MS of the empty and balloon-filled rectum affected rise of the rectal pressure (p<0.001), decline of the rectal neck pressure (p>0.001) and no significant change of the intragastric pressure (p>0.05). The balloon was expelled to the exterior in all the patients. Conclusions: Sacral MS succeeded in distending to the exterior the water-filled rectal balloon. The method is simple, easy, non-invasive, non-radiologic and can be performed on an outpatient basis for the treatment of PPS.

Key words: constipation; anismus; outlet obstruction; puborectalis non-relaxing syndrome.

**INTRODUCTION**

Constipation is a common medical problem. It has various etiologies among which is outlet obstruction. The latter defines the inability to completely expel the stools that have reached the rectum, due to the failure of the rectal neck (anal canal) to open in front of the descending fecal mass.

Normal defecation requires the coordination of pelvic floor muscles and anal sphincters with rectal detrusor. Dysfunction of these muscles would result in outlet obstruction. Failing of these muscles to relax (anismus) or their contraction (dyssynergia) in response to the rectal contraction would lead to excessive straining at defecation (strainodynia), although the stools may be soft and bulky.

Puborectalis paradoxical syndrome (PPS) causes outlet obstruction. It presents with constipation. Upon straining at stool, the puborectalis muscle does not relax or even may contract. This has been demonstrated by defecography and EMS studies.

Various lines of treatment for PPS have been adopted including myotomies and biofeedback but the results are variable. The efficiency rate in biofeedback therapy ranged from 18 to 100%, and this appears to depend mainly on the type of biofeedback utilized and the number of sessions which the patient attended. Recently, some investigators reported on the treatment of PPS with botulin toxin and the result were promising.

Earlier studies have shown that sacral pathways can be stimulated by means of functional magnetic stimulation (MS). Magnetic pulses applied with a stimulating coil placed over the sacrum evoke motor potentials in the electromyograms of the pelvic sphincter muscles. High-frequency magnetic stimulators can elicit functional responses from striated muscles. MS of the sacral roots produces contractions of toe flexors and pelvic floor muscles. Furthermore, it can suppress unstable detrusor contractions in man. MS induces its effect by creating, according to Faradays law, an electric field which stimulates the neuromuscular tissues. Magnetic stimulators are also applied for neurophysiologic investigations. Sacral MS has been used for the treatment of idiopathic constipation and for neuromodulation of vesical rectal hyperreflexia and evacuation of the neuropathic rectum and urinary bladder.
Other investigators recorded motor evoked potentials from the external anal sphincter in response to transcranial MS of the motor cortex and lumbar sacral region. They demonstrated that cortical pathways to the external anal sphincter are facilitated by prior lumbar sacral and pudendal nerve stimulation indicating that sensorimotor interactions are important in the central neural control of sphincter function.

Lin et al. demonstrated, both in dogs and in humans, that MS of the urinary bladder by a magnetic coil placed in the suprapubic or sacral region, affected bladder emptying.

Previous studies have demonstrated experimentally, as well as in subjects with idiopathic constipation and rectal hyperreflexia that sacral MS of both the full and the empty rectum effected a significant increase in rectal and vesical pressures and a decline of the rectal neck pressure; evacuation of the full rectum was achieved. In view of these results it was thought of using this therapeutic modality in the treatment of PPS. The current communication embodies the results of this study.

MATERIAL AND METHODS

Subjects

Eleven subjects were enrolled in the study after giving informed consent. They complained of constipation and excessive straining at defecation (strainodynia) of 4 - 8 years duration. Their clinical data are depicted in Table 1. The study was approved by our Faculty Review Board and Ethics Committee.

Physical examination of the patients was normal. Neurologic assessment was unremarkable. The diagnosis of PPS was based on physiologic and radiologic studies. The intestinal transit was performed using the technique described by Hinton, Lennard-Jones and Young. A single capsule of 20 radiopaque rings was ingested and followed by daily abdominal radiograph. 13-15 pellets were retained in the rectum of the patients by the 5th post ingestion day and 10-12 by the 7th day. Our laboratory tests defined as normal when 16 or more of the markers have passed by the 5th post ingestion day and when all have been evacuated by the 7th day. The EMG of the external anal sphincter, measured by a previously described technique, showed increased activity upon straining; this result was confirmed by defecography. The anorectal angle in defecography did not increase and in some patients decreased during straining. Fecoflowmetry showed the typical curve of obstructive constipation (Fig. 1). The volume expelled (mean 125 +/- 14.3 ml, range 108-140) as well as the mean and maximum flow rates (mean 9.6 +/- 1.4 ml/s, range 8-12, mean 31.6 +/- 6.4 ml/s, range 25-40, respectively) were significantly diminished (p<0.05, p<0.05, p<0.05, p<0.05, respectively) compared to the normal values in our laboratory (mean volume 416.3 +/- 47.1 ml/s, mean flow rate 20.6 +/- 4.6 ml/s, maximal flow rate 84.4 23.9 ml/s). The time to maximal flow was prolonged (mean 11.6 +/- 3.25, mean normal 17.7 +/- 0.9 s, p) and the fecoflowmetric curve showed a plateau (Fig. 1) in contrast to the obelisk-shaped normal curve.

