



LSWT

Linear Shockwave Therapy for Erectile Dysfunction Clinical Data and Reports



November 2015



Table of Contents

Safety and efficacy of low intensity shockwave (LISW) treatment in patients with erectile dysfunction.....	4
A. Ruffo, M. Capece, D. Prezioso, G. Romeo, E. Illiano, L. Romis, G. Di Lauro, F. Iacono Int. Braz. J. Urol., 2015	
Linear Shock Wave Therapy in the Treatment of Erectile Dysfunction.....	12
M. Pelayo-Nieto, E. Linden-Castro, A. Alias-Melgar, D. Espinosa-Pérez Grovas, F. Carreño-de la Rosa, F. Bertrand-Noriega, R. Cortez-Betancourt Actas Urol Esp. 2015	
Effectiveness of Low-Intensity Extracorporeal Shock Wave Therapy on Patients with Erectile Dysfunction (ed) Who Have Failed to Respond to PDE5i Therapy. A Pilot Study.....	16
A. Bechara, A. Casabé, W. De Bonis, J. Nazar Archivos Españoles de Urología, April 2015	
Initial Experience with Linear Focused Shockwave Treatment for Erectile Dysfunction: a 6-Months Follow-Up Pilot Study.....	25
Y. Reisman, A. Hind, A. Varaneckas, I. Motil Internation Journal of Impotence Research, October 2014	
Safety and Efficient Duration of Linear Focused Shockwave Treatment for Erectile Dysfunction – A 12 months Follow-up Pilot Study.....	30
Y. Reisman 16 th World Meeting on Sexual Medicine, Sao Paulo, October 2014	
Long Term Efficacy of Low Intensity Linear Focused Shockwave Therapy for Vascular Erectile Dysfunction Patients: 20 months follow-up.....	32
A. Casarico, P. Puppo 22 nd National Congress of the Italian Urological Association, Bologna, May 2015	
Initial Clinical Experience of Linear Focused, Low Intensity Shockwave for Treatment of ED Patients with Different Severity Symptoms.....	37
N. Cruz, A. Morales 16 th World Meeting on Sexual Medicine, Sao Paulo, October 2014	
Efficacy and Safety of Linear Focused Shockwaves for Erectile Dysfunction (RENOVA) – A Second Generation Technology.....	39

Y. Reisman, A. Hind, A. Varaneckas, I. Motil

12th Congress of Latin American Society for Sexual Medicine (SLAMS), Cancun,

August 2013

Low intensity shock wave (LISW) treatment (Renova) in order to improve male sexual function: A preliminary data on 42 patients..... 41

F. Iacono, A. Ruffo, D. Prezioso, G. Romeo, E. Illiano, L. Romis, G. Di Lauro

16th Congress of the European Society for Sexual Medicine (ESSM), Istanbul,

February 2014

Low Intensity Linear Focused Shockwave Therapy: a New Treatment to Improve the Quality of Life of Vascular Erectile Dysfunction Patients..... 43

P. Puppo, A. Casarico

21st National Congress of the Italian Urology Association, Rome, June 2014

Linear Low Intensity Shockwaves Treatment of Vasculogenic ED – First Results..... 46

I. Motil, T. Šramkova

102nd Annual Meeting of the Japanese Urological Association (JUA), Kobe, April

2014

Efficacy and Safety of Linear Focused Shockwaves for Erectile Dysfunction (RENOVA) – A Second Generation Technology..... 48

Y. Reisman, A. Hind, A. Varaneckas, I. Motil

2nd Biennial Meeting of the Middle East Society for Sexual Medicine (MESSM),

Dubai, November 2013

Line Focused Shock Wave for Erectile Dysfunction – a different technological approach..... 50

A. Hind, O. Saleh, Y. Abu Asbeh

5th Pan Arab Congress of Sexual Medicine, Dubai, April 2013

The Effect of Low Intensity Shockwave Therapy on the Erectile Function of Smokers and Non-smokers - Initial Report with a Dedicated System..... 53

P. Puppo, A. Casarico

30th Italian society of Andrology Congress (SIA), Maratea, May 2014



Safety and efficacy of low intensity shockwave (LISW) treatment in patients with erectile dysfunction

A. Ruffo ¹, M. Capece ¹, D. Prezioso ¹, G. Romeo ¹, E. Illiano ¹, L. Romis ², G. Di Lauro ², F. Iacono ¹

¹ Department of Urology, Federico II University, Naples, Italy; ² Department of Urology, Hospital Santa Maria delle Grazie, Naples, Italy

ABSTRACT

The primary goal in the management strategy of a patient with ED would be to determine its etiology and cure it when possible, and not just to treat the symptoms alone. One of the new therapeutic strategies is the use of low intensity extracorporeal shockwave (LISW) therapy. The mechanism of shockwave therapy is not completely clear. It is suggested that LISW induces neovascularization and improvement of cavernosal arterial flow which can lead to an improvement of erectile function by releasing NO, VEGF and PCNA.

Materials and Methods: 31 patients between February and June 2013 with mild to severe ED and non-Phosphodiesterase 5 inhibitors responders were enrolled. Patients underwent four weekly treatment sessions. During each session 3600 shocks at 0.09mJ/mm² were given, 900 shocks at each anatomical area (right and left corpus cavernosum, right and left crus). Improvement of the erectile function was evaluated using the International Index of Erectile Function (IIEF-EF), the Sexual Encounter Profile (SEP) diaries (SEP-Questions 2 and 3) and Global Assessment Questions (GAQ-Q1 and GAQ-Q2).

Results: At 3-month follow-up IIEF-EF scores improved from 16.54±6.35 at baseline to 21.03±6.38. Patients answering 'yes' to the SEP-Q2 elevated from 61% to 89% and from 32% to 62% in the SEP-Q3. A statistically significant improvement was reported to the Global Assessment Questions (GAQ-Q1 and GAQ-Q2).

Conclusion: In conclusion, we can affirm that LISW is a confirmed therapeutic approach to erectile dysfunction that definitely needs more long-term trials to be clarified and further verified.

ARTICLE INFO

Key words:

Erectile Dysfunction;
Therapeutics; Lithotripsy

Int Braz J Urol. 2015; 41: 967-74

Submitted for publication:
October 30, 2014

Accepted after revision:
April 25, 2015

INTRODUCTION

Erectile dysfunction (ED) is the main complaint in male sexual medicine and is defined as the persistent inability to attain and maintain an erection sufficient to permit satisfactory sexual performance. Although ED is a benign disorder, it may affect physical and psychosocial health and may have a significant impact on the quality of life (QoL) of patients and their partners (1).

ED seems to affect 52% of 40-70-year-old men (2). Advances in basic and clinical research on ED during the past 15 years have led to the development of a variety of new treatment options, including pharmacological agents for intracavernous, intraurethral, and oral use and the use of vacuum erection devices (1).

Oral therapies have changed the diagnostic and therapeutic approach to ED becoming a major tool in treating ED. In fact, phosphodiesterase-5

inhibitors (PDE5-i) in the late 1990s and early 2000s completely revolutionized the field of sexual medicine becoming the most popular treatment and the first-line monotherapy for ED (3).

Unfortunately, they are limited for being used before the sexual act and do not modify the physiologic mechanism of penile erection (4).

After the initial enthusiasm of the use of the PDEi, the psychological impact-artificiality of erections and planning for sexual intercourse as well as a not proven curative effect (5) have slightly limited the use of these drugs, leaving the field open to the development of new therapies to treat or maybe cure patients with ED. Furthermore, the frequently reported side-effects of PDE5i, such as headache, dyspepsia, muscular pains, and hot flushes can affect a normal sexual intercourse (6).

The primary goal in the management strategy of a patient with ED would be to determine its etiology and cure when possible, and not just the treatment of symptoms. One of the new therapeutic strategies is the use of low intensity extracorporeal shockwave (LISW) therapy.

Shockwaves (SWs) are longitudinal acoustic waves that travel in the speed of water in ultrasound through body tissue and that carry energy (7). SWs have been widely used in urology to treat urinary stone disease (8), and less often in Peyronie's disease (9) or chronic pelvic pain syndrome (CPPS) in males (10).

The mechanism of action of low-intensity shock waves (LISW) is still not very clear. Many authors suggested that LISW improves erectile function increasing cavernous blood flow and inducing a neovascularization (11). Neovascularization is promoted

by the expression of angiogenesis-related growth factors, such as endothelial nitric oxide synthase (NOS), vascular endothelial growth factor (VEGF), and endothelial cell proliferation factors, e.g., proliferating cell nuclear antigen (PCNA) (12).

The aim of our study is to evaluate the improvement of erectile function after therapy with LISW in men affected by mild to moderate ED.

