ABSTRACT

Objective To use CT scanning to evaluate the precision with which acupuncture needles can be inserted into sacral foramina to establish sacral nerve modulation by electroacupuncture.

Methods The subjects were five adult women (mean age 71.6 years). These five cases were divided into two groups. In the first three subjects (group A) the intention was to insert acupuncture needles in the S3 and S4 foramina; in the remaining two subjects (group B) the intention was to insert acupuncture needles in the S2 and S3 foramina.

Results CT scanning showed that in subject 1 of group A, the acupuncture needle intended for insertion in S3 was actually in the S4 foramen, and the acupuncture needle intended for insertion in S4 was actually distal to the sacral body. In subjects 2 and 3, the acupuncture needles were inserted accurately in the S3 and S4 foramina. In the three subjects who had acupuncture needles inserted in the S4 foramen, the tip of the acupuncture needle was an average distance of 6.0 mm from the rectum. The acupuncture needles inserted in subjects 4 and 5 of group B were inserted accurately into the S2 and S3 foramina.

Conclusions Inserting acupuncture needles into the sacral foramina of S2 and S3 at an angle of about 60° has the potential to be used for sacral nerve modulation by repeated electroacupuncture stimulation. Needling may be less accurate in subjects with higher body mass index. Because of the potential risk of perforating the rectum with the needle, this technique must be used by specialists only.

Trial registration number : 2013-026

INTRODUCTION

Sacral neuromodulation (SNM) is the name given to a formal technique approved by the US Food and Drug Administration for the treatment of urge incontinence in 1997 and for urgency or frequency and non-obstructive urinary retention in 1999. SNM is classified into non-invasive therapies such as anticholinergics or pelvic floor training, and surgical procedures such as bladder augmentation and urinary deviation. Over 40,000 patients worldwide have received this therapy to treat a variety of non-obstructive urinary retention and urgency or frequency conditions for which conservative therapies have failed.

SNM is commonly a two-stage procedure performed in the operating room. Patients undergo a test stimulation period in which an electrode is placed and used to stimulate the S3 sacral nerve root continuously at subthreshold levels for 2 weeks to determine whether symptoms will improve (stage 1). If patients meet the standard criteria of improvement, they can receive the full implanted system (stage 2). It has been hypothesised that SNM causes inhibition of the somatic afferent pathways in the spinal roots, which in turn modulate voiding and continence reflex pathways in the central nervous system.

Previous reports have described the treatment of lower urinary tract symptoms using acupuncture needles, with manual and electrical stimulation performed at the posterior sacrum surface. This treatment differs from formal SMN because it stimulates different nerves and is given intermittently. However, there has been no detailed consideration of those procedures using imaging.

It is difficult to evaluate the inserted portion of the needle during acupuncture treatment; it is not common procedure to insert needles using guided imagery to confirm their position, depth or the relationship between internal organs and the tip of the needle. However, we considered that in order to perform sacral nerve electrical stimulation using acupuncture needles, it is important to evaluate the safety and legitimacy of acupuncture needle insertion into the sacral foramina.
Therefore, we evaluated CT images of inserted acupuncture needles to determine if this SNM treatment can be performed reproducibly and safely.

METHODS

Participants
Study subjects comprised five adult female outpatients with interstitial cystitis with a mean age of 71.6 ± 4.5 years. These five cases were divided into two groups (A and B). The study protocol was approved by the institutional review board and performed in accordance with the principles of the Declaration of Helsinki. All participants provided written informed consent.

Acupuncture procedure
Group A comprised subjects 1, 2, and 3, in whom the acupuncture needles were intended to be inserted into the S3 foramen and S4 foramen. Group B comprised subjects 4 and 5, who had acupuncture needles intended to be inserted into the S2 foramen and S3 foramen. The acupuncture needles used were disposable, stainless steel, 0.4 mm in diameter, and 50 mm in length (Seirin Kasei, Shimizu, Japan). All subjects were laid in prone position on the CT scanning bed (Somatom Definition AS; Siemens AG, Germany). Sacral foramen positions were identified according to bony landmarks. The S4 foramen was taken to be at the level of the sacral notch, one finger breadth lateral to the midline. The S2 foramen was taken to be at the level of the posterior superior iliac spine, one finger breadth lateral to the midline. The S3 foramen was taken to be in the middle of these two points. Once these positions were located, the needle was inserted at an entry point along the axis of the medial edge of the foramen, at a 60° angle from the skin towards the coccyx. When the needle tip struck the subcutaneous fat at the level of S4 was thinner than at the level of S2 and S3 (table 1).