Figure 1
FECALOMETRY OF A PATIENT WITH PUBORECTALIS PARADOXICAL SYDROME
a) The defecation flow curve. It shows the features of constipation which include: the flow time and time to maximal flow are prolonged, the ascending limb of the curve rises more gradually than normal and the curve has a plateau.

Figure 1
FECALOMETRY OF A PATIENT WITH PUBORECTALIS PARADOXICAL SYDROME
b) intra-abdominal pressure curve. The pressure curve was simultaneously recorded with the flow curve. The former showed bouts of increased intra-abdominal pressure (straining) before the start of evacuation. The flow began when the pressure reached its maximum and was maintained as long as the pressure was sustained. When the pressure decreased, the flow diminished. This indicated that the patient strains to initiate and maintain rectal evacuation.

All the 11 patients were transferred to us from a biofeedback center where they had been treated with unsatisfactory results. A 20-minute session per week for 10-15 weeks was carried out for each patient. The methods used for biofeedback are shown in Table 1. Sacral MS was performed for the treatment of these patients.

METHODS

The method has been previously described and will be mentioned briefly. The patients were instructed to fast during the night and a saline enema was performed in the morning one hour before testing so as to guarantee that
Table 1

THE CLINICAL DATA OF THE 11 PATIENTS WITH PPS

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Sex</th>
<th>Stool frequency/week</th>
<th>Duration of PPS (years)</th>
<th>Assisted evacuation</th>
<th>Previous treatment</th>
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<td>36</td>
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<tr>
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<td>50</td>
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<td>Enemas</td>
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<tr>
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<td>39</td>
<td>F</td>
<td>1</td>
<td>8</td>
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<tr>
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<td>M</td>
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<td>4</td>
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<td>F</td>
<td>0</td>
<td>5</td>
<td>Enemas</td>
<td>M-FB</td>
</tr>
</tbody>
</table>

MG-FB=Electromyographic feedback
F-M-FB=Manometry feedback

Table 2

RESULTS OF MEASUREMENTS OF THE RECTAL, RECTAL NECK AND INTRAGASTRIC PRESSURES OF THE 11 PTS WITH PPS UPON SACRAL MS OF THE EMPTY AND BALOON-FILLED RECTUM

<table>
<thead>
<tr>
<th></th>
<th>Rectal</th>
<th>Rectal neck</th>
<th>Intragastric</th>
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<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Basal</td>
<td>6.2+/-.1.2</td>
<td>5-8</td>
<td>73.2+/-.7.6</td>
</tr>
<tr>
<td>MS of empty rectum</td>
<td>52.4+/-.7.8**</td>
<td>40-63</td>
<td>15.4+/-.3.8**</td>
</tr>
<tr>
<td>Balloon filling without MS</td>
<td>58.6+/-.8.3**</td>
<td>48-67</td>
<td>106.4+/-.12.7*</td>
</tr>
<tr>
<td>Balloon filling and MS</td>
<td>51.7+/-.**</td>
<td>42-58</td>
<td>17.8+/-.4.3**</td>
</tr>
</tbody>
</table>

*p<0.05  *p<0.05  **p<0.001
- Values were given as the mean+/ standard deviation (SD)
- P values of each group were compared with the basal value of the same group.

MAGNETIC STIMULATION

A magnetic stimulator (High-speed MES-10, Cadwell, Kennewick, WA, USA) and a 9-cm round magnetic coil were used in the study (fig. 2). When measured at the coil center, the MES-10 could generate a maximum field strength of 2.2 Tesla. The subject lay prone and the lower part of the back was shaved. The magnetic coil was placed firmly on the back with its center located between L4 and L5 along the midline. The parameters for magnetic stimulation were set at 70% of maximum intensity.
i.e. 175 Joules per pulse, 40 Hz frequency and a 2-second burst length with 2 seconds off. These parameters were found to be appropriate to avoid coil overheating and to provide, in the same time, an adequate neuromuscular stimulation. During MS, the rectal, rectal neck and gastric pressures were recorded.

**BALLOON EXPULSION TEST**

After MS of the empty rectum, the procedure was performed on the full rectum using the balloon expulsion test. The empty balloon was introduced into the rectum and filled with 100 ml of saline. All the patients failed to expel the balloon filled with 100 ml of saline from the rectum to the exterior, even with excessive straining. In the healthy subjects in our laboratory the 100 ml-filled balloon is spontaneously expelled to the exterior.