MATERIALS AND METHODS

Study population

31 patients between February and June 2013 with mild to severe ED, and non-Phosphodiesterase 5 inhibitors responders were assessed for this study. Only 2 (6.4%) underwent treatment with PDE5-i in the last four weeks before starting the treatment (Table-1). They all signed an informed consent.

Inclusion criteria were: good general health, ED for at least six months, IIEF-EF between 7 to 24 (=mild to moderate).

Exclusion criteria included: neurological pathology, past radical prostatectomy or extensive pelvic surgery, recovering from cancer during the last year, any unstable medical, psychiatric disorder, spinal cord injury, penile anatomical abnormalities, clinically significant chronic hematological disease, anti-androgens or radiotherapy treatment of the pelvic region.

The medical and psychosexual history of all patients were evaluated at baseline to detect comorbidities. Table-2 summarizes the patients' organic comorbidities: cardiovascular diseases in 7 pts (22%), hypertension in 18 pts (58%), diabetes in 12 pts (38%) and abnormal total serum cholesterol in 13 pts (41%).

Table 1 - The pretreatment characteristics of population.

Variable	Patients	P value
Age (years)		0.39
Mean±SD	59.93±12.16	
N.of subjects analysed	31	
Time suffering from ED (yrs)		0.50
Mean±SD	3.66±4.57	
N.of subjects analysed	31	
Treatment with PDE5-I in the last 4 weeks (%)	6.45	0.12
Proportion	2/31	

Table 2 - Analysis of self-reported measures at baseline , 1-month and 3-month follow up by treatment cohort.

Variable	Baseline	Follow-up 1 month	p value	Follow-up 3 months	P value
IIEF – EF	16.54±6.35	21.13±6.31	P=0.0075	21.03±6.38	p=0.0096
SEP-Q₂ (%)	61 (yes)	86 (yes)	P=0.0292	89 (yes)	P=0.0112
	38 (no)	13 (no)		10 (no)	
		2 drop-out			
SEP-Q₃ (%)	32 (yes)	58 (yes)	P=0.0402	62 (yes)	P=0.0207
	67 (no)	41 (no)		37 (no)	
		2 drop-out			

(IIEF-EF): International Index of Erectile Function; (SEP-Q2): Sexual Encounter Profile-Q2; (SEP-Q3): Sexual Encounter Profile-Q3

Study design

This is a pilot clinical study evaluating safety and efficacy of LISW treatment (performed with Renova ®) on symptomatic ED patients versus baseline.

Study schedule

a) screening

Patients were visited (visit 1) and those who were using PDE5-i had to go to a flush-out period of three weeks before starting the treatment. Furthermore, they committed to refrain from usage of PDE5-i during the duration of the treatment session.

b) Treatment

Patients underwent four weekly treatment sessions. During each session 3600 shocks at 0.09 mJ/mm² were given. Shocks were applied at the penis shaft at right corpus cavernosum and left corpus cavernosum, right crus and left crus, 900 shocks at each area.

The treatment areas were the same for every session, so that at the end of the full treatment (four sessions) each area received 3600 shocks at an average 0.09mJ/mm. We used this protocol under the guidance of Direx Group LTD.

LISW utilize low energy-0.09mJ/mm²-equivalent to 10% of the energy used by conventional kidney stone lithotripters in the treatment of urinary tract stones. This device generates a low intensity shockwave focused along a line of 70mm and hence is able to apply shockwaves to the corpora cavernosa and crura effectively.

For the past 3 years, a similar LISW technique has been used in different sites using the same level of energy density to treat ED (13). Shockwaves are created by a special generator and are focused using a specially designed shockwave applicator apparatus. The shockwaves are delivered through the applicator covering the entire corpora cavernosa of the penis.

The treatment does not inflict pain and does not require any anesthesia or sedation.

Each session lasts approximately 30 minutes.

c) Primary efficacy objective

To evaluate the increase of number of points in the International Index of Erectile Function (IIEF-EF) questionnaire from baseline (visit 1) to 1 and 3 months after treatment regarding the severity of the symptoms according to minimal clinically important differences in the erectile function domain of the IIEF scale (14). The IIEF-EF was chosen as primary clinical efficacy assessment tool in this study. It has been reported to be brief and reliable, psychometrically sound, and easy to administer in both research and clinical settings. It is available (and cross-culturally validated) in 10 languages and demonstrates adequate sensitivity and specificity for detecting treatment-related changes in erectile function (15).

d) Secondary efficacy objective

To study the clinical efficacy of LISW in terms of improvement in sexual activity leading to optimal penetration at 1 and 3 months post-treatment by using the Sexual Encounter Profile

(SEP) diaries (SEP-Questions 2 and 3). Patients recorded efficacy information after each sexual encounter by answering the two yes/no questions of the test: SEP Question 2: “Were you able to insert your penis into your partner’s vagina?” and SEP Question 3: “Did your erection last long enough for you to have successful intercourse?”.

In addition, patients underwent further evaluation with the Global Assessment Question (GAQ) by answering the two yes/no questions of the test: (GAQ-Q1) “Over the past four weeks has the treatment you have been taking improved your erectile function?” and (GAQ-Q2) “If yes, has the treatment improved your ability to engage in sexual activity over the past four weeks”.

Statistical analysis

Statistical analysis was performed by the program Statistical Package for Social Sciences for Windows, version 11.5.1 (SPSS Inc., Chicago, IL, USA), using X^2 test and T-student for categorical data comparisons.

RESULTS

All patients had mild to severe ED at least six months, were non PDE-5i responders, with a mean age of 59.93 ± 12.16 years. Median

follow-up was of 3 months (range 2-5 months). Global patient perceptions after treatment with LISW significantly improved. Indeed IIEF-EF score showed significant improvement (baseline 16.54 ± 6.35 vs 21.13 ± 6.31 after 1 month $P=0.0075$; baseline 16.54 ± 6.35 vs 21.03 ± 6.38 after 3 months $p=0.0096$) (Table-2; Figure 1-3). About 86% ($P=0.0292$) and 89% ($P=0.0112$) of patients answered with a positive answer to SEP Q2 question (“Were you able to insert your penis into your partner’s vagina?”) 1 month and 3 months after treatment, respectively, versus 61% positive answers pre-treatment (Table-2). SEP Q3 question (“Did your erection last long enough for you to have successful intercourse?”) was answered positively by 58% ($P=0.0402$) 1 month after LISW treatment and 62% ($P=0.0207$) after 3 months. After 1 month of treatment there were two drop-outs (Table-2). Table-3 shows patients’ satisfactions of treatment with GAQ-Q1 (“Over the past four weeks has the treatment you have been taking improved your erectile function?”) and GAQ-Q2 questions (“If yes, has the treatment improved your ability to engage in sexual activity over the past four weeks”). Regarding the individual answers for the GAQ questions, we noticed that 89% and 62% of patients at 1 and 3 months respectively answered “Yes” to the GAQ-Q1 while in the same period 79% and 76% of patients answered “Yes” to the

