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The usefulness of shear wave elastography in evaluating erectile dysfunction severity before and after prostaglandin E1 test

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ABSTRACT

Prostaglandin E1 intracavernous injection test is an established method for diagnosing erectile dysfunction. However, the evaluation is non-objective and often influenced by the evaluator's subjectivity. Herein, we measured and objectively evaluated shear wave elastography results of the corpus cavernosum before and after injection in 16 patients who underwent prostaglandin E1 testing. The response score of prostaglandin E1 tests were "1" in 2 cases, "2" in 2 cases, and "3" in 12 cases. The average transmission velocity before the injection and at the time of maximum erection after the injection were 2.21 m/s and 1.57 m/s, respectively. Transmission velocity decreased during erection in 14 of 16 cases (87.5%). The overall rate of change in transmission velocity due to injection was –26.7% and was significantly different between the poor (responses 1 and 2: –16.1%) and good erection (response 3: –30.2%) groups. To the best of our knowledge, this is the first attempt to evaluate erectile phenomenon using percutaneous ultrasonic elastography in Japan. Rate of change in shear wave transmission velocity due to prostaglandin E1 injection in the corpus cavernosum penis was associated with the degree of erection. Therefore, the rate of change in shear wave transmission velocity in the corpus cavernosum penis could be used as an objective index of erectile phenomenon. Percutaneous ultrasonic elastography is a non-invasive and useful test method for diagnosing erectile dysfunction, determining the therapeutic effect, and predicting prognosis.

Keywords: erectile dysfunction, shear wave elastography, prostaglandin E1 test, shear wave transmission velocity, corpus cavernosum

Abbreviations:
ED: erectile dysfunction
PGE1: prostaglandin E1
SWE: shear wave elastography
SWTV: shear wave transmission velocity

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INTRODUCTION

Erectile dysfunction (ED) is defined as the failure to achieve or maintain a rigid penile erection suitable for satisfactory sexual intercourse. It is one of the most common male sexual dysfunctions.[1] The cause of ED may be organic (vasculogenic, neurogenic, hormonal, or drug induced), psychogenic (anxiety, depression, relationship distress), or mixed. Prostaglandin E1 (PGE1) intracavernous injection test is an established method for diagnosing vasculogenic ED.[1,2] However, its evaluation is often influenced by the subjectivity of the evaluator. Penile ultrasonography is a high-performance, non-invasive imaging modality capable of depicting the normal anatomy and macroscopic pathologic changes in real time. Additionally, temporal changes in penile blood flow, as observed in vasculogenic ED, can be analyzed using color Doppler ultrasound.[1,3] Shear wave elastography (SWE) is a recently developed technique that has been widely used to measure the stiffness of target soft tissues and organs.[4] SWE has been used to examine several organs and pathologies, and has yielded effective outcomes for breast, thyroid, prostate, and liver diseases.[5,6] SWE is thought to be a promising candidate for non-invasive evaluation of stiffness of cavernosal tissues, including penile rigidity.

Herein, we aimed to measure and evaluate SWE in the corpus cavernosum before and after erection during the PGE1 test to determine whether it was possible to objectively and quantitatively evaluate penile erection and hardness using percutaneous ultrasonic elastography.

MATERIALS AND METHODS

Study design and participants

We reviewed the clinical data of consecutive outpatients with ED. These participants met the following inclusion criteria: (a) ≥20 years of age with an average 1-year history of ED and (b) provided consent for measurement and evaluation of penile erection and hardness using ultrasound

