J. Phys. Ther. Sci.
27: 209–212, 2015

Original Article

Effects of xenon irradiation of the stellate ganglion region on fibromyalgia

Fukami Nakajima, MD[1–4], Akihiro Komoda, PT[1], Satoko Aratani, PhD[3, 7, 8], Hidetoshi Fujita PhD[3, 7, 8], Mariko Kawate, MD, PhD[4], Kou Nakatani, MD, PhD[5], Masako Akiyama, PharB[6], Koshi Makita, MD, PhD[2], Toshihiro Nakajima, MD, PhD[1, 3, 5, 7, 8]*

[1] *Daiichi Rehabilitation Hospital, Japan*
[2] *Department of Anesthesiology, Graduate School of Medical and Dental Science, Tokyo Medical and Dental University: 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519, Japan*
[3] *Department of Locomotor Science, Institute of Medical Science, Tokyo Medical University, Japan*
[4] *Nishiogi Pain Clinic, Japan*
[5] *Bayside Misato Medical Center, Japan*
[6] *University Research Administration Office, Tokyo Medical and Dental University, Japan*
[7] *Future Medical Science Institute of Medical Science, Tokyo Medical University, Japan*
[8] *Integrated Genome Editing Section (iGES) Institute of Medical Science, Tokyo Medical University, Japan*

Abstract. [Purpose] The aim of the study was to determine the effect of xenon irradiation of the stellate ganglion region on fibromyalgia. [Subjects] The study included 5 men and 22 women (age, 56.4 ± 16.3 years [range, 25–84 years]) who were diagnosed with fibromyalgia according to the modified 2010 criteria of the American College of Rheumatology between July and August 2013. [Methods] Bilateral xenon light irradiation (0.38–1.1 μm) around the stellate ganglion was performed in the supine position by physical therapists using a xenon phototherapy device. We evaluated pain before and after irradiation using the visual analogue scale. [Results] We did not observe a relationship between the change in the visual analogue scale score and duration of fibromyalgia. However, we observed a relationship between the change in the visual analogue scale score and the score for the Japanese version of the Fibromyalgia Impact Questionnaire using the Cochran-Armitage test for trend. [Conclusion] Xenon light irradiation of the stellate ganglion significantly decreased the visual analogue scale score in patients with fibromyalgia having a higher score in the Fibromyalgia Impact Questionnaire, suggesting that a stronger effect could be obtained in patients with more severe fibromyalgia.

Key words: Fibromyalgia, Xenon light irradiation, Stellate ganglion

(This article was submitted Jun. 19, 2014, and was accepted Aug. 3, 2014)

INTRODUCTION

Fibromyalgia (FM) is predominantly found in women[1, 2] and is characterized by widespread chronic pain[3]. Other symptoms including allodynia, sleep disturbances, fatigue, depression, and cognitive impairment[4] are also observed.

Patients with FM are treated with pharmacotherapy, functional therapy, cognitive behavioral therapy and alternative therapies[5–8]. However, because the cause of FM is unclear, there is no clinically effective treatment method at present. For most patients, pharmacotherapy cannot reduce the pain as markedly as they expect, and reduction of pain is difficult because of the indefinite nature of the symptoms.

Bengtsson et al. performed stellate ganglion block (SGB) in eight FM patients and reported its effects on reducing both the number of tender points and pain at rest[9]. However, noninvasive methods for SGB have been suggested for several reasons. First, FM patients tend to feel excessive pain from the needle injection during SGB. Second, complications can occur during SGB such as intravenous or intra-arterial injection. Third, serious adverse effects following SGB, such as death caused by retropharyngeal hematoma, have been reported[10–12].

Yoshida et al. reported that Xenon light irradiation on the skin surface at the needle insertion site in SGB produced sympathetic block effects similar to those of conventional SGB[13]. Many studies have shown the effects of stellate ganglion irradiation (SGI) with various types of light in patients with diverse diseases who responded to SGB[14, 16]. SGI, with its lack of serious side effects, may be a promising treatment method that could replace SGB[13, 15].

We performed SGI in patients with primary FM by using xenon light generated by high-intensity electrical stimulation of xenon gas and evaluated its effects on pain.