Figure 1 - IIEF-EF score at baseline and after 1 month follow-up

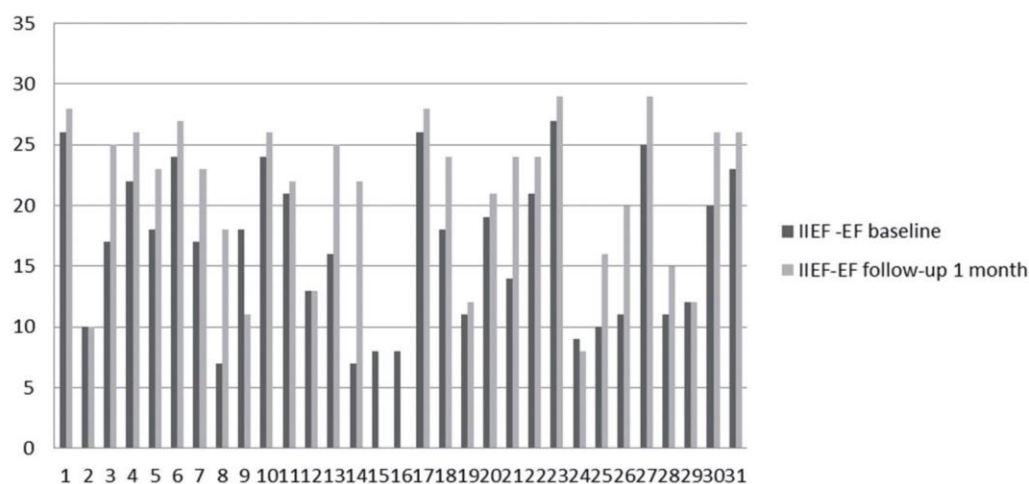


Figure 2 - IIEF-5 score at baseline and after 3 month follow-up

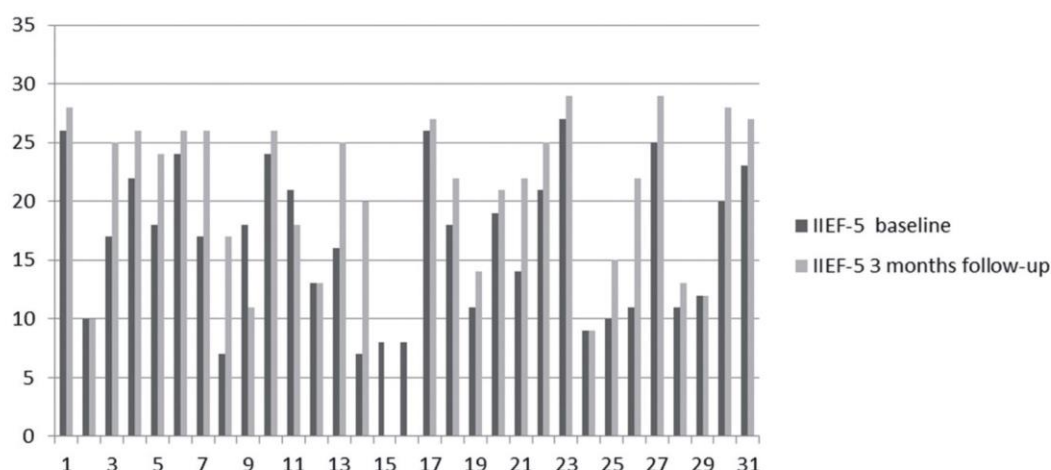
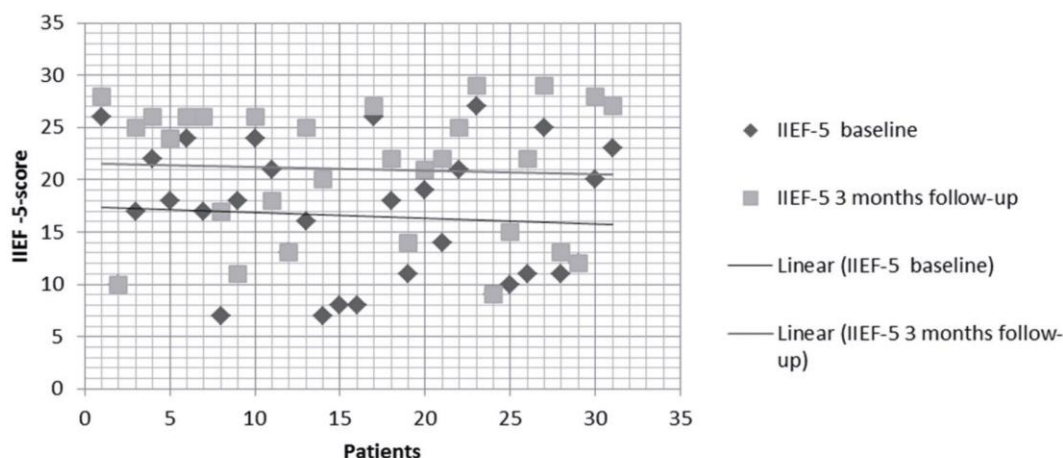


Figure 3 - Dispersion date IIEF score baseline and 3 month follow-up



GAQ-Q2 demonstrating success with the treatment (Table-3).

No adverse events were reported during and following treatment.

DISCUSSION

According to others author's data LISW appears to be significantly effective for increasing erectile function thanks to the improvement in

penile hemodynamics (13, 11). By releasing neo-angiogenic factors and subsequent neovascularization of the treated tissue, LISW therapy leads to tissue regeneration (16). In fact, it has been shown that this low intensity energy acts on vascularization inducing a non-enzymatic production of physiologic amounts of nitric oxide (17). Nitric oxide (NO), the smallest known signaling molecule, is produced by three isoforms of NO synthase (NOS; EC 1.14.13.39). Neuronal NOS (nNOS, NOS 1) is

Table 3 - Analysis of self-reported measures at 1-month and 3-month follow up by treatment cohort.

Variable	Follow-up 1 Month	Follow-up 3 Month	P value
GAQ-Q ₁ (%)	89 (yes)	62 (yes)	P=0.141
	10 (no)	38 (no)	
	2 droup-out	2 droup-out	
GAQ-Q ₂ (%)	79 (yes)	76 (yes)	P=0.7259
	20 (no)	24 (no)	
	2 droup-out	2 droup-out	

(GAQ-Q1): Global Assessment Question- Q1; (GAQ-Q2): Global Assessment Question- Q2

constitutively expressed in central and peripheral neurons and in some other cell types. Its functions include synaptic plasticity in the central nervous system (CNS), central regulation of blood pressure, smooth muscle relaxation, and vasodilatation via peripheral nitrergic nerves. Nitrergic nerves are of particular importance in the relaxation of corpus cavernosum and penile erection (18). In corpus cavernosum nNos-derived NO activates guanylyl cyclase which synthesizes cyclic GMP (cGMP) from GTP which in turn is the basis for the pro-erectile function of PDE5 inhibitors (19).

The most important isoform is eNOS, which keeps blood vessels dilated, controls blood pressure, and has numerous other vasoprotective and anti-atherosclerotic effects inhibiting DNA synthesis, mitogenesis, and proliferation of vascular smooth muscle cells as well as smooth muscle cell migration. eNOS is mostly expressed in endothelial cells and synthesizes NO in a pulsatile manner (20).

eNOS appears to be a homeostatic regulator of numerous essential cardiovascular functions: in fact, eNOS-derived NO causes vasodilation in all types of blood vessels by stimulating soluble guanylyl cyclase and increasing cyclic GMP in smooth muscle cells that regulates the activity of calcium channels as well as intracellular contractile proteins that affect the relaxation of corpus cavernosum smooth muscle (21). Qiu et al. reported that LISW can partially ameliorate Diabetes Mellitus (DM)-associated ED in rat model by promoting regeneration of nNOS-positive ner-

ves, endothelium, and smooth muscle in the penis. These beneficial effects appear to be mediated by recruitment of endogenous mesenchymal stem cells (MSCs) (22). Wang and colleagues discovered that LISW stimulates the expression of angiogenesis-related growth factors, such as endothelial nitric oxide synthase (eNOS) and vascular endothelial growth factor (VEGF), and endothelial cell proliferation factors, such as proliferating cell nuclear antigen (PCNA).

The eNOS and VEGF began to rise in as early as one week and remained high for 8 weeks, then declined to baseline in 12 weeks; whereas the increase of PCNA and neo-vessels began in 1 week and persisted for 12 weeks and longer (12).

The effect of LISW on intracellular VEGF levels in human umbilical vein endothelial cells (HUVECs) has also been reported by Nishida et al. (23), who found that LISW significantly increased the expression of VEGF mRNA and its receptor, Flt-1. Their studies on the effects of LISW on a porcine model of chronic myocardial ischemia also showed that VEGF expression was significantly upregulated in the ischemic myocardial cells after treatment inducing neovascularization and improving myocardial perfusion (24).

Furthermore, it has been proved that SW therapy improved symptoms and myocardial perfusion in patients with severe coronary artery disease without any complications or adverse effects (24-26).

Regarding erectile dysfunction, Vardi et al. have been the first ones to believe in the use of

LISW to improve male sexual function (27). In the first randomized, double-blind, sham-controlled study, they demonstrated a positive short-term clinical and physiological effect on the erectile function of men who respond to oral PDE5Is (28). In another trial they reported an improvement in penile hemodynamics and endothelial function, as well as IIEF-EF domain score in severe ED patients who were poor responders to PDE5Is.

In this paper we demonstrated the efficacy of LISW in the medical management of ED. Our data show a statistically significant improvement of IIEF-EF score (5 points) and an increase of SEP and GAQ scores after treatment.

Limitations of this study are the lack of a sham controlled arm and the relatively low number of participants.

CONCLUSIONS

LISW has a well-documented positive clinical and physiological effect on erectile function. The preliminary data at 1 and 3 months follow-up are very encouraging and indicate a therapeutic success of this second generation technology for treating ED with linear low-intensity shockwaves. We also noticed that this treatment is feasible and easy to administer and with no side effects reported. Clearly, we cannot assure the long-term efficacy of LISW, so further studies are needed in order to strengthen these results and to assess whether is possible to repeat cyclically the treatment.

CONFLICT OF INTEREST

None declared.

