Introduction

Functional dyspepsia includes several chronic and recurrent upper gastrointestinal symptoms, such as epigastric pain, epigastric bloating, early satiation, and fullness, and can be diagnosed in the absence of significant organic reasons for the symptoms1).

In Oriental medicine, one of the most critical diagnostic methods for functional dyspepsia symptoms, such as epigastric distention (心下痞硬), is measuring the pressure pain threshold (PPT) with an algometer2-4).

However, studies of abdominal examination
that include PPT measurements obtained with an algometer, particularly PPT values and symptom improvement before and after treatment, are lacking. Studies assessing the PPT measured with an algometer and symptom improvement after the selection of acupuncture points found that PPT measurements can be important diagnostic markers related to the associated symptoms and prognosis of functional dyspepsia and can help to determine patient prognosis.

The purpose of this study was to determine whether the comparison of the PPT measured using an algometer before and after treatment can predict the diagnosis and progression of functional dyspepsia. The correlation between PPT measured with an algometer and symptom improvement before and after treatment was also analyzed.

Methods

1. Participants

Among the patients admitted to OO Korean Medical Hospital between April 14, 2020 and January 21, 2021, we selected patients with functional dyspepsia who experienced varying symptoms in the epigastrium, such as epigastric bloating, early satiation, epigastric heartburn or pain, nausea, and belching for more than six months without any organic findings. Their average period of illness was 72.64±94.32 months, ranging from at least 3 months to at least 360 months (30 years). In addition, during the hospitalization period, acupuncture and herbal medicine treatments, and complex oriental medicine treatments that depends on the symptoms. Patients who refused to respond to the questionnaire or missed any of the items were excluded from the survey. This study was approved by the Institutional Review Board of OO Korean Medical Hospital (IRB No.: OO00003-21-CR-001), and oral consent was provided by all patients before treatment for the usage of their data in this retrospective study.

2. Methods for measurement

1) PPT measurement using an algometer

An algometer is an instrument in which a numerical value corresponding to force rises as the pressure on the measuring site is increased. For accurate pressure intensity measurements, an electronic algometer (FPX 25; Wagner Instruments, Greenwich, CT, USA) was used. On the 1st and 14th days of hospitalization (after breakfast, before treatment), a Korean medical doctor placed the algometer vertically on the selected abdominal location and then gradually applied pressure at a constant rate (1 kg/s) to measure the pressure of the first pain complaint point (kg/cm²) twice at 1-min intervals. The selected abdominal locations were acupuncture points Juque (巨厥, CV14), Shangwan (上脘, CV13), Zhongwan (中脘, CV12), Xiawan (下脘, CV10), Guanuan (關元, CV4), right-side Tianshu (天樞, ST25), left-side Tianshu (天樞, ST25), right-side Daju (大巨, ST27), and left-side Daju (大巨, ST27). Among each acupuncture points, especially Zhongwan (中脘, CV12), Guanuan (關元, CV4), and Tianshu (天樞, ST25), which are the abdominal Front Point (募穴) of the stomach, small intestine, and large intestine, were selected, and the rest of acupuncture points were mainly those complaining of abdominal tenderness in clinical practice.
2) VAS measurement of patient symptoms

On the 1st and 14th days of hospitalization, participants were asked to record changes in the visual analog scale (VAS) for the 11 categories of symptoms, including gastrointestinal and associated clinical symptoms, such as epigastric discomfort, bloating, belching, reflux; chest discomfort; breathing difficulty; heart palpitations; irritated or sore throat; back pain; headache; and dizziness.

3. Research instruments

The research instruments used in this study are as follows:

1) Algometer: FPX 25; Wagner Instruments, Greenwich, CT, USA (Fig 1)
2) VAS scale: Korea Medical Information Cooperation, Korea, pain assessment scale.

4. Statistical analyses

Statistical significance was defined as $P < 0.05$. The data were processed and analyzed using SPSS software for Windows (Release 19.0K, IBM Corp., Armonk, NY, USA).

The PPT values measured with an algometer and the VAS scores for patient symptoms were analyzed for numerical changes following treatment using a paired sample t-test. The correlation between PPT measured using an algometer and the VAS score for patient symptoms was examined using a correlation analysis.

Results

1. Baseline characteristics of patients

The average age, height, weight, body mass index, and male-to-female ratio of the 99 patients with functional dyspepsia included in the study were 55.30±13.13 years, 161.95±7.80 cm, 55.06±14.31 kg, 21.72±3.28 km/m², and 1:2.7, respectively. A total of 65 patients were in the age group of 50-60 years and accounted for 66% of the participants (Table 1).