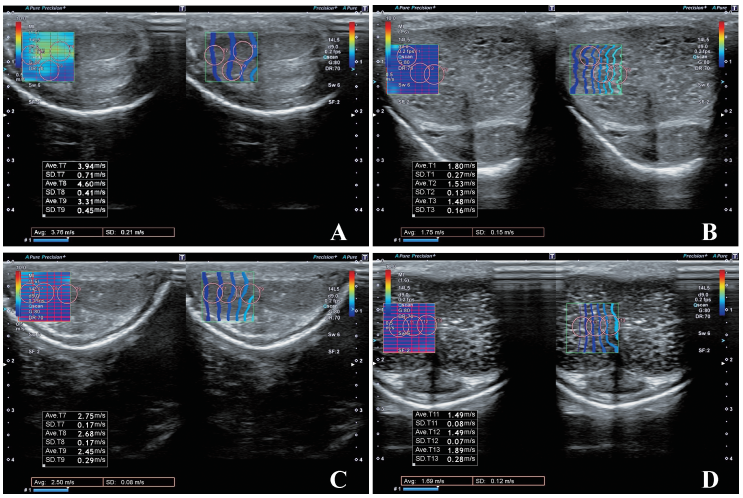

Fig. 1 Real-time shear wave elastography of corpus cavernosum; short axis view
Upper half (**A** and **B**): Good erection (patient No. 1, Response score 3); lower half (**C** and **D**): Poor erection (patient No. 2, Response score 2); left half (**A** and **C**): SWE before PGE1 test; right half (**B** and **D**): SWE after PGE1 test.
SWE: shear wave elastography
PGE1: prostaglandin E1

elastography. The severity of ED was interpreted using the published criteria.[7]

SWE in the corpus cavernosum was performed using percutaneous ultrasonic elastography (Aplio i800 TM; Canon Medical Systems Co, Ltd, Otawara, Tochigi, Japan) before and after injection by a single doctor in 16 patients who underwent the PGE1 test at Chubu Rousai Hospital between April 2020 and March 2022. The four circled points along with the base and tip on both sides of the corpus cavernosum were the measurement sites. The average value of shear wave transmission velocity (SWTV) of each part was adopted as an individual value (Fig. 1). If the function of the vascular system was normal, erection occurred within 10 min of PGE1 injection and lasted for more than 30 min. Erectile response was classified into five stages (Response score): Response 0, No response; Response 1, Swelling but insufficient hardness and duration; Response 2, Adequate firmness, but not sustained; Response 3, Sufficient hardness and durability; Response 4, Prolonged erection (sustained erection).[2]

Ethical considerations

All procedures performed in this study were in accordance with the tenets of Declaration of Helsinki. This prospective study was reviewed and approved by the Asahikawa Medical University Research Ethics Committee 114 (No. 19030) and the Chubu Rousai Hospital Research Ethics Committee (No. 115 201911-01). The requirement for informed consent was waived due to the de-identified and untraceable nature of the data.

Statistical analyses

SAS 9.0 software (SAS, Chicago, IL, USA) was used for statistical analyses. Quantitative data were expressed as mean ± standard deviation (SD). Statistical significance was set at $P < 0.05$.

RESULTS

The response score of PGE1 tests were "1" in 2 cases, "2" in 2 cases, and "3" in 12 cases. Response 0 and 4 were not observed (Table 1). The average SWTV before injection and at the time of maximum erection after injection were 2.21 m/s and 1.57 m/s, respectively. SWTV decreased during erection in 14 of 16 patients (87.5%). The SWTV was significantly reduced after the injection compared to before the injection ($p = 0.00061$) (Data not shown). The overall average rate of change in SWTV due to injection was –26.7%. Average rate of change in SWTV due to injection was –16.1% in the poor erection group (ie, Responses 1 and 2) and –30.2% in the good erection group (ie, Response 3). Differences were observed between the poor and good erection groups. However, the difference was not statistically significant ($p = 0.116$) (data not shown).

Figure 2 shows the receiver operating characteristic (ROC) curve based on the rate of change in velocity. If "–30%" was set as the threshold value, the value beyond this could be judged as good erection with 100% specificity and 58.3% sensitivity (area under the curve, 0.729; 95% confidence interval, 0.475–0.984).