*Corresponding author. Toshihiro Nakajima (E-mail: marlin@tokyo-med.ac.jp)

SUBJECTS AND METHODS

This study was initiated after obtaining approval from the ethics committee of Daiichi Rehabilitation Hospital on May 17, 2013 (FMS-0003). The study group consisted of 5 men and 22 women (age, 56.4 ± 16.3 years [range, 25–84 years]; FM duration, 3.6 ± 2.4 years [range, 1–10 years]) (Table 1) who visited the FM clinic of Daiichi Rehabilitation Hospital (Kochi, Japan) between July 2013 and August 2013. Patients were diagnosed with FM according to the modified 2010 American College of Rheumatology (ACR) diagnostic criteria for fibromyalgia and gave written consent to participate in this study after proper explanation of the procedure. At the time of the first consultation, patients were asked about their age and duration since onset. Bilateral xenon light SGI was performed by physical therapists (PT) in the supine position on a bed (Fig. 1A) using a xenon phototherapy device (AUVE, Nihon Iko Co., Ltd., Tokyo, Japan) for 15 min (once per second during the first 1-minute period and once every 4 s for the subsequent 14-minute period). Before and after irradiation, the effects on pain were evaluated by the physical therapists using a visual analogue scale (VAS) consisting of 101 levels (0–100). In addition, the Japanese version of the Fibromyalgia Impact Questionnaire (J-FIQ)[17] was completed before irradiation. In responders to xenon light SGI, the duration of the immediate effects (time until pain returned to the pre-SGI level) was evaluated using a selection-type questionnaire. Because all patients were also receiving drug therapy, evaluation of the long-term effects of xenon-light SGI alone was impossible.

Xenon light, which is generated by high-intensity electrical stimulation of xenon gas, is used for wound-healing and analgesia, including analgesia against joint pain, as a low-level light therapy (LLLT)[13]. The emission spectrum of xenon consists of continuous complex wavelengths (380–1,100 nm) (Fig.1B). Ultraviolet rays of 400 nm or less are cut using filters in this device (AUVE, Nihon Iko Co., Ltd. Tokyo Japan). In addition, because the wavelength range is in the near-infrared region, the risk of burns is low, and absorption by water, melanin, and hemoglobin is minimal. Therefore, xenon reaches deep areas of the body, with excellent permeability. In general, the light emission pattern is continuous or pulsed. For treatment of deep areas of the body, high energy is necessary. When light energy is increased using continuous waves, the local temperature rises. Light energy can be increased while thermal energy is inhibited by using pulse waves employing a pulse width shorter than the time required for thermal diffusion. Hashmi et al. reviewed studies on LLLT performed between 1970 and 2010 and reported stronger effects for pulse waves than for continuous waves[18]. This xenon phototherapy device provides high-energy light (18 J/pulse) by reducing the pulse width to 5/1,000 s. Fig.1C shows the device characteristics (Nihon Iko Co., Ltd.). In the present study, this effect was examined using the Cochran-Armitage test for trend (CA-trend test) and JMP10 (SAS Institute Inc., Cary, NC, USA).

Table 1. Patients' characteristics, changes in the visual analogue scale (VAS) score, and duration of the immediate effects of stellate ganglion irradiation (SGI)

Patient No.	Age	Sex	Age of onset	Duration of FM (year)	J-FIQ	%VAS	Duration of immediate effects
1	55	F	51	4	60.1	100	
2	25	F	21	4	42.1	100	
3	65	F	63	2	32.5	100	
4	45	F	nc	nc	27.6	100	
5	45	F	37	8	70.9	90	24 hours
6	58	F	56	2	83.9	100	
7	84	F	83	1	84.1	81	No answer
8	44	F	43	1	59.2	63	24 hours
9	84	M	83	1	58.8	80	2–3 hours
10	49	M	47	2	75.6	94	24 hours
11	71	F	66	5	70.0	90	12 hours
12	40	M	37	3	76.9	92	No answer
13	38	M	35	3	48.2	100	
14	74	F	64	10	79.2	75	12 hours
15	71	F	61	10	95.6	88	3 days
16	32	F	31	1	63.8	100	
17	55	F	53	2	63.1	100	
18	52	F	48	4	75.0	92	Within 30 minutes
19	53	F	nc	nc	73.0	91	3 days
20	59	F	nc	nc	40.6	100	
21	42	F	37	5	45.6	100	
22	71	F	70	1	68.3	87	No answer
23	71	F	nc	nc	46.9	72	No answer
24	74	F	73	1	28.4	106	
25	36	M	28	8	62.0	100	
26	80	F	77	3	39.9	100	
27	51	F	48	3	95.6	100	