2. Analysis results of PPT measurement using the algometer

The paired sample t-test in the patient group showed that the PPT value (kg/cm²) measured in Juque (巨厥, CV14) gradually and significantly increased from 3.46±1.36 kg/cm² on the 1st day...
of hospitalization to 4.26±1.29 kg/cm² on the 14th day of hospitalization (P < 0.05). Similarly, the PPT values measured in Shangwan (上脘, CV13), Zhongwan (中脘, CV12), Xiawan (下脘, CV10), Guanuan (關元, CV4), right-side Tianshu (天樞, ST25), left-side Tianshu (天樞, ST25), right-side Daju (大巨, ST27), and left-side Daju (大巨, ST27) increased gradually and significantly (P < 0.05) (Table 2, Fig 2).

3. Results of VAS measurement for patient symptoms

The results of the paired sample t-test showed that the VAS scores for symptoms significantly decreased from the days 1 to 14 in all 11 categories, including epigastric discomfort, bloating, belching, reflux, chest discomfort, breathing difficulty, palpitations, irritated or sore throat, back pain, headache, and dizziness (Table 3, Fig 3).

4. Correlation analysis of the PPT measured using the algometer and VAS score for patient symptoms

Analysis of the correlation between the PPT measured using the algometer and VAS for patient symptoms showed a significant negative correlation. In particular, on the 1st day of hospitalization, the PPT at Juque (巨厥, CV14) showed a significant negative correlation with the VAS score for belching (-0.429) and palpitations (-0.401). Negative correlations with VAS scores for several symptoms were also seen in Shangwan (上脘, CV13), Zhongwan (中脘, CV12), Xiawan

---

Table 2. Pressure pain threshold measured using an algometer

<table>
<thead>
<tr>
<th></th>
<th>CV14</th>
<th>CV13</th>
<th>CV12</th>
<th>CV10</th>
<th>CV4</th>
<th>ST25 (R)</th>
<th>ST25 (L)</th>
<th>ST27 (R)</th>
<th>ST27 (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Day</td>
<td>3.46±1.36</td>
<td>2.95±1.04</td>
<td>2.75±0.93</td>
<td>2.58±0.85</td>
<td>2.62±1.00</td>
<td>2.98±1.20</td>
<td>2.89±1.08</td>
<td>2.75±1.10</td>
<td>2.83±1.12</td>
</tr>
<tr>
<td>14th Day</td>
<td>4.26±1.29</td>
<td>3.76±1.30</td>
<td>3.44±1.16</td>
<td>3.18±0.95</td>
<td>3.08±0.96</td>
<td>3.60±1.21</td>
<td>3.71±1.31</td>
<td>3.46±1.24</td>
<td>3.60±1.24</td>
</tr>
</tbody>
</table>

CV14, Juque (巨厥); CV13, Shangwan (上脘); CV12, Zhongwan (中脘); CV10, Xiawan (下脘); CV4, Guanuan (關元); ST25 (R), right-side Tianshu (天樞); ST25 (L), left-side Tianshu (天樞); ST27 (R), right-side Daju (大巨); ST27 (L), left-side Daju (大巨).
Table 3. Visual analog scale scores for patient symptoms

<table>
<thead>
<tr>
<th></th>
<th>Epigastric discomfort</th>
<th>Burping*</th>
<th>Bloating*</th>
<th>Reflux*</th>
<th>Chest discomfort</th>
<th>Palpitation*</th>
<th>Irritated or sore throat</th>
<th>Breathing difficulty*</th>
<th>Back pain*</th>
<th>Headache*</th>
<th>Dizziness*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st day</td>
<td>5.11±2.95</td>
<td>3.87±3.00</td>
<td>5.14±2.97</td>
<td>4.05±3.16</td>
<td>4.93±3.13</td>
<td>3.54±2.92</td>
<td>4.38±3.31</td>
<td>4.27±3.27</td>
<td>3.71±3.27</td>
<td>3.97±3.04</td>
<td></td>
</tr>
<tr>
<td>14th day</td>
<td>2.96±2.74</td>
<td>3.02±2.49</td>
<td>3.15±2.76</td>
<td>2.41±2.71</td>
<td>3.04±2.84</td>
<td>2.29±2.55</td>
<td>2.39±2.58</td>
<td>3.07±2.90</td>
<td>2.36±2.50</td>
<td>2.17±2.66</td>
<td>2.10±2.42</td>
</tr>
</tbody>
</table>

