

Radiology

Influence of Low-Intensity Shock Waves Therapy on Penile Arterial Microcirculation

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(Presented by Academy Member Teimuraz Naneishvili)

Total of 890 patients with erectile dysfunction (ED) sought treatment at our hospital. Many had previously tried short-term solutions, but these treatments did not improve penile microcirculation. We randomly selected 378 individuals with vasculogenic ED. They were divided into four groups and received low-intensity shockwave therapy (LI-SWT) on an outpatient basis. The first group received treatment regardless of age, duration of ED, severity of ED, and different comorbidities. The second group, with mild ED, also received phosphodiesterase 5 inhibitors (PDE5i). The third group, with penile trauma and mild ED, received platelet-rich plasma (PRP) treatment in addition to LI-SWT. The fourth group, comprising individuals with severe ED and deteriorated penile microcirculation after prior LI-SWT, underwent angioplasty and repeated LI-SWT. Patients were evaluated using demographic data, lipid, and hormonal profile detection, penile ultrasound with Doppler, pelvic CT angiography (patients of group 4 only), and the IIEF5 and EHS questionnaires. The treatments improved penile artery imaging, blood flow velocity, and sexual function. The age, disease duration, stage of ED, and comorbidities were found to influence these outcomes. Combining PD5i in low dosage with shockwave treatments showed improved results. Furthermore, LI-SWT with PRP injections and pudendal artery stenting had long-term positive effects on arterial dynamics. It is suggested that LI-SWT is an effective treatment for arterial vasculogenic ED. © 2024 Bull. Georg. Natl. Acad. Sci.

penile angiogenesis, shock waves therapy, penile ultrasound and Doppler, PRP, pelvic CT angiography

In recent decades, shock-wave therapy has gained widespread recognition in medical practice [1-3]. Several studies determined that low-energy shock waves are characterized by constructive, reparative, and angiogenic properties [4-6]. The unique ability of low-energy shock waves to restore damaged microcirculation revolutionized the treatment of many diseases [7-9]. This led to the adoption of LI-

SWT to stimulate angiogenesis in patients affected by ED [10]. In the last decade, many new methods were also utilized [11-14].

Materials and Methods

Since 2015 a total of 890 patients with various forms of erectile dysfunction have sought treatment at the Health House. Many had previously tried short-

term solutions, with PDE5i, intracavernosal injections, vacuum pumps, but these treatments did not improve penile microcirculation. 378 patients with vasculogenic ED were randomly assigned to four groups and underwent LI-SWT after providing informed consent. During screening, patients underwent demographic evaluation, lipid and hormonal profile detection, and penile ultrasound with Doppler. All patients completed different questionnaires: the Erection Hardness Score (EHS) and the short version of the International Index of Erectile Function (IIEF-5) following worldwide recommendations for evaluating such patients [15-17].

The Storz Medical device Duolith SD1-Ultra, based on electromagnetic technology, was utilized for treating patients with erectile dysfunction (ED). The energy ranged from 0.10 to 0.30 mJ/mm², with a frequency of 4 Hz. During each session, 3000 shock pulses were administered to the corpora cavernosa in 6 different areas, with 500 pulses applied to each area on both sides of the penis. Three treatment plans were used: (I) daily procedures for six days; (II) two procedures weekly for three weeks; (III) two procedures weekly with a one-week break for five weeks.

The first group included 242 patients with various stages of vasculogenic ED. The disease duration ranged from 6 months to 10 years, with an age distribution from 21 to 77 years (mean age 56) and different comorbidities. They received treatment with all 3 plans.

In the second group with 3 weeks of LI-SWT, there were 109 patients with mild and mild to moderate stages of vasculogenic erectile dysfunction. Their ED duration was up to 2 years, with ages ranging from 26 to 49 years (mean age of 41 years). 35 patients received only LI-SWT, 46 received LI-SWT with low doses of PDE5i, 14 received only low doses of PDE5i, and 14 received Sham treatment (that was considered to be the control subgroup).

In the third group, sixteen patients aged 23-35 (mean age 31) suffered penile injuries during

intercourse in the last 6 months, resulting in penile curvature, erectile pain, and mild ED. Seven patients received LI-SWT and platelet-rich plasma (PRP) injections, five received only LI-SWT, and four received no treatment (control subgroup). The Visual Analog Scale (VAS), IIEF, and EHS were assessed in this group.