Table 1 Patients' list and the results of measurement

No	Age (yrs.)	Response score	Before mean (m/s)	After mean (m/s)	Rate of change (%)
1	52	3	3.22	1.80	–44.3
2	33	2	2.20	1.83	–16.7
3	24	3	2.24	1.76	–21.5
4	60	3	2.10	1.35	–35.6
5	58	3	2.12	1.44	–32.2
6	73	1	1.68	1.26	–25.3
7	76	3	2.12	1.20	–43.4
8	33	3	1.76	1.57	–10.8
9	80	1	1.97	1.51	–23.4
10	79	3	2.27	2.42	6.4
11	43	3	3.29	1.38	–58.2
12	79	2	1.69	1.71	1.2
13	25	3	2.58	1.22	–52.6
14	54	3	1.99	1.50	–24.9
15	21	3	1.96	1.66	–15.3
16	74	3	2.19	1.53	–29.9

Before: the transmission velocity in SWE before PGE1 test, After: the transmission velocity in SWE after PGE1 test, Rate of change: After compared to Before (Before-After/Before).
yrs.: years
SWE: shear wave elastography
PGE1: prostaglandin E1

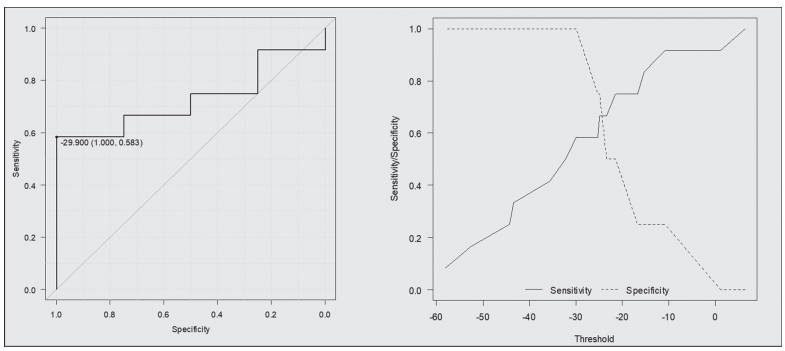

Fig. 2 Receiver operating characteristic curve based on the rate of change in SWTV
SWTV: shear wave transmission velocity

DISCUSSION

Proof of nocturnal penile erection by Rigiscan® and PGE1 test are the only two techniques that have been established as direct evaluation methods for erection.[1] Rigiscan® can measure and evaluate physiological erection. However, facilities providing this service are limited. On the

contrary, PGE1 tests are widely conducted, but the judgment is affected by the subjectivity of the evaluator. In addition, discrepancy between the subjectivity of the evaluator and that of the patient has been reported.[2] Therefore, it is desirable to establish an erection evaluation method that is less invasive, objective, and universal.

Several international studies have reported the use of SWE in measuring ED.[8-12] These studies concluded that although the instruments and methods used were different, SWE was effective in evaluating ED. The first report[8] on using SWE for the corpus cavernosum, revealed that SWE was a non-invasive test, demonstrating significant differences in subjective symptoms between non-erectile (normal) and erectile states. All subsequent reports[9-12] conducted around the same period of time as ours, which assessed the efficacy of SWE in evaluating erectile state induced by PGE1 tests, showed that penile hardness could be measured. Contrary to the findings of a study by Cheng et al,[9] revealing that the value of SWVT of the corpus cavernosum albuginea was a superior indicator of penile hardness to that of the corpus cavernosum, other studies[10-12] showed that the SWVT value of the corpus cavernosum using SWE could be an indicator of erection.

To the best of our knowledge, this is the first study to evaluate erectile phenomenon using SWE in Japan. We found an erection equivalent to Response 3 with 100% specificity and 58.3% sensitivity when the rate of change in the SWTV exceeded –30%. The rate of change in SWTV in the PGE1 test correlated significantly with the degree of erection, and thus, severity of ED. Thus, the rate of change in SWTV in the corpus cavernosum could be used as an objective index of erectile phenomenon.

The non-invasive and objective method used in the current report could be highly beneficial from the clinical practice standpoint compared with subjective symptom scores that have long been used for assessing ED. Our method might have a great potential to make a paradigm shift in both diagnosing ED and/or penile hardness, determining the therapeutic effect. However, the number of evaluated cases is still limited. In addition, the PGE1 tests were solely used for before-and-after evaluations in this study. Therefore, further research is warranted to determine the predictive factors and definitive diagnosis, including the level of ED in the non-erectile state in patients with ED.

CONFLICT OF INTEREST

All the authors declare that they have no conflicts of interest.

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