Table 4. Pearson correlation analysis between the algometer pressure pain threshold and symptom visual analog scale scores for patient symptoms on the 1st & 14th day

<table>
<thead>
<tr>
<th></th>
<th>Epigastric discomfort</th>
<th>Burping*</th>
<th>Bloating*</th>
<th>Reflux*</th>
<th>Chest discomfort</th>
<th>Palpitation*</th>
<th>Irritated or sore throat</th>
<th>Breathing difficulty*</th>
<th>Back pain*</th>
<th>Headache*</th>
<th>Dizziness*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st day</td>
<td>CV14</td>
<td>-0.337**</td>
<td>-0.253*</td>
<td>-0.429**</td>
<td>-0.181</td>
<td>-0.258**</td>
<td>-0.401**</td>
<td>-0.142</td>
<td>-0.138</td>
<td>-0.205*</td>
<td>-0.217*</td>
</tr>
<tr>
<td></td>
<td>CV13</td>
<td>-0.308**</td>
<td>-0.211*</td>
<td>-0.396**</td>
<td>-0.113</td>
<td>-0.261**</td>
<td>-0.373**</td>
<td>-0.068</td>
<td>-0.118</td>
<td>-0.111</td>
<td>-0.213*</td>
</tr>
<tr>
<td></td>
<td>CV12</td>
<td>-0.292**</td>
<td>-0.215*</td>
<td>-0.347**</td>
<td>-0.140</td>
<td>-0.215*</td>
<td>-0.342**</td>
<td>-0.042</td>
<td>-0.112</td>
<td>-0.078</td>
<td>-0.165</td>
</tr>
<tr>
<td></td>
<td>CV10</td>
<td>-0.330**</td>
<td>-0.198*</td>
<td>-0.347**</td>
<td>-0.142</td>
<td>-0.242**</td>
<td>-0.388**</td>
<td>-0.079</td>
<td>-0.150</td>
<td>-0.077</td>
<td>-0.252*</td>
</tr>
<tr>
<td></td>
<td>CV4</td>
<td>-0.280**</td>
<td>-0.209*</td>
<td>-0.292**</td>
<td>-0.126</td>
<td>-0.257**</td>
<td>-0.366**</td>
<td>-0.077</td>
<td>-0.155</td>
<td>-0.113</td>
<td>-0.250*</td>
</tr>
<tr>
<td></td>
<td>ST25 (R)</td>
<td>-0.285**</td>
<td>-0.180</td>
<td>-0.291**</td>
<td>-0.079</td>
<td>-0.282**</td>
<td>-0.308**</td>
<td>-0.047</td>
<td>-0.106</td>
<td>-0.095</td>
<td>-0.253*</td>
</tr>
<tr>
<td></td>
<td>ST25 (L)</td>
<td>-0.201*</td>
<td>-0.207*</td>
<td>-0.163</td>
<td>-0.090</td>
<td>-0.197</td>
<td>-0.201*</td>
<td>-0.080</td>
<td>-0.198</td>
<td>-0.131</td>
<td>-0.083</td>
</tr>
<tr>
<td></td>
<td>ST27 (R)</td>
<td>-0.371**</td>
<td>-0.289**</td>
<td>-0.381**</td>
<td>-0.194</td>
<td>-0.361**</td>
<td>-0.396**</td>
<td>-0.119</td>
<td>-0.230*</td>
<td>-0.158</td>
<td>-0.376**</td>
</tr>
<tr>
<td></td>
<td>ST27 (L)</td>
<td>-0.177</td>
<td>-0.204*</td>
<td>-0.168</td>
<td>-0.182</td>
<td>-0.186</td>
<td>-0.107</td>
<td>0.007</td>
<td>-0.269*</td>
<td>-0.169</td>
<td>-0.084</td>
</tr>
<tr>
<td></td>
<td>ST27 (R)</td>
<td>-0.272**</td>
<td>-0.112</td>
<td>-0.222*</td>
<td>-0.051</td>
<td>-0.202*</td>
<td>-0.309**</td>
<td>-0.002</td>
<td>-0.074</td>
<td>-0.075</td>
<td>-0.258*</td>
</tr>
<tr>
<td></td>
<td>ST27 (L)</td>
<td>-0.264**</td>
<td>-0.235*</td>
<td>-0.186</td>
<td>-0.135</td>
<td>-0.255*</td>
<td>-0.239*</td>
<td>-0.147</td>
<td>-0.267**</td>
<td>-0.212*</td>
<td>-0.119</td>
</tr>
<tr>
<td></td>
<td>ST27 (R)</td>
<td>-0.325**</td>
<td>-0.263**</td>
<td>-0.336**</td>
<td>-0.179</td>
<td>-0.348**</td>
<td>-0.362**</td>
<td>-0.145</td>
<td>-0.262**</td>
<td>-0.182</td>
<td>-0.258*</td>
</tr>
<tr>
<td></td>
<td>ST27 (L)</td>
<td>-0.237*</td>
<td>-0.235*</td>
<td>-0.146</td>
<td>-0.132</td>
<td>-0.207*</td>
<td>-0.178</td>
<td>-0.060</td>
<td>-0.271**</td>
<td>-0.140</td>
<td>-0.062</td>
</tr>
</tbody>
</table>