In the fourth group, 11 patients with severe ED, aged 51-69 years (mean age 63), and with a disease duration of up to 5 years, with different comorbidities, had absent, or very low penile Doppler data in five patients after LI-SWT treatment in the past. Pelvic CT angiography diagnosed iliac and pudendal artery disorders in eight of them. Six patients underwent pelvic arteriography, with four receiving pudendal artery stenting and balloon dilatation. Later, all four patients received shock wave treatment after interventional angioplasty.

23 patients from the last two subgroups of the second group, along with 3 patients from the control subgroup of the third group, received standard LI-SWT treatment, but were subsequently excluded from the main study group due to lack of follow-up.

The patients of the first group were evaluated immediately after the treatment termination and 6, 12, and 24 months after the end of the therapy. The patients of the second, third, and fourth groups were evaluated immediately after the treatment termination and in 3, 6, and 9 months respectively. The follow-up was based on the Penile Doppler study and Questionnaires.

Statistical analysis. The statistical processing of the collected data was done using IBM SPSS Statistics 23, mixed design ANOVA.

Results

In the first group, the treatment frequency significantly impacts artery visualization and improves velocity, regardless of disease duration, or the side of impaired penile arterial vessels. The results indicate a main effect of treatment frequency on

artery visualization ($F(1.89, 447.07) = 408.895$, $p < .001$, $h^2 = 0.634$) and velocity ($F(1.58; 372.37) = 89.89$, $p < .001$, $h^2 = 0.278$). Artery visualization tends to increase over time, with mean levels of 1.3 at baseline, improving after treatment termination to 1.96, and reaching 2.342 six months after treatment. Similarly, velocity measures differed at screening timing (15.07), after treatment (21.45), and 6 months after treatment (23.67), showing an overall improvement tendency.

Our findings indicate slightly higher measurements of detection of the penile artery on the left side compared to the right side. For the left side, measurements were 1.43 ± 0.07 during screening, 2 ± 0.07 after treatment termination, and 2.35 ± 0.05 after 6 months. On the right side, measurements were 1.18 ± 0.07 , 1.9 ± 0.73 , and 2.3 ± 0.06 , respectively. Despite this difference, visualization for both sides was improved. The mean difference between the screening and 6-month measurements was 1.15 ± 0.006 for the right side and 0.91 ± 0.058 for the left side ($p < 0.05$ for both cases).

In the Velocity study, no interaction was found between the frequency of treatment and the treated side. There were no significant differences in the measurements of the right and left arteries. The measurements of the left artery (21.25 ± 0.8) were slightly higher than those of the right side (18.83 ± 0.93), with a non-statistically significant P-value of 0.11.

We observed increased velocity measures across all treatments and significant improvement for patients with a disease duration of over 2, 5, and 10 years. A study comparing three different shock wave treatment schedules found no significant differences in visualization and velocity outcomes between the schedules. However, significant differences were observed between different time points in all treatment groups, indicating no significant differences in treatment outcomes between the schedules.

In a second group of 109 patients, we found that different treatments had a significant effect on the

IIEF5 scores ($F(3,105) = 17.43$; $P < 0.05$), on EHS points ($F(7.89,276.04) = 33.99$; $P < 0.001$) and penile arterial blood velocity (PBFV)- ($F(3,105) = 52.109$, $P < 0.01$). IIEF5, EHS measurements, and PBFV for different treatment subgroups were similar to the baseline, but the mean scores for the LI-SWT and LI-SWT+ PDF5i subgroups significantly increased over time, particularly compared to the PDF5i Only and Sham (Control) subgroups. The PDF5i Only subgroup showed a significant reduction over time.

Our research found that both A and B subgroups in the third group showed improvements in IIEF-5 and EHS scores, with subgroup A showing more significant progress. Subgroup A also demonstrated notable improvement in plaque volume, penile curvature, and VAS compared to group B. The arterial flow velocity gradually improved in both treated subgroups, remaining unchanged in the control subgroup. Additionally, subgroup A showed a significant improvement in sexual activity compared to subgroup C.

Eleven patients from the fourth group had very poor penile ultrasound and Doppler data. Provided LI-SWT in the past in five patients from this group did not show marked improvements. Among them, five had coronary artery stenting, seven took hypotensive drugs, and six had diabetes. A thorough examination is crucial for patients with vasculogenic disorders, especially those with a history of coronary artery stenting, to check for potential underlying peripheral vascular diseases. After pelvic CT angiography, we conducted arteriography of the internal iliac and internal pudendal arteries and placed stents in narrowed areas. Patients exhibited improved artery filling and shape and better penile Doppler parameters. Four patients received LI-SWT treatment and one received it for the second time. Following angioplasty, all patients reported stable appearance of the morning erections and improvements in sexual activity.