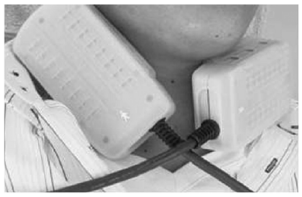
%VAS = (VAS score after SGI/that before SGI) × 100
nc: not clear

RESULTS

Table 1 shows the patients' characteristics, the changes in the VAS score (%VAS = [VAS score after SGI/VAS score before SGI] × 100), and the duration of the immediate effects of SGI. There were 4 patients who did not complete the questions on the duration of the immediate effects in the questionnaire because they had only a vague memory of the effect and could not accurately remember the duration of the immediate effect when answering the questionnaire. One patient showed an increase in the VAS score after the therapy, which was considered to result from neck dorsiflexion during irradiation compared with the posture in daily life. This adverse effect can likely be improved by adjusting the pillow height during irradiation.

Patients were classified according to the duration after onset into 10 groups (1–10 years) and according to the severity as established by the J-FIQ into 3 groups: (J-FIQ ≥

Fig. 1A



Wavelength	Linearly polarized 0.38-1 μm (spectral peak 0.8-1 μm)
Source	Xenon flash lamp
Applicator aperture	27.2 cm²
Duty cycle	Once per sec and during the first 1-minute period and once per 4 seconds for the subsequent 14-minute period (light moment of 5/1000 seconds)
Treatment duration	900 seconds
Treatment energy	18 J

Fig. 1C

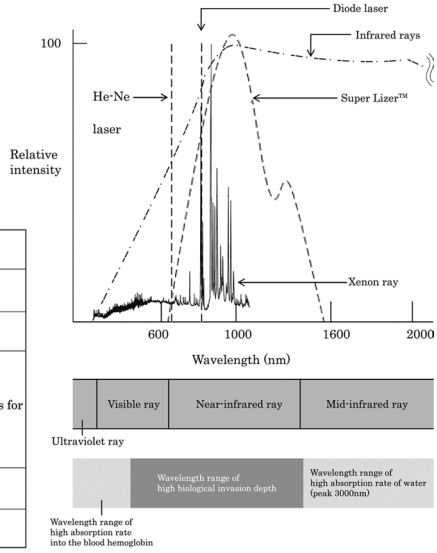


Fig. 1B

Fig. 1. A: Use of emission probes of the xenon phototherapy device for irradiation around the stellate ganglion region. B: The emission spectrum of xenon consists of continuous complex wavelengths (380–1,100 nm). C: Characteristics of the xenon phototherapy device (Nihon Iko Co., Ltd.)

Table 2. Changes in the visual analogue scale (VAS) score according to the duration of fibromyalgia (FM)

Duration of FM (year)	1	2	3	4	5	6	7	8	9	10
%VAS<100 (people)	4	1	2	1	1	0	0	1	0	2
%VAS=100 (people)	3	3	3	2	1	0	0	1	0	0

Table 3. Changes in the visual analogue scale (VAS) score according to the severity of fibromyalgia (FM)

Severity	%VAS=100	%VAS<100
Mild	8	2
Moderate	4	3
Severe	2	8

70.0 (severe), 70.0 > J-FIQ > 50.0 (moderate), and J-FIQ ≤ 50.0 (mild)[19]. No clear relationship was detected between the change in VAS score and the duration of FM. (Tables 1 and 2). However, a clear relationship was detected between the change in VAS score and the severity of FM. Table 3 shows the number of patients with a decrease or no change in the VAS score after SGI in each group. The VAS score decreased in 81% of the patients with a J-FIQ score of ≥70.0, in 43% of those with a score of <70.0 and >50.0, and in 11% of those with a score of ≤50.0. The trend was statistically examined using the Cochran-Amitage test for trend, and with a higher pre-SGI J-FIQ score, the VAS score tended to significantly decrease after SGI ($p = 0.0036$). Next, we used the paired t-test to compare the VAS scores before and after SGI in patients with severe FM. The difference was statistically significant ($p=0.001$).

DISCUSSION

The main finding in this study is that the VAS score decreased significantly after SGI in patients with a higher J-FIQ score.