Endpoints
In this study, primary endpoints were evaluated as the needle positions in each sacral foramen; secondary endpoints were determined with regard to safety, such as distance between rectum and acupuncture needle, pain at the insertion site, and presence or absence of infection and nerve paralysis.

RESULTS

CT scanning showed the mean thickness of subcutaneous fat and sacrum in the five patients was 47.6 ± 6.4 mm at the level of S2, 37.3 ± 6.8 mm at S3, and 29.7 ± 4.4 mm at S4. The thickness of the sacrum and the subcutaneous fat at the level of S4 was thinner than at the level of S2 and S3 (table 1).

In group A, CT scanning showed the mean thickness of subcutaneous fat and sacrum was 35.0 mm at S3, and 29.3 mm at S4. CT assessment of the primary endpoint in subject 1 showed that the acupuncture needle intended for insertion in the S3 foramen was actually in the S4 foramen, and the acupuncture needle intended for insertion in the S4 foramen was actually at the inferior edge of the sacrum (figure 1). Subjects 2 and 3 had the acupuncture needles inserted properly in the S3 and S4 foramina. CT assessment of secondary endpoints showed that a safe distance between the rectum and the acupuncture needles was maintained when the needles were inserted into the S3 foramen. In the three subjects who had needles inserted in the S4 foramen, the tip of the acupuncture needle was in the vicinity of the rectum. The average distance from the rectum to the tip of the acupuncture needle was only 6.0 mm.

In group B, CT scanning showed the mean thickness of subcutaneous fat and sacrum was 47.5 mm at S2, and 40.5 mm at S3. CT assessment of primary endpoint in subjects 4 and 5 showed accurate insertion of acupuncture needles in the S2 and S3 foramina. CT assessment of secondary endpoints showed that a safe distance was maintained between the rectum and the acupuncture needles in subjects 4 and 5 (figure 2).

All subjects complained of pain during the insertion of acupuncture needles, but this was transient. There were no adverse events such as infection or nerve damage identified in this study. Acupuncture needles were accurately inserted in four out of the five subjects. The results are summarised in table 2. The angle between the skin and acupuncture needle was approximately 45° in subject 1. However, insertion was at approximately 65° in subjects 2, 3, 4, and 5 in whom the needles were correctly inserted (figure 3).

DISCUSSION

SNM has been used successfully in refractory cases of interstitial cystitis or painful bladder syndrome (IC/ PBS) and faecal incontinence. SNM has been reported to have a high therapeutic effect. Previous studies have reported the long-term success rates of
96 SNM devices implanted in 88 women and eight men with idiopathic urinary retention, urgency urinary incontinence, and bladder pain syndrome, as 87.5%, 84.8%, and 73%, respectively. Patients included those with idiopathic overactive bladder symptoms. All cases were refractory to conservative treatments or could not tolerate the associated side effects. Voiding diary analysis showed that 38 of 59 patients (64%) were successfully treated. In experiments on animals, neuromodulation reduced the frequency of bladder voiding in rats with hydrochloric acid-induced cystitis, and in spinalised rats associated with a reduced c-fos gene expression. Expression of the TPRV-1 receptor, a pro-nociceptive capsaicin, and heat receptors in C fibres can be reduced by S1 stimulation in rats.

Several studies have used acupuncture to modulate the nervous system via the sacral nerves, hoping to imitate SNM for treating lower urinary tract disorders. One report described the insertion of an acupuncture needle into each side of the sacral foramen sufficiently deep for the tip to be placed close to the sacral periosteum, with the bilateral needles then manually agitated up and down. In another description, acupuncture needles were inserted near the S3 foramen about 6–8 cm deep at an angle of about 45° until the patient felt heaviness and numbness locally or even radiated sensation to the genitalia; needles

### Table 1 Characteristics of subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age (years)</th>
<th>Body mass index (kg/m²)</th>
<th>Subcutaneous fat thickness (mm)</th>
<th>Thickness of the sacrum (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>S2</td>
<td>S3</td>
</tr>
<tr>
<td>1</td>
<td>72</td>
<td>23.1</td>
<td>42.0</td>
<td>33.5</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>20.8</td>
<td>27.0</td>
<td>17.0</td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>22.2</td>
<td>33.0</td>
<td>27.0</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>20.7</td>
<td>33.0</td>
<td>32.0</td>
</tr>
<tr>
<td>5</td>
<td>69</td>
<td>20.5</td>
<td>30.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Average</td>
<td>71.0±4.5</td>
<td>21.5±1.0</td>
<td>33.0±5.2</td>
<td>27.1±5.8</td>
</tr>
</tbody>
</table>