With the filled balloon located in the rectum, intermittent sacral MS stimulation was performed using a 70% intensity, 40Hz frequency and 2-second burst length with 2 seconds off. During sacral MS the rectal, rectal neck and intragastric pressures were registered.

To assure reproducibility of the results, the aforementioned measurements were repeated at least twice and the mean value was calculated. The results were analyzed statistically using the Students t-test. Differences assumed statistical significance at p, and values were given as mean standard deviation (SD).

**RESULTS**

All the patients were evaluated and no adverse effects occurred during or after sacral MS. There was no abnormal sensation or pain when MS was applied.

The pressures in the rectum, rectal neck and the stomach at rest and upon sacral MS of the empty and the balloon-filled rectum are shown in table 2. The filled balloon was not expelled from the rectum to the exterior, although the rectal pressure was significantly elevated (p<0.001, table 2). The rectal neck pressure, too, rose significantly on balloon filling (p<0.05, table 2).

Upon intermittent sacral MS the rectal pressure showed a significant rise (p<0.001), the rectal neck pressure a decline (p<0.001, table 2) and the rectal balloon was expelled to the outside. The intragastric pressure showed no significant pressure rise (p>0.05). Significant diminution of the rectal neck pressure and opening of the rectal neck occurred after at least 2 magnetic pulsings with a mean of 4.6±1.3 pulsings (range 2 - 6).

The aforementioned results were reproducible with no significant difference when the test was repeated in the same subject.

**DISCUSSION**

The current study demonstrates the effectiveness of sacral MS in diminishing the rectal neck pressure and expelling balloon expulsion in PPS patients. Puborectalis paradoxical contraction was induced by balloon filling of the rectum. The rectal neck pressure was elevated instead of being reduced as occurs under normal conditions; the balloon could not be expelled to the exterior. The balloon expulsion test succeeded to provoke puborectalis paradoxical contraction in all the patients with PPS.

Sacral MS during the provoked puborectalis paradoxical contraction appears to effect acute suppression of the puborectalis muscle contraction so that rectal contraction, induced by balloon filling of the rectum, would initiate the recto-anal inhibitory reflex 49. This results in internal sphincter relaxation, opening of the rectal neck and balloon expulsion to the exterior. It may not be clear why MS caused the puborectalis muscle to relax while Pelliccioni et al 49 reported that the magnetic field is stimulator rather than inhibitory. However, the findings of Pelliccioni et al do not contradict our results because MS, as mentioned by investigators 31,38,39 produces neuromodulation. In vesical and rectal hyperreflexia MS relieved the uninhibited vesical or rectal contractions 38,39. We believe that MS produced the same effect in the PPS. It probably causes acute suppression of the puborectalis muscle contraction. It appears that the neuromodulating effect of MS does not depend on the site or parameters of stimulation.

The cause of paradoxical puborectalis contraction is not known. We suggest that it could result from a disorder of the recto-anal inhibitory reflex. Under normal physiologic conditions, rectal distension produces internal sphincter relaxation and momentary external anal sphincter contraction 49,51. It has been previously demonstrated that the puborectalis muscle is a part of the external anal sphincter 52. The involuntary contraction of the external anal sphincter upon rectal contraction appears to be a protective mechanism which is suggested to prevent fecal soiling due to the involuntary relaxation of the internal anal sphincter upon rectal contraction. The external anal sphincter continues contracting until impulses reach the conscious level and decide whether to defecate or not. If conditions are favorable, the external sphincter relaxes voluntarily and defecation occurs. If conditions are inopportune, the external anal sphincter continues contracting and this evokes the voluntary inhibition reflex 53 with a resulting rectal relaxation and waning of the desire to defecate.

In PPS, we suggest that the patient fails to voluntarily relax the external anal sphincter when it contracts upon rectal contraction. Consequently, the rectal neck remains closed and the rectal contents cannot be evacuated. Failure of the internal anal sphincter to relax due to the contracting external sphincter seems to initiate the voluntary inhibition reflex 53 which results in suppression of the desire to defecate. This cycle of rectal distension, puborectalis contraction, initiation of the voluntary inhibition reflex, rectal relaxation and waning of the desire to defecate is repeated several times with a resulting failure of the patient to evacuate the rectum. It is postulated that sacral MS causes suppression of puborectalis muscle contraction thus interrupting the aforementioned cycle and effecting rectal evacuation.
CONCLUSION

In conclusion, sacral MS succeeded in effecting rectal evacuation of the filled balloon. The method is simple, easy, non-invasive and non-radiologic, and can be performed on an outpatient basis. Further studies are needed to assess its usefulness in clinical practice.

REFERENCES

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