Because the VAS for pain, used as the outcome measure in this study, is subjective, a true double-blind trial with a placebo would have been desirable[20, 21]. However, placebo irradiation could not be performed because irradiation produces a specific, warm sensation in the upper half of the body, so it would be obvious to subjects when the irradiation was a placebo. In addition, although subjects can be blindfolded so that they cannot see light emission during irradiation, the operator can readily determine whether or not the irradiation is a placebo based on light emission.

In this study, only immediate effects were evaluated based on VAS scores immediately before and immediately after SGI. Although the VAS score decreased compared with the pre-SGI score, the effects were transient. The pre-SGI level of pain returned within 3 days. However, continuation of this treatment at regular intervals is expected to gradually reduce the level of pain returning after SGI compared with the pre-SGI level[22]. Therefore, if the VAS score is measured before each SGI when SGI is performed regularly, the pre-SGI VAS score may decrease in the long term. However, because all patients were also receiving drug therapy, evaluation of the long-term effects of xenon SGI alone was impossible. Moreover, the number of patients was not sufficient for statistical analysis; therefore, the results of the Cochran-Amitage test for trend may be inaccurate. Although our results may have been influenced by the placebo effect and by an inaccurate statistical analy-

sis, we strongly suggest that SGI may be a beneficial treatment for FM. Because the cause of FM is unclear at present, there is no definitive treatment method for FM, and drug therapy also only serves as a palliative method to relieve pain[5]. Some patients endure severe pain for a long period because drug therapy cannot reduce the pain to the degree they expected[23]. In such patients, methods such as SGI that reduce pain (even slightly) are beneficial because they facilitate pain control to improve the quality of life (QOL)[24]. Our study suggested stronger effects of SGI in patients with more severe symptoms, i.e., with a higher J-FIQ score. Pain control is more difficult in patients with a higher severity of symptoms. Treatment methods that reduce pain without side effects and do not require special training help to improve the QOL of FM patients with severe symptoms[24].

The cause of FM is unclear. However, studies in various fields have suggested it is caused by neuroendocrine abnormalities[25], neurotransmitter abnormalities[26], or sympathetic hyperactivity[27]. It is possible that SGI reduces sympathetic overactivity[13], which may be more closely associated with pain in FM patients with a higher J-FIQ score, as suggested by our results.

In this study, SGI did not induce Horner syndrome. It is speculated that SGI has a much weaker effect than SGB, which may be why the effect observed in the present study was weaker than that obtained by Bengtsson et al[9].

In conclusion, in this study, we demonstrated that irradiation of the stellate ganglion region with xenon (0.38–1.1 μm) decreases the VAS score in patients with FM having a higher J-FIQ score, which suggests that stronger effects could be obtained in patients with more severe FM.

ACKNOWLEDGEMENTS

We thank all of the physical therapists who contributed to this study. We are grateful to all of the staff at Daiichi Rehabilitation Hospital in Kochi, Japan.