REFERENCES

- Hatzimouratidis K, Amar E, Eardley I, Giuliano F, Hatzichristou D, et al. Guidelines on male sexual dysfunction: erectile dysfunction and premature ejaculation. *Eur Urol*. 2010;57:804-14.
- Feldman HA, Goldstein I, Hatzichristou DG, Krane RJ, McKinlay JB. Impotence and its medical and psychosocial correlates: results of the Massachusetts Male Aging Study. *J Urol*. 1994;151:54-61.
- de Araujo AC, da Silva FG, Salvi F, Awad MC, da Silva EA, Damião R. The management of erectile dysfunction with placebo only: does it work? *J Sex Med*. 2009;6:3440-8.
- Yetik-Anacak G, Sorrentino R, Linder AE, Murat N. Gas what: NO is not the only answer to sexual function. *Br J Pharmacol*. 2015;172:1434-54.
- Tsertsvadze A, Yazdi F, Fink HA, MacDonald R, Wilt TJ, Bella AJ, et al. Oral sildenafil citrate (viagra) for erectile dysfunction: a systematic review and meta-analysis of harms. *Urology*. 2009;74:831-836.e8.
- Montorsi F, Verheyden B, Meuleman E, Jünemann KP, Moncada I, Valiquette L, et al. Long-term safety and tolerability of tadalafil in the treatment of erectile dysfunction. *Eur Urol*. 2004;45:339-44; discussion 344-5.
- Apfel RE. Acoustic cavitation: a possible consequence of biomedical uses of ultrasound. *Br J Cancer Suppl*. 1982;5:140-6.
- Srisubut A, Potisat S, Lojanapiwat B, Setthawong V, Laopaiboon M. Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones. *Cochrane Database Syst Rev*. 2009;(4):CD007044.
- Hatzichristodoulou G, Meisner C, Gschwend JE, Stenzl A, Lahme S. Extracorporeal shock wave therapy in Peyronie's disease: results of a placebo-controlled, prospective, randomized, single-blind study. *J Sex Med*. 2013;10:2815-21.
- Zimmermann R, Cumpas A, Miclea F, Janetschek G. Extracorporeal shock wave therapy for the treatment of chronic pelvic pain syndrome in males: a randomised, double-blind, placebo-controlled study. *Eur Urol*. 2009;56:418-24.
- Lei H, Liu J, Li H, Wang L, Xu Y, Tian W, et al. Low-intensity shock wave therapy and its application to erectile dysfunction. *World J Mens Health*. 2013;31:208-14.
- Wang CJ, Wang FS, Yang KD, Weng LH, Hsu CC, Huang CS, et al. Shock wave therapy induces neovascularization at the tendon-bone junction. A study in rabbits. *J Orthop Res*. 2003;21:984-9.
- Gruenewald I, Appel B, Kitrey ND, Vardi Y. Shockwave treatment of erectile dysfunction. *Ther Adv Urol*. 2013;5:95-9.
- Rosen RC, Allen KR, Ni X, Araujo AB. Minimal clinically important differences in the erectile function domain of the International Index of Erectile Function scale. *Eur Urol*. 2011;60:1010-6.
- Rosen RC, Cappelleri JC, Gendrano N 3rd. The International Index of Erectile Function (IIEF): a state-of-the-science review. *Int J Impot Res*. 2002;14:226-44.
- Romeo P, Lavanga V, Pagani D, Sansone V. Extracorporeal shock wave therapy in musculoskeletal disorders: a review. *Med Princ Pract*. 2014;23:7-13.

17. Mariotto S, Cavalieri E, Amelio E, Ciampa AR, de Prati AC, Marlinghaus E, et al. Extracorporeal shock waves: from lithotripsy to anti-inflammatory action by NO production. *Nitric Oxide*. 2005;12:89-96.
18. Toda N, Ayajiki K, Okamura T. Nitric oxide and penile erectile function. *Pharmacol Ther*. 2005;106:233-66.
19. Boolell M, Allen MJ, Ballard SA, Gepi-Attee S, Muirhead GJ, Naylor AM, et al. Sildenafil: an orally active type 5 cyclic GMP-specific phosphodiesterase inhibitor for the treatment of penile erectile dysfunction. *Int J Impot Res*. 1996;8:47-52.
20. Burnett AL. The role of nitric oxide in erectile dysfunction: implications for medical therapy. *J Clin Hypertens (Greenwich)*. 2006;8:53-62.
21. Qiu X, Lin G, Xin Z, Ferretti L, Zhang H, Lue TF, et al. Effects of low-energy shockwave therapy on the erectile function and tissue of a diabetic rat model. *J Sex Med*. 2013;10:738-46.
22. Ito K, Fukumoto Y, Shimokawa H. Extracorporeal shock wave therapy as a new and non-invasive angiogenic strategy. *Tohoku J Exp Med*. 2009;219:1-9.
23. Nishida T, Shimokawa H, Oi K, Tatewaki H, Uwatoku T, Abe K, et al. Extracorporeal cardiac shock wave therapy markedly ameliorates ischemia-induced myocardial dysfunction in pigs in vivo. *Circulation*. 2004;110:3055-61.
24. Kikuchi Y, Ito K, Ito Y, Shiroto T, Tsuburaya R, Aizawa K, et al. Double-blind and placebo-controlled study of the effectiveness and safety of extracorporeal cardiac shock wave therapy for severe angina pectoris. *Circ J*. 2010;74:589-91.
25. Vasyuk YA, Hadzegova AB, Shkolnik EL, Kopeleva MV, Krikunova OV, Iouchtchouk EN, et al. Initial clinical experience with extracorporeal shock wave therapy in treatment of ischemic heart failure. *Congest Heart Fail*. 2010;16:226-30.
26. Vardi Y, Appel B, Jacob G, Massarwi O, Gruenwald I. Can low-intensity extracorporeal shockwave therapy improve erectile function? A 6-month follow-up pilot study in patients with organic erectile dysfunction. *Eur Urol*. 2010;58:243-8.
27. Vardi Y, Appel B, Kilchevsky A, Gruenwald I. Does low intensity extracorporeal shock wave therapy have a physiological effect on erectile function? Short-term results of a randomized, double-blind, sham controlled study. *J Urol*. 2012;187:1769-75.
28. Gruenwald I, Appel B, Vardi Y. Low-intensity extracorporeal shock wave therapy-a novel effective treatment for erectile dysfunction in severe ED patients who respond poorly to PDE5 inhibitor therapy. *J Sex Med*. 2012;9:259-64.

Correspondence address:

Antonio Ruffo, MD
Department of Urology
University of Naples Federico II, Naples, Italy
Via S.Pansini 5
CAP 80100, Naples, Italy
Telephone: + 39 081 746-2607
Email: antonio.ruffo7@gmail.com



Actas Urológicas Españolas

www.elsevier.es/actasuro



CASUISTRY

Linear shock wave therapy in the treatment of erectile dysfunction[☆]M. Pelayo-Nieto^{*}, E. Linden-Castro, A. Alias-Melgar, D. Espinosa-Pérez Grovas, F. Carreño-de la Rosa, F. Bertrand-Noriega, R. Cortez-Betancourt

Departamento de Urología, Centro Médico Nacional 20 de Noviembre, México Distrito Federal, Mexico

KEYWORDS

Erectile dysfunction;
Vasculogenic erectile dysfunction;
Linear shock wave;
Linear shock wave therapy

Abstract

Introduction: Linear shock wave therapy (LSWT) is a new noninvasive therapy that uses low-intensity shock waves to induce local angiogenesis promising modality in the treatment of erectile dysfunction (ED).**Objective:** To evaluate the effectiveness of LSWT in men with vasculogenic erectile dysfunction (ED), in a Tertiary Care Center.**Material and methods:** Included 15 men aged 45–70 years, sexually active with mild and moderate vascular ED evaluated with the International Index of Erectile Function (IIEF). The study was conducted in three stages: screening, treatment and results. Treatment stage: 4 weekly sessions LSWT (RENOVA[®]) 5000 waves (.09 mJ/mm²). Erectile function was assessed with IIEF-EF, SEP (Sexual Encounter Profile) and GAQ (Global Assessment Questions) at one and six months after treatment.**Results:** The rate of success was 80% (12/15). Patients with mild ED (6/15) 40% and moderate ED (9/15) 60%. We found a positive association between IIEF-Basal (average 14.23 pts) and IIEF at one month and six months after therapy (19.69 pts) a difference of 5.46 pts ($p < .013$).**Conclusions:** The feasibility and tolerability of this treatment, and rehabilitation potential features, make it this an attractive new treatment option for patients with ED.

© 2014 AEU. Published by Elsevier España, S.L.U. All rights reserved.

PALABRAS CLAVE

Disfunción eréctil;
Disfunción eréctil vasculogénica;
Ondas de Choque Lineal;
Terapia de Ondas de Choque Lineal

Terapia de ondas de choque lineales en el tratamiento de la disfunción eréctil

Resumen

Introducción: La terapia de ondas de choque lineales (LSWT) es una nueva terapia no invasiva que utiliza ondas de choque de baja intensidad para inducir la angiogénesis local controlada y mejorar significativamente la función eréctil.**Objetivo:** Evaluar la eficacia de la LSWT en hombres con disfunción eréctil vasculogénica (DE) en un centro de atención de tercer nivel.[☆] Please cite this article as: Pelayo-Nieto M, Linden-Castro E, Alias-Melgar A, Espinosa-Pérez Grovas D, Carreño-de la Rosa F, Bertrand-Noriega F, et al. Terapia de ondas de choque lineales en el tratamiento de la disfunción eréctil. Actas Urol Esp. 2015. <http://dx.doi.org/10.1016/j.acuro.2014.09.010>^{*} Corresponding author.E-mail address: marcelapelayo@hotmail.com (M. Pelayo-Nieto).