Figure 1 Group A: Image evaluation of acupuncture needles inserted in the S3 and S4 foramina (subjects 1, 2, and 3). Panel A: The acupuncture needle intended for insertion into the S4 foramen of subject 1 was actually distal to the sacral body. Panel B: Acupuncture needles were correctly inserted in the foramina of S3 and S4 in subjects 2 and 3. Panel C: The tip of the acupuncture needle inserted into the S4 foramen was in the vicinity of the rectum.
were stimulated bilaterally manually and then electrically via a 20 Hz disperse-dense wave. Sacral acupuncture was found to be effective in improving symptoms of acetic acid-induced bladder irritation in rats through inhibition of capsaicin-sensitive C-fibre activation. These authors believed that stimulation of the sacral periosteum is actually a type of SNM. Electrical stimulation therapy using acupuncture needles has been used for stimulating the lumbar nerve, pudendal nerve, and posterior tibial nerve. Sciatica is improved by electrical stimulation to the L5 and S1 nerve root, while urinary symptoms and pelvic pain are improved by electrical stimulation of the pudendal nerve and posterior tibial nerve.

Our study is the first to evaluate the procedure and placement of inserted needles. Although conventional SNM surgery involves embedding the lead while using fluoroscopic guidance to check the position of the sacral foramina, in our study the acupuncture needles were inserted without imaging guidance, after determining the location of the sacral foramina using palpation of external bony landmarks.

The neural circuitry that controls micturition is complex, involves pathways at many levels of the brain, the spinal cord and the peripheral nervous system, and is mediated by multiple neurotransmitters. In the brain, many neuron populations are involved in the control of the bladder, the urethra and the urethral sphincter. The regulation of micturition requires...
connections between many areas in the brain and extensive tracts in the spinal cord that involve the sympathetic, parasympathetic and somatic systems. Sympathetic fibres such as the hypogastric nerve arising from the T11–L3 cord segments release nor-epinephrine (noradrenaline), which activates β-adrenergic inhibitory receptors in the detrusor muscle to relax the bladder, α-adrenergic excitatory receptors in the urethra and the bladder neck, and α- and β-adrenergic receptors in the bladder ganglia. Presynaptic fibres arise from neurons in the S2–S4 cord segments, and release both cholinergic and non-adrenergic, non-cholinergic transmitters. Cholinergic transmission is the major excitatory mechanism in the human bladder; it results in detrusor contraction and consequent urinary flow, and is mediated principally by the M3 muscarinic receptor. Somatic cholinergic motor nerves that supply the striated muscles of the external urethral sphincter arise in the S2–S4 motor neurons in Onuf’s nucleus and reach the periphery through the pudendal nerves. The S2–S4 sacral foramina were chosen as the stimulation sites in the current study because the pelvic nerve and the pudendal nerve are composed of S2–S4 nerves. When acupuncture needles are inserted at an angle of 60° or greater towards the coccyx from the dorsal surface of the sacrum, there is less probability of entering a different foramen from the intended sacral foramen. So the inaccurate insertion may have been caused by the more acute insertion angle used as well as subject 1’s larger body type.

In group B, subjects 4 and 5 had acupuncture needles accurately inserted into the S2 and S3 foramina. A safe distance was maintained between the needles and the rectum. The thicknesses of the subcutaneous tissue and the sacrum at the level of S2 and S3 were thicker than at S4. Therefore, there was a larger distance between the sacrum and rectum, making the S2 and S3 sites safer insertion positions. A previous report has shown similar success and failure rates for the S3 and S4 nerve. However, as the subcutaneous tissue and the sacrum become thinner caudally, there is a possibility of puncturing the rectum by an acupuncture needle inserted in the S4 foramen. It is also difficult to palpate the sacrum accurately in obese patients, therefore sacral nerve electrical stimulation of acupuncture needles inserted into the S4 foramen has potential problems with reproducibility and safe insertion. Our CT images showed that rectal penetration can be avoided by inserting needles into the S2 and S3 foramina rather than the S4 foramen.

Adverse events associated with SNM include infection, pain, and change in clinical effect; these adverse effects are often due to migration of leads. Adverse events considered in this study were infection, nerve damage, pain during needle insertion, and penetration of the rectum. Although the incidence of infection during SNM has been reported as 2–12%, the procedure used in this study was less likely to cause infection as the acupuncture needles were not retained for a long period of time, and there was no need for surgical incision.