Discussion

The imaging and blood flow restoration in the penile artery depends on factors such as age, disease duration, stage of ED and concurrent conditions. After treatment, younger patients with a shorter disease duration showed increased blood flow, mainly on the left side. Patients undergoing LI-SWT and PDE5i combination therapy experienced significant improvements in penile artery measurements. LI-SWT treatment led to improved penile blood flow velocity across all age groups and treatment schemes. Patients with mild to moderate ED experienced higher improvements in velocity and sexual life. Penile velocity in severe ED patients stabilized after 6 months of treatment and remained constant after 12 and 24 months.

Traumatic accidents during sexual intercourse can cause damage to tunica albuginea with Peyronie's disease (PD) like changes, which leads to pain, curvature, decreased blood flow in the penis, and ED. While low-intensity shockwave therapy (LI-SWT) may not be very effective for PD, a combination of LI-SWT and platelet-rich

plasma (PRP) shows promise in improving blood flow, reducing plaque volume, and relieving pain and improving sexual function. Further research is needed to determine the best treatment options and dosage for PRP injections. Following low-intensity shockwave therapy (LI-SWT), decreased blood flow in the penile arteries and reduced velocity can lead to long-term erectile dysfunction (ED). Up to 75% of non-responsive ED patients have narrow iliac-pudendal-penile arteries, resulting in inadequate blood supply to the male genital organ. Revascularization of the pudendal arteries' proximal branches can significantly improve ED-related symptoms and quality of life [18].

Conclusion

The effectiveness of LI-SWT depends on the disease duration, the patient's age, and any concomitant diseases. It relies on visualizing the penile arteries and observing increased Doppler and velocity characteristics. Daily intake of PDE5i in low doses during LI-SWT improves the final result.

რადიოლოგია

დაბალი ინტენსივობის შოკური ტალღებით მკურნალობის ზეგავლენა პენალურ არტერიულ მიკროცირკულაციაზე

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(წარმოდგენილია აკადემიის წევრის თ. ნანიშვილის მიერ)

890 პაციენტმა მომართა კლინიკას ერექციული დისფუნქციის გამო, რაც განპირობებული იყო წარსულში სხვადასხვა მედიკამენტებითა და მეთოდებით წარუმატებელი მკურნალობით. შემთხვევითი შერჩევის წესით მათგან 378 პაციენტი გამოირჩა და ედ-ის სხვადასხვა სტადიის, დაავადების ხანგრძლივობის, თანმხლები დაავადებებისა და ასაკის შესაბამისად ოთხ სამკურნალო ჯგუფში გადანაწილდა. დაბალი ინტენსივობის შოკური ტალღებით მკურნალობა ამბულატორიულად ტარდებოდა. შოკური ტალღებით ბაზისურ მკურნალობასთან ერთად პაციენტებს თრომბოციტებით გამდიდრებული პლაზმის (თგპ) ინიექციები და სასირცხო არტერიების ანგიოპლასტიკაც ჩაუტარდათ. დემოგრაფიულ მონაცემებთან და ბაზისურ ანალიზებთან ერთად ტარდებოდა სასქესო ასოს ულტრაბგერითი გამოკვლევა დოპლერით. პაციენტები ერექციული ფუნქციის შესაფასებლად სპეციალურ კითხვარებსაც ავსებდნენ. დადგინდა, რომ პაციენტების ასაკი, დაავადების ხანგრძლივობა, ედ სტადია და თანმხლები დაავადებები პირდაპირპროპორციულ გავლენას ახდენდნენ მკურნალობის გამოსავალზე. სტატისტიკურად სარწმუნოდ დადგინდა დაბალი ინტენსივობის შოკური ტალღების ეფექტურობა ვასკულოგენური ედ-ის დროს. ამის დასტურია პენალური არტერიების ულტრაბგერითი გამოსახულებისა და მათში სისხლის ნაკადის ზრდა სქესობრივი ფუნქციის აღდგენასთან ერთად. ფოსფოდიესტერაზა 5-ის ინჰიბიტორებთან და თრომბოციტებით გამდიდრებული პლაზმის (თგპ) ინიექციებთან შერწყმული შოკური ტალღებით თერაპიის უახლესი და შორეული შედეგები ასევე სარწმუნო იყო. დამამედებელი იყო ანგიოპლასტიკის შემდეგ ჩატარებული შოკური ტალღებით თერაპიაც.

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