Material y métodos: Se incluyeron 15 hombres de edades comprendidas entre 45 y 70 años, sexualmente activos con DE vascular leve y moderada, evaluados con el índice internacional de función eréctil (IIEF). El estudio se realizó en 3 etapas: detección, tratamiento y seguimiento. Recibieron 4 sesiones de LSWT semanales (RENOVA®) 5.000 ondas (0,09 mJ/mm²). La función eréctil se evaluó con IIEF-EF, Perfil del encuentro sexual (SEP) y Cuestionario de evaluación global (GAQ) al mes y a los 6 meses después del tratamiento.

Resultados: La tasa de éxito fue del 80% (12/15). Pacientes con DE leve 40% y DE moderada 60%. Se encontró una asociación positiva entre el IIEF-basal (promedio 14,23 pts) y IIEF un mes y 6 meses después del tratamiento (19,69 pts) una diferencia de 5,46 puntos ($p < 0,013$).

Conclusiones: La factibilidad y tolerabilidad de este tratamiento, y sus características potenciales de rehabilitación, hacen que pueda ser una nueva opción terapéutica atractiva para pacientes con DE.

© 2014 AEU. Publicado por Elsevier España, S.L.U. Todos los derechos reservados.

Introduction and clinical scenario

Erectile dysfunction (ED) is the persistent inability to achieve and maintain the erection sufficient to permit satisfactory sexual intercourse.¹ Vasculogenic ED is due to diseases such as diabetes mellitus, hypertension, hyperlipidemia, smoking, or vascular occlusive disease.^{2,3} Although ED is a benign disorder, it affects physical, mental, and social health and has a significant impact on quality of life of men and their partners.⁴ LSWT stimulates the expression of angiogenesis-related growth factors, such as endothelial nitric oxide synthase, vascular endothelial growth factor, and endothelial cell proliferation factors. Also LSWT induces neovascularization and cell proliferation.⁵ LSWT could improve penile blood flow and endothelial function by stimulating angiogenesis in the penis.⁶ This technology is becoming a new modality in the treatment of patients with ED.

Clinical cases

We evaluated 15 men, with vasculogenic ED, between 45 and 70 years of age sexually active (sexual activity with a partner or manual stimulation) with mild to moderate vasculogenic ED. Patients were assessed with the International Index of Erectile Function (IIEF-EF). The study was conducted in three stages, from June to December 2013. The first stage consisted of screening, including complete medical history and physical examination. The second stage was the treatment, which in turn was carried out in two phases, the first phase is called "physical therapy" in which all patients received 4 sessions with LSWT (RENOVA®) 5000 waves of 0.09 mJ/mm², 300 intensity waves/min (5 Hz), 40 mm deep, in four areas (cavernosum right, left waves on each side 900, and left and right crus waves 1600 on each side); each session lasting 20 min with an interval of one week between each session.

The treatment is performed on an outpatient basis without using any anesthetic. The second phase of treatment consisted of "rehabilitation" at home between sessions (sexual activity with a partner or manual stimulation); and finally, the third stage of the study, evaluating the clinical results using IIEF, EHS (Erection Hardness Score),

SEP (Sexual Encounter Profile), GAQ (Global Assessment Questions) at one month and six months after treatment.

We analyzed quantitative and qualitative variables such as age, body mass index (BMI), smoking history, diabetes mellitus, hypertension, ischemic heart disease, Basal IIEF (Grade ED), EHS, SEP, years with ED. The statistical analysis is done with GraphPad Prism 6.0 and SPSS 19 statistics using the following tests: Student *t* distribution (*t*), Pearson correlation (*r*), (*p*).

Results

Fifteen men with a mean age of 59.6 years (45–70) with mild to moderate ED were enrolled. 40% of patients (6/15) had mild ED, and 60% had moderate ED (9/15). Patients with mild ED had a basal IIEF-EF average of 18 points, and 13 points for patients with moderate ED. Treatment efficacy was evaluated with IIEF-EF, GAQ, and SEP.

Success of treatment was defined as an increase of >2 points and >5 points in groups of mild and moderate, respectively (9). No adverse effects occurred. The rate of success was 80%. We found a positive association between the basal IIEF (average 14.23 pts) and IIEF after one month and six months (19.69 pts) with a difference of 5.46 pts ($p < 0.013$) (Table 1).

Patients with mild ED 83% (5/6) had improvement >2 pts; and patients with moderate ED 78% (7/9) had an increase of >5 pts ($p < 0.56$).

We found no association between minor age (mean 59.6 years) and treatment success, (7/15) 46% of patients were >60 years, all these (7/7) had a positive response to treatment, and (8/15) 54% patients were <60 years in this group, 62% (5/8) were successful with the treatment ($p < 0.01$).

We observed that patients who had 1–5 years with ED 60% (9/15) showed an improvement of 4 points in 67% (6/9) of patients, ($p < 0.20$); and we did not find an association between the IPSS (average 9 points) and the success of treatment ($p = 0.0712$).

We analyzed the influence of the smoking index on the response to the treatment. Patients had a smoking index <20 and >20, and there is a negative association ($p < 0.05$) between these groups, 73% (11/15) of patients had a smoking index (SI) <20, 92% (10/11) of them were successful with

Table 1 Results of sexual function questionnaires before and 1 month after low-intensity extracorporeal shockwave therapy.

Test Score	Baseline Score	Score 1 mo after treatment	<i>p</i> value
IIEF	15 (11–18) pts	20 (11–23) pts	<i>p</i> < 0.013
EHS	2 (2–3) pts	4 (2–4) pts	<i>p</i> < 0.01
SEP III	7 patients	12 patients	<i>p</i> = 0.0013
GAQ	–	12 patients	

IIEF: International Index of Erectile Function 21–25 points = normal, 16–20 = mild erectile dysfunction, 11–15 = moderate erectile dysfunction, 5–10 = severe erectile dysfunction. EHS: 0 = the penis enlarges, 1 = the penis enlarges, but not flabby, 2 = the penis hardens, but not enough for penetration, 3 = the penis is hard enough for penetration but not completely hard, 4 = the penis is completely hard and stiff. SEP: Sexual Encounter Profile; GAQ: Global Assessment Questions.

the treatment, and only 50% (2/4) of patients with a SI >20 showed improvement.

There is no influence between obesity and treatment response in these patients, according to the BMI. Overweight 73% (11/15) and obese 27% (4/15) patients, in the obese patients group had 50% (2/4) success with the treatment, the trend is that there is no association between obesity and no improvement in IIEF (*p* = 0.15).

Diabetic patients were 53% (8/15), of which 62% (5/8) had a favorable response to treatment, and 47% (7/15) of non-diabetic patients were successful with the treatment.

During the study, we compared the strength of erection with baseline and post-treatment level, finding that 53% (8/15) of patients had EHS <2, and of these, 33% (3/8) showed improvement with treatment (*p* < 0.01) (Table 2).

In reviewing the responses on the GAQ, in our study we found that 80% (12/15) of patients responded “yes”, therefore we consider it a successful treatment for these patients (Table 1).

Discussion

All treatments available for ED improve sexual function and the quality of erections, but they are not curative. The search for a cure for ED is the next step, and it should be the goal in the coming years. Scientific evidence casts controversial results, so efficiency will be demonstrated in LSWT double-blind controlled studies.

We selected measurement tools validated and accepted as the IIEF and EHS, these questionnaires have a high degree of sensitivity and specificity for detecting changes in the mechanism of erection associated to the treatment.^{7–9}

The results in our study show that EHS was >3 in 80% of patients after LSWT. It is a remarkable improvement in patients, and it is noteworthy that it was achieved without using any medication. Subjective evaluation of erectile function coincides with the fact that LSWT has an effect on the mechanism of erection by improving blood flow to the penis.¹⁰ It is suggested that successful LSWT for mild to moderate ED is defined as an increase >2 and >5 points in the IIEF.¹¹

Table 2 Patient characteristics and the effect of low-intensity extracorporeal shockwave therapy on the International Index of Erectile Function score.