Because the acupuncture needles were inserted from the rear surface of the sacrum, it is expected that the
Needles were stuck in Waldeyer’s fascia. This originates from the presacral fascia at the S2–S4 level and fuses with the posterior leaf of the mesorectal parietal fascia. Waldeyer’s fascia divides the retrorectal space into inferior and superior compartments, with the upper leaf constituting the floor of the superior compartment and the lower leaf constituting the dome of the inferior compartment; there are no nerves, blood vessels or lymphatic vessels within the two leaves. Therefore, we consider that the type of needle insertion used in the current study is safe when performed by professionals. To avoid sacral nerve damage, the advancement of acupuncture needles should be slow and halted when the patient reports any sensation or pain in the area supplied by the nerve, such as the perineal region or lower limbs. Risk of nerve damage can be further minimised by using thin acupuncture needles and avoiding rough insertion. There have been no reports of nerve damage using acupuncture needle stimulation even in the lumbar nerve root, sacral nerve root, pudendal nerve, and posterior tibial nerve. Patients often report pain if the acupuncture needle touches the posterior sacral surface, but this is temporary and reversible. No nerve damage or infection occurred in the present study.

CT-guided acupuncture needle insertion can be advantageous in confirming the exact needle depth and position, but increases X-ray exposure and complicates the procedure. Therefore, it is not recommended for routine use. The results of this study revealed the importance of careful insertion of acupuncture needles for sacral nerve electrical stimulation. If patients are overweight, it can be difficult to palpate the bony landmarks accurately; conversely, if patients are underweight, there is a shorter distance between the surface and the sacrum. The posterior superior iliac spine is a landmark that is easily identified in obese patients. By identifying the S2 sacral foramen located at the same height as the posterior superior iliac spine, we consider that insertion of longer acupuncture needles into the S3 foramen can be facilitated.

SNM involves continuous nerve stimulation using an insulated needle; in contrast, the procedure used in the current study provided intermittent stimulation using an acupuncture needle that was not insulated. Although the mechanism of neuromodulation by electrical stimulation of sacral roots has not yet been determined, the mode of action is probably different for continuous compared with intermittent stimulation. Confirming the motor and sensory response of the innervated area to electrical stimulation intraoperatively will aid in selecting the best place to insert needles to elicit the desired neural reaction. To insert acupuncture needles into the sacral foramen reproducibly and safely, the needle should be angled approximately 60° towards the coccyx from the site that has been identified by palpation of bony landmarks; it should be inserted into the S2 and S3 foramen at approximately 20 mm from the posterior sacral surface.

This was a preliminary study to demonstrate the therapeutic potential of acupuncture for lower urinary tract disorders such as overactive bladder, pelvic pain syndrome, neurogenic bladder, faecal incontinence, constipation, and sexual dysfunction. Limitations of this study were that only five subjects were evaluated, and that the clinical effect was not validated. However, this is the first study using CT imaging to evaluate the accuracy of acupuncture needle insertion into sacral foramina, and the positional relationship of the inserted needles to the rectum. Further research is necessary to investigate a larger number of cases for safety and validity of the insertion site, and also to assess the clinical effect.

CONCLUSIONS

We used CT imaging to evaluate the validity and safety of inserting acupuncture needles into S2, S3, and S4 sacral foramina. We recommend that acupuncture needles should not be inserted into the S4 foramen, which must be regarded as a procedure for use by specialists only, because of the risk of needle insertion distal to the sacral body and the high risk of rectal puncture. Inserting acupuncture needles into the sacral foramina of S2 and S3 at an angle of approximately 60° shows potential as a non-invasive method of sacral nerve modulation by electroacupuncture.

Summary points

- We investigated acupuncture needling of sacral foramina.
- S2 and S3 foramina were accurately needled in non-obese subjects.
- Needling was inaccurate in the subject with the greatest body mass index.
- Needling of S4 involves the risk of penetrating the rectum and should only be attempted by specialists.

Contributors YK drafted the report, performed the acupuncture procedure and approved the final version of the manuscript. RN performed the CT examinations. TK, HW performed the safety management of the subjects. SM and TK drafted the report and contributed to the final version of the manuscript. All authors read and approved the final manuscript.

Competing interests None declared.

Patient consent Obtained.

Ethics approval Obtained from the ethical review board of the Miyazaki University medical department.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

CT evaluation of acupuncture needles inserted into sacral foramina

Yuichi Katayama, Toyoharu Kamibeppu, Ryuichi Nishii, Shoichiro Mukai, Hironobu Wakeda and Toshiyuki Kamoto

Acupunct Med 2016 34: 20-26 originally published online August 5, 2015
doi: 10.1136/acupmed-2015-010775

References
This article cites 21 articles, 1 of which you can access for free at:
http://aim.bmj.com/content/34/1/20#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/