* P < 0.05  ** P < 0.01

CV14, Juque (巨厥); CV13, Shangwan (上脘); CV12, Zhongwan (中脘); CV10, Xiawan (下脘); CV4, Guanuan (關元); ST25 (R), right-side Tianshu (天樞); ST25 (L), left-side Tianshu (天樞); ST27 (R), right-side Daju (大巨); ST27 (L), left-side Daju (大巨).
(下脘, CV10), Guanuan (關元, CV4), right-side Tianshu (天樞, ST25), left-side Tianshu (天樞, ST25), right-side Daju (大巨, ST27), and left-side Daju (大巨, ST27) (Table 4).

**Discussion**

Increased PPT indirectly indicates a gradual reduction in the abdominal stiffness after treatment. The significant reduction in VAS scores for patient symptoms, such as epigastric discomfort, bloating, belching, reflux, chest discomfort, breathing difficulty, palpitations, irritated or sore throat, back pain, headache, and dizziness, indicated improvements in symptoms resulting from treatment and indirectly reflected diminished abdominal stiffness.

The PPT measured using the algometer showed a significant negative correlation with several VAS scores for patient symptoms, especially at Juque (巨厥, CV14), Shangwan (上脘, CV13), Zhongwan (中脘, CV12), Xiawan (下脘, CV10), Guanuan (關元, CV4), right-side Tianshu (天樞, ST25), left-side Tianshu (天樞, ST25), right-side Daju (大巨, ST27), and left-side Daju (大巨, ST27), on the 1st day of hospitalization. This can be seen as a result of treatment, indicating that there is some association between symptom improvement and relief of abdominal stiffness. In addition, efficacy of each acupuncture point, which mainly complains of abdominal tenderness, and Zhongwan (中脘, CV12), Guanuan (關元, CV4), and Tianshu (天樞, ST25), which are the abdominal Front Point(募穴) of the stomach, small intestine, and large intestine, is mainly related to gastrointestinal diseases, suggesting the possibility that each acupuncture point can be a diagnostic and treatment point for FD symptoms. The severity of functional dyspepsia symptoms and treatment progress can be objectified and quantified using an algometer. Furthermore, previous studies have shown that algometers are beneficial for assessing treatment status, as they can infer the change in PPT, which is related to improvement in symptoms with treatment progress. Moreover, its high sensitivity for diagnosis suggests that the algometer can be a critical tool for objective measurement of changes in symptoms of functional dyspepsia.

As this study was limited by its relatively small sample size and restriction to patients with functional dyspepsia, further studies that expand on other gastrointestinal diseases are required. As in this study, there are existing previous studies to objectification of abdominal examination through PPT measurement, but additional analysis of the case for patients with worsening individual symptoms is needed. Further, although this study increased the objectivity of progression and prognosis of functional dyspepsia using an algometer, more research is needed to obtain and apply standard cutoff values. Cross-validation with more participants and additional objective examinations is necessary to verify the utility of our findings.

**Conclusions**

The present study found that the VAS scores for the symptoms of 99 patients with functional dyspepsia significantly decreased with treatment. The abdominal PPT measurements using the
algometer significantly increased with treatment progression, which corresponds to the decrease in the patient symptoms and abdominal stiffness after treatment. Hence, the present findings suggest that when symptoms of functional dyspepsia improve, abdominal stiffness decreases. PPT values can be useful as an objective tool for the quantification of symptoms and treatment progress in the diagnosis and treatment of patients with functional dyspepsia.

References


ORCID

Gi-Hwan Rho https://orcid.org/0000-0003-4361-577X
Gyu-Ho Choi https://orcid.org/0000-0001-7982-5141
Sang-Hyun Lee https://orcid.org/0000-0002-7115-4504
Hyeon-Min Noh https://orcid.org/0000-0002-5441-4212
Seo-Hyung Choi https://orcid.org/0000-0002-6939-5085