Patient characteristics	No. Patient that improve IIEF	<i>p</i> value
<i>ED grade</i>		
Mild	(5/6)	<i>p</i> < 0.56
Moderate	(7/9)	
<i>Age</i>		
<60 years	(5/8)	<i>p</i> < 0.01
>60 years	(7/7)	
<i>ED duration</i>		
>3 years	(6/6)	<i>p</i> < 0.20
<3 years	(6/9)	
<i>Smoking index</i>		
>20	(2/4)	<i>p</i> < 0.05
<20	(10/11)	
<i>Quality of life</i>		
QoL >15	(10/10)	<i>p</i> = 0.19
QoL <15	(2/5)	
<i>Body mass index</i>		
>30	(2/4)	<i>p</i> = 0.009
<30	(10/11)	
<i>Diabetes mellitus</i>		
Diabetic patients	(5/8)	<i>p</i> = 0.1
Non-diabetic Patients	(7/7)	
<i>Trust to achieve and maintain erection</i>		
Q15 >3	(10/10)	<i>p</i> = 0.19
Q15 <3	(2/5)	

SEP evaluates sexual encounters with two questions; SEP-2 in the past 4 weeks, were you able to penetrate your partner?, SEP-3 Have you had an erection long enough for you to have successful intercourse? The GAQ questionnaire evaluates treatment; GAQ-1 in the past 4 weeks, Has the treatment you have been following improved erectile function?, GAQ-2 if the response to GAQ-1 is YES, Has the treatment improved its ability to engage in sexual activity during the past 4 weeks? In reviewing the responses to these questionnaires, in our study we found that 80% of patients responded “yes”, so it is considered a successful treatment for these patients.

The initial trend indicators help us identify risk factors that contribute to negative results. We consider that monitoring should be extended to obtain long-term results, and so far there are no reports of long-term results.

Conclusions

Our short-term results are encouraging, but they demand a long-term evaluation. Based on our results, LSWT can be effective and safe for the treatment of vasculogenic ED. The feasibility and tolerability of this treatment make it an attractive new treatment option for patients with vasculogenic ED.

Conflict of interest

The authors declare that they have no conflict of interest.

References

1. Persu C, Cauni V, Gutue S, Albu ES, Jinga V, Geavlete P. Diagnosis and treatment of erectile dysfunction. *J Med Life*. 2009;2:394–400.
2. Robert C, Lue TF. Physiology of penile erection and pathophysiology of erectile dysfunction. *Urol Clin North Am*. 2005;32:379–403.
3. Wespes E, Amar E, Eardley I, Giuliano F, Hatzichristou D, Hatzimouratidis K, et al. Guía clínica sobre la disfunción sexual masculina: disfunción eréctil y eyaculación precoz. *Eur Urol*. 2010;5:846–99.
4. Johannes CB, Araujo AB, Feldman HA, Derby CA, Kleinman KP, McKinlay JB. Incidence of erectile dysfunction in men 40 to 69 years old: Longitudinal results from the Massachusetts Male Aging Study. *J Urol*. 2000;163:460–3.
5. Wang CJ, Wang FS, Yang KD, Weng LH, Hsu CC, Huang CS, et al. Shock wave therapy induces neovascularization at the tendon-bone junction: a study in rabbits. *J Orthop Res*. 2003;21:984–9.
6. Lei H, Liu J, Li H, Wang L, Xu Y, Tian W, et al. Low-intensity shock wave therapy and its application to erectile dysfunction. *World J Mens Health*. 2013;31:208–14.
7. Rosen RC, Cappelleri JC, Gendrano N 3rd. The International Index of Erectile function (IIEF): a state-of-the-science review. *Int J Impot Res*. 2002;14:226–30.
8. Rosen RC, Allen KR, Ni X, Araujo AB. Minimal clinically important differences in the erectile function domain of the International index of erectile function scale. *Eur Urol*. 2011;60:1010–6.
9. Vardi Y, Dayan L, Apple B, Gruenwald I, Ofer Y, Jacob G. Penile and systemic endothelial function in men with and without erectile dysfunction. *Eur Urol*. 2009;55:979–85.
10. Vardi Y, Appel B, Jacob G, Massarwi O, Gruenwald I. Can low-intensity extracorporeal shockwave therapy improve erectile function? A 6-month follow-up pilot study in patient with organic erectile dysfunction. *Eur Urol*. 2010;58:243–8.
11. Vardi Y, Appel B, Kilchevsky A, Gruenwald I. Does low intensity extracorporeal shock wave therapy have a physiological effect on erectile function? Short-term results of a randomized, double-blind, sham controlled study. *J Urol*. 2012;187:1769–75.

EFFECTIVENESS OF LOW-INTENSITY EXTRACORPOREAL SHOCK WAVE THERAPY ON PATIENTS WITH ERECTILE DYSFUNCTION (ED) WHO HAVE FAILED TO RESPOND TO PDE5I THERAPY. A PILOT STUDY

Amado Bechara¹, Adolfo Casabé², Walter De Bonis³ and Julián Nazar⁴.

¹Jefe de Unidad de la División Urología del Hospital Durand. Buenos Aires, Argentina. Profesor de Urología de la UBA. Co-Director Médico del Instituto Médico Especializado (IME).

²Encargado del Sector Medicina Sexual de la División Urología del Hospital Durand. Co-Director Médico del IME Buenos Aires, Argentina.

³Urólogo de la División Urología del Hospital Durand y del IME. Buenos Aires, Argentina.

⁴Urólogo de la División Urología del Hospital Durand. Buenos Aires, Argentina.

Summary.- Low-intensity extracorporeal shock wave therapy (LIESWT) of the penis has recently emerged as a promising modality in the treatment of ED.

OBJECTIVES: The objective of this paper is to assess the effectiveness and safety of LIESWT on patients with ED who have failed to respond to PDE5i treatment.

METHODS: Open label, prospective, longitudinal observational study. The study involved an uncontrolled population of 25 patients. The treatment consisted in applying 20,000 shock waves during a period of four weeks. In each session the patient received 5000 shock

waves of 0.09 mJ/mm²: 1800 were applied on the penis (900 on each corpus cavernosum), and 3200 were applied on the perineum (1600 on each crus). During the active treatment and follow-up phases, all patients remained on their regular high on demand or once-a-day dose PDE5i schedules.

Main Outcome Measures: Effectiveness was assessed by IIEF-6, SEP2, SEP3 and GAQ. Patients were considered to be responders whenever they improved on all three erection assessment parameters and respond positively to the GAQ at three months post-treatment. Adverse events were recorded. Statistical variables were applied and findings were considered to be statistically significant whenever the P value was < 0.05.

RESULTS: Eighty percent (median age 63) of the patients (20/25) completed the study. Five patients were lost to follow-up and were excluded from the analysis.

Sixty percent (60%) of the patients responded to the treatment, improved the 3 efficacy evaluating parameters and responded positively to the GAQ. The increase in mean IIEF-6 score was of 9 points after the third post-treatment month. There were no patients reporting treatment-related adverse events.

CONCLUSIONS: LIESWT for men with ED and that are PDE5i non-responders was safe and effective and restoring PDE5i response in more than 50% of patients. A large-scale multicenter study is required to determine the benefits of this treatment for ED.



CORRESPONDENCE

Amado Bechara
Jefe de Unidad de la División Urología
del Hospital Durand.
Buenos Aires, (Argentina).

amadobechara@fibertel.com.ar

Accepted for publication: December 8th, 2014

Keywords: Low Intensity Extracorporeal Shock Wave Therapy. Erectile dysfunction. PDE5i.

Resumen.- Las LISW son una novedosa modalidad de tratamiento en pacientes con disfunción eréctil (DE).

OBJETIVO: Evaluar la efectividad y seguridad de las LISW en varones con DE no respondedores a IPDE5.

MÉTODO: Estudio naturalístico, prospectivo, longitudinal, observacional que incluyó una población de 25 pacientes no respondedores a dosis máxima de IPDE5. El tratamiento consistió en aplicar 20000 LISW durante 4 semanas (4 sesiones). En cada sesión el paciente recibió 5000 ondas de choque de 0,09 mJ/mm². 1800 aplicadas en el pene (900 en cada cuerpo cavernoso) y 3200 en el periné (1600 en la raíz derecha e izquierda cavernosa). Durante el tratamiento y fases de seguimiento se mantuvo igual dosis de IPDE5 como venía siendo tratado. Los cambios sobre la erección fueron evaluados utilizando el Índice Internacional de la Función Eréctil-6 (IIEF-6) y las preguntas 2 y 3 del Perfil de Encuentro Sexual (SEP). Complementariamente se agregó una pregunta sobre eficacia global del tratamiento (GAQ). Consideramos respondedor al paciente que mejoraba significativamente los 3 parámetros de rigidez y que respondiera afirmativamente a la GAQ, 3 meses post-tratamiento. Fueron aplicadas variables de cálculo para considerar una significancia estadística con una $p < 0,05$.