REFERENCES

1) Wolfe F: Fibromyalgia. Rheum Dis Clin North Am, 1990, 16: 681–698. [Medline]
2) Wolfe F, Ross K, Anderson J, et al.: The prevalence and characteristics of fibromyalgia in the general population. Arthritis Rheum, 1995, 38: 19–28. [Medline] [CrossRef]
3) Wolfe F: Fibrositis, fibromyalgia, and musculoskeletal disease: the current status of the fibrositis syndrome. Arch Phys Med Rehabil, 1988, 69: 527–531. [Medline]
4) Hawkins RA: Fibromyalgia: a clinical update. J Am Osteopath Assoc, 2013, 113: 680–689. [Medline] [CrossRef]
5) Ablin JN, Buskila D: Fibromyalgia syndrome—novel therapeutic targets. Maturitas, 2013, 75: 335–340. [Medline] [CrossRef]
6) Ablin J, Fitzcharles MA, Buskila D, et al.: Treatment of fibromyalgia syndrome: recommendations of recent evidence-based interdisciplinary guidelines with special emphasis on complementary and alternative therapies. Evid Based Complement Alternat Med, 2013, 2013: 485272. [Medline] [CrossRef]
7) Sumpton JE, Moulin DE: Fibromyalgia. Handb Clin Neurol, 2014, 119: 513–527. [Medline] [CrossRef]
8) Xu L, Shi R, Wang B, et al.: 21-day balneotherapy improves cardiopulmonary function and physical capacity of pilots. J Phys Ther Sci, 2013, 25: 109–112. [CrossRef]
9) Bengtsson A, Bengtsson M: Regional sympathetic blockade in primary fibromyalgia. Pain, 1988, 33: 161–167. [Medline] [CrossRef]
10) Takanami I, Abiko T, Koizumi S: Life-threatening airway obstruction due to retropharyngeal and cervicomediastinal hematomas following stellate ganglion block. Thorac Cardiovasc Surg, 2009, 57: 311–312. [Medline] [CrossRef]
11) Higa K, Hirata K, Hirota K, et al.: Retropharyngeal hematoma after stellate ganglion block: analysis of 27 patients reported in the literature. Anesthesiology, 2006, 105: 1238–1245, discussion 5A–6A. [Medline] [CrossRef]
12) Okuda Y, Urabe K, Kitajima T: Retropharyngeal or cervicomediastinal haematomas following stellate ganglion block. Eur J Anaesthesiol, 2003, 20: 757–759. [Medline] [CrossRef]
13) Yoshida H, Nagata N, Denpouya T: Effects of transcutaneous xenon light irradiation around the stellate ganglion on autonomic functions. J Phys Ther Sci, 2009, 21: 1–6. [CrossRef]
14) Basford JR, Sandroni P, Low PA, et al.: Effects of linearly polarized 0.6–1.6 microM irradiation on stellate ganglion function in normal subjects and people with complex regional pain (CRPS I). Lasers Surg Med, 2003, 32: 417–423. [Medline] [CrossRef]
15) Yoshida H, Nagata K, Narita H, et al.: Does instability during standing occur just after transcutaneous xenon light irradiation around the stellate ganglion? J Phys Ther Sci, 2009, 21: 355–359. [CrossRef]
16) Mii S, Kim C, Matsui H, et al.: Increases in central retinal artery blood flow in humans following carotid artery and stellate ganglion irradiation with 0.6 to 1.6 microm irradiation. J Nippon Med Sch, 2007, 74: 23–29. [Medline] [CrossRef]
17) Osada K, Oka H, Isomura T, et al.: Development of the Japanese version of the Fibromyalgia Impact Questionnaire (JFIQ): psychometric assessments of reliability and validity. Int J Rheum Dis, 2011, 14: 74–80. [Medline] [CrossRef]
18) Hashmi JT, Huang YY, Sharma SK, et al.: Effect of pulsing in low-level light therapy. Lasers Surg Med, 2010, 42: 450–466. [Medline] [CrossRef]
19) Martinez JE, Casagrande PM, Ferreira PP, et al.: Correlation between demographic and clinical variables and fibromyalgia severity. Rev Bras Reumatol, 2013, 53: 460–463. [Medline] [CrossRef]
20) Breivik H, Borchgrevink PC, Allen SM, et al.: Assessment of pain. Br J Anaesth, 2008, 101: 17–24. [Medline] [CrossRef]
21) Cook KF, Dunn W, Griffith JW, et al.: Pain assessment using the NIH Toolbox. Neurology, 2013, 80: S49–S53. [Medline] [CrossRef]
22) Ip VH, Tsui BC: The catheter-over-needle assembly facilitates delivery of a second local anesthetic bolus to prolong supraclavicular brachial plexus block without time-consuming catheterization steps: a randomized controlled study. Can J Anaesth, 2013, 60: 692–699. [Medline] [CrossRef]
23) Durif-Bruckert C, Roux P, Rousset H: Medication and the patient-doctor relationship: a qualitative study with patients suffering from fibromyalgia. Health Expect, 2014. [Medline] [CrossRef]
24) Cassisi G, Sarzi-Puttini P, Casale R, et al.: Pain in fibromyalgia and related conditions. Reumatismo, 2014, 66: 72–86. [Medline] [CrossRef]
25) Di Franco M, Iannuccelli C, Valesini G: Neuroendocrine immunology of fibromyalgia. Ann N Y Acad Sci, 2010, 1193: 84–90. [Medline] [CrossRef]
26) Clauw DJ, Arnold LM, McCarberg BH, FibroCollaborative: the science of fibromyalgia. Mayo Clin Proc, 2011, 86: 907–911. [Medline] [CrossRef]
27) Martinez-Lavin M: Biology and therapy of fibromyalgia. Stress, the stress response system, and fibromyalgia. Arthritis Res Ther, 2007, 9: 216. [Medline] [CrossRef]