RESULTADOS: El 80% de los pacientes (20/25) completaron el estudio. La mediana de la edad fue de 63 años. Cinco fueron excluidos del análisis por pérdida de seguimiento. Del grupo evaluado, 12 (60%) mejoraron los 3 parámetros de erección y respondieron afirmativamente a la GAQ. El incremento promedio del IIEF-6 fue de 9 puntos. Ningún evento adverso fue reportado.

CONCLUSIONES: LISW en varones con DE no respondedores a IPDE5 fue eficiente y seguro, restaurando la respuesta a los IPDE5 en más de la mitad de los pacientes. Estudios multicéntricos, controlados y con mayor número de pacientes confirmaran el beneficio de esta nueva línea de tratamiento.

Palabras clave: Terapia de ondas de choque de baja intensidad. Disfunción eréctil. IPDE5.

INTRODUCTION

The treatment of erectile dysfunction (ED) has evolved considerably over the last decade, following the introduction of type 5 phosphodiesterase inhibitors (PDE5i), which have become the first line of treatment for this complaint.

Despite the effectiveness of these drugs, a number of patients ranging from 40% to 50% (depending on the etiology of their disease) do not respond to drug therapy even after optimization approaches such as treatment combinations have been implemented (1-5).

The second and third lines of treatment are the self-injection of vasoactive drugs and penile prosthetic implants, which many patients are reluctant to accept.

Recently, two observational and one controlled trial have been published reported efficacy and safety of low-intensity extracorporeal shock wave therapy (LI-ESWT), particularly for patients with ED of vascular origin who are PDE5i non-responders (6-8).

Young and Dyson discovered that therapeutic ultrasound encourages angiogenesis by enhancing the expression of vascular endothelial growth factor. (9). Nurzynska et al. demonstrated that shock waves have positive influence on both the proliferation and the differentiation of cardiomyocytes, smooth muscle and endothelial cells precursors, with a more obvious effect being evident in the cells from normal heart than in those taken from pathologic hearts (10).

From these initial reports, LI-ESWT was implemented in the past decade in the treatment of chronic myocardial ischemia, diabetic foot ulcers, among other applications (11-15).

LI-ESWT involves a very small amount of energy (0.09 mJ/mm²), equivalent to 10% of the energy used by conventional lithotripters for the treatment of urinary tract stones.

Initially, LI-ESWT systems essentially involved orthopedic extracorporeal shock wave therapy devices delivering targeted energy (7).

The mechanism of action is still not completely elucidated. However, it has been shown that low-intensity energy induces the production of a physiologically significant amount of non-enzymatic nitric oxide and activates the intracellular cascade pathways that trigger the release of angiogenic factors (16).

Based on the above assumptions, the aim of this study has been to evaluate the effectiveness and safety of low-intensity extracorporeal shock wave therapy on patients with ED that are PDE5i non-responders.

AIM

To assess the effectiveness and safety of low-intensity extracorporeal shock wave therapy on patients with Erectile Dysfunction (ED) who have failed to respond to PDE5i treatment

METHODS

This was a prospective, longitudinal, observational and independent study, designed to evaluate the safety and efficacy of LI-ESWT in a population uncontrolled sexually active men with erectile dysfunction and associated vascular risk factors (VRFs) are PDE5i non responders.

The inclusion criteria involved sexually active ED male patients who were non-responders to oral PDE5i therapy and exhibited vascular risk factors (VRFs) (e.g., diabetes, hypertension, dyslipidemia and coronary artery disease). Patients with untreated hypogonadism or a history of pelvic surgery, as well

as patients with ED of neurological origin (resulting from prostatectomy, pelvic surgery or spinal cord injury) were excluded.

They were considered non-responders to PDE5 inhibitors those patients who after completing all optimization measures commonly suggested manifested not achieve and / or maintain erections sufficient for penetration and had an International Index of Erectile Function 6 questions (IIEF-6) under action of these drugs <26 points (17,18).

The study involved a total population of 25 patients. During the active treatment and follow-up phases, all the patients remained on their regular high on demand or once-a-day dose PDE5i schedules (Table I).

The following evaluation criteria were used: the International Index of Erectile Function Questionnaire (IIEF-6) to assess ED severity (19); questions 2 and 3 from the Sexual Encounter Profile (SEP2 and SEP3) to assess penetration and erection sustainability; and a Global Assessment Question (GAQ): Does the treatment has improved the quality of your erections?.

The severity of ED was classified into five categories according to the IIEF-6 score: no ED -score 26 to 30-, mild -score 22 to 25-, mild to moderate

Table I. Study design and procedures.

	VISIT 1 Screening (Baseline)	VISIT 2 1 st week of treatment	VISIT 3 2 nd week of treatment	VISIT 4 3 rd week of treatment	VISIT 5 4 th week of treatment	VISIT 6 1 st month evaluation	VISIT 7 3 rd month evaluation
PDE5i	X	X	X	X	X	X	X
Medical history	X						
Physical Examination	X	X	X	X	X	X	X
LSWT		X	X	X	X		
IIEF-EF, SEP 2-3	X					X	X
GAQ						X	X
Treatment		X	X	X	X		
Adverse Effects		X	X	X	X	X	X

-score 17 to 21-, moderate -score 11 to 16-, and severe -score 6 to 10- (17).

The evaluation criteria were assessed before treatment as well as one month and three months after treatment completion. Patients were always evaluated while on PDE5i therapy.

After the treatment the patients were considered to be responders whenever they improved on all three assessment erection parameters and to respond positively to the GAQ at three months post-treatment.

This trial was performed using RENOVA NR, a LI-ESWT device manufactured by Direx Group. The treatment consisted in applying 20,000 shock waves during a period of four weeks (four sessions). In each session, the patient received 5000 shock waves of 0.09 mJ/mm²: 1800 were applied on the penis (900 on each corpus cavernosum), and 3200 were applied on the perineum (1600 on each crus). The treatment areas were the same in all four sessions. All sessions were performed without anesthesia and in an outpatient setting, and each lasted 20 minutes.

The study was conducted according to Good Clinical Practices and the Helsinki Declaration, it was approved by the local Research Ethics Committee, and all the patients signed an informed consent form.

Considering the number of patients included and the rate of loss to follow for the calculation of the variables of demographic characteristics of responders and non-responders and the efficacy variables, medians were compared using nonparametric tests as Mann-Whitney test and the Wilcoxon test Match respectively. A $p < 0.05$ was considered statistical significance

RESULTS

Eighty percent (80%) of the patients (20/25) completed the study. Five patients were lost to follow-up and were excluded from the analysis.

The median age and the duration of ED were 63 years and 42 months respectively (Table II). Additional demographic details are shown in Table II.

Erectile dysfunction as per the IIEF-6 score was severe in 20% of the patients, moderate in 40%, mild to moderate in 35%, and mild in 5%. The mean age of the patients was 54.3, 62.3, 63.4 and 58, respectively, for severe, moderate, mild to moderate and mild ED. ED duration as related to ED severity was 28.5, 66, 60 and 36 months for severe, moderate, mild to moderate and mild patients, respectively.

Table II. Baseline data of the patients.

n	20
Median Age	63
Age range (years)	46-78
Median ED duration (months)	42
Range (months)	12-132
Cardiovascular risk factors	n (%)
Hypertension	11 (55 %)
Diabetes Mellitus	11 (55 %)
Dyslipidemia	5 (12,5 %)
Coronary artery disease	5 (12,5 %)

Sixty percent (60%) of the patients (12/20) responded to the treatment, improved the 3 parameters for evaluating efficacy and responded positively to the GAQ. The baseline characteristics of the patients that responded and failed to respond to the therapy are shown in Table III.

The increase in the IIEF-6 score in responders patients was statistically significant as from the first-month evaluation, and attained a mean of 9 points after the third month post-treatment (Figure 1).

Improvements on the IIEF score were more dramatic whenever ED was more severe, with changes of 14, 10.8 and 5.8 points for patients with severe, moderate and mild-to-moderate ED respectively. Four patients reached a score equal to or higher than 26 points in the IIEF, and the degree of severity dropped in the remaining patients (Table IV).

Towards the end of the study, significant changes were encountered in the responder group with regard to questions 2 and 3 of the Sexual

Encounter Profile. In the non-responder group of patients, the changes in these two questions were not statistically significant (Figure 2).

15 of 20 patients (75 %) stated that the therapy had improved their erectile response.

There were no patients reporting treatment-related adverse events.

DISCUSSION

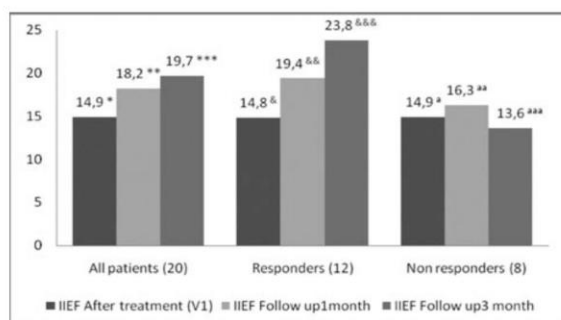
Erectile dysfunction, a highly prevalent complaint in men over 50, can almost always be traced back to a history of vascular risk factors (19).

Many studies have emphasized the status of ED as a potential indicator of cardiovascular disease later in life, while other clinical trials have found a high rate of ED in men with vascular factors such as metabolic syndrome, diabetes and hypertension (20, 21).

Table III. Demographic characteristics of patients (both responders and non-responders).

Patients	Responders	Non-responders
n	12	8
Median Age (years)	56.5*	60**
Age range (years)	46-78	62-65
Median ED durations (months)	36&	30 &&
Range (months)	12-132	6-120
Cardiovascular risk factors	n (%)	n (%)
Hypertension	6 (50 %)	5 (62.5 %)
Diabetes Mellitus	7 (58 %)	4 (50 %)
Dyslipidemia	2 (42 %)	3 (37.5)
Coronary artery disease	4 (33.3 %)	1 (12.5)
ED Severity according to the IIEF	n (%)	n (%)
Severe	1 (8.3 %)	3 (37.5 %)
Moderate	6 (50 %)	2 (25 %)
Mild to Moderate	5 (41.7 %)	2 (25 %)
Mild	0 (0 %)	1 (12.5 %)

Mann Whitney test: * vs ** $P > 0.05$; & vs && $P > 0.05$
ED::Erectile dysfunction



* vs ** P < 0.05	& vs && P < 0.05	a vs aa P < 0.05
* vs *** P < 0.05	& vs &&& P < 0.05	a vs aaa P > 0.05
** vs *** P > 0.05	&& vs &&& P < 0.05	aa vs aaa P > 0.05

Figure 1. Evolution of changes in IIEF-6 score after the first and third month of treatment.

Introduced in 1998, PDE5i have changed the treatment paradigm for patients with ED as a result of this therapy, approximately 60 % of patients can recover their erectile function and lead a satisfactory sex life as a result (22).

The choice of PDE5i and their dose regimen are specific to each patient. However, some patients are all too hastily considered to be non-responders because of prescription dosage errors. With the right dose optimization, an increase in sexual stimuli, a correction of testosterone levels and proper patient dietary training whenever short-acting PDE5i are used, around one-third of non-responders succeed in recovering their erectile function (18).

However, despite these measures, about 40 % of men fail to achieve an adequate response to PDE5i, and must resort to second or third-line options; others abandon all treatment possibilities altogether when they realize that they are not responding to oral therapy.

For some years now, low-intensity extracorporeal shock wave therapy has been implemented to optimize the response of PDE5i.

Qiu X et al have demonstrated that shock wave therapy significantly restored erectile function in rats with streptozotocin-induced diabetes mellitus, to levels similar to those exhibited by healthy controls, thus validating the animal model as comparable to prior clinical trials performed on humans. According to trial results, improvements in erectile function might be attributable to the positive effects afforded by the shock waves on endothelial and smooth muscle regeneration in the penis. These effects appear to be mediated by the recruitment of endogenous smooth muscle cells (23).

Vardi et al presented the first randomized, double-blind, sham-controlled study that demonstrated that low-intensity extracorporeal shock wave therapy has a positive clinical and physiological short-term effect on erectile function for patients that are PDE5i responders (8).

These experts used a compact electrohydraulic system fitted with a targeted shock wave source (Omnispec ED1000, Medispec Ltd, Germantown, MD, USA). Unlike the system we used on our patients, they had to stretch the penis and manually apply the transducer to it proximally, medially and distally, and then apply it to the perineum. With this operator-

Table IV. Changes in ED severity following shock wave treatment concurrently with PDE5I therapy (responders patients).

	Before treatment	After treatment
	n (%)	n (%)
Severe Erectile dysfunction (ED)	1 (8.3)	0 (0)
Moderate ED	6 (50)	0 (0)
Mild to Moderate ED	5 (41.7)	4 (33.3)
Mild ED	0 (0)	4 (33.3)
No ED	0 (0)	4 (33.3)

dependent method, the selected treatment protocol consisted of two sessions per week over a period of three weeks, and was repeated after a treatment-free interval of three weeks.

It is worth pointing out that, unlike the group of patients presented by Vardi et al (6), those patients included in this presentation were only non-responder patients to oral therapy at the maximum dose, and only after having indicated and verified that all optimization indications had been fulfilled. PDE5i were never suspended, and they continued with their regular scheme throughout the four-week treatment with LISW, as well as during the follow up period of 1 to 3 months.

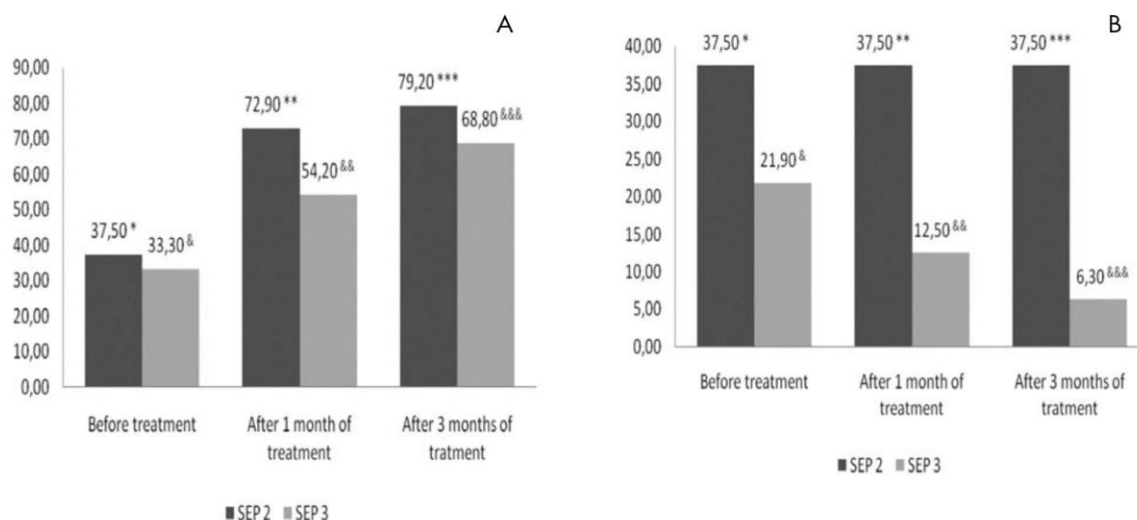
As mentioned before, the device selected for our trial (Renova NR), is manufactured by Direx Group, and involves a special LI-ESWT technology. This operator-independent system is fitted with a transducer that is capable of delivering shock waves

all along the penis, spanning an area of 70mm and thus eliminating the need for penis manipulation. Furthermore, the transducer does not even need to be held by the operator, as it can be secured to the perineum.

Study design was as suggested by the manufacturer, i.e. four weekly sessions, each lasting 20 minutes.

In our trial, improvements in the IIEF-6 score were evident as early as the first month after treatment completion, but the four efficacy parameters became clearly apparent as of the third month after treatment completion, with an average improvement of 9 points in the IIEF.

In a recent report featured at the Congress of the Latin American Society for Sexual Medicine, Reisman et al presented a prospective, multicentric, open-label pilot study which was conducted at four



A. Wilcoxon matched pairs test

* vs **	p<0.05
* vs ***	p<0.01
** vs ***	p>0.05
& vs &&	p>0.05
& vs &&&	p<0.05
&& vs &&&	p>0.05

B. Wilcoxon matched pairs test

* vs **	p>0.05
* vs ***	p>0.05
** vs ***	p>0.05
& vs &&	p>0.05
& vs &&&	p>0.05
&& vs &&&	p>0.05

Figure 2. Evolution of changes in SEP 2 and SEP 3 after treatment in responders (A) and nonresponders (B).

sites and involved 52 patients with mild to severe ED. The patients were treated with the same device as the one used in this trial, with results assessed using IIEF-EF, SEP 2-3 and GAQ at one and three months post-treatment. Success was defined as an increase in the IIEF-EF score between baseline and the second follow-up. Significant changes were reported for 78.8% of the patients in the IIEF score, which exhibited a 6.8 increase (24).

It should be noted that in contrast with Reisman's report, in our trial patients had to exhibit changes across all four PDE5i response enhancement variables (IIEF6, SEP2, 3 and GAQ) –i.e., not just the IIEF score– in order for them to be considered treatment responders. This adds robustness to our results, as numeric changes in the IIEF score alone do imply improvement, but do not necessarily guarantee complete or successful intercourse. In our results, not all patients improved their IIEF6, had better SEP 2 and SEP 3 and many of those who claimed that the treatment had improved (GAQ), not reflected in the IIEF or SEP 2 or SEP3.

In addition, four out of twelve responders in our trial (33 %) attained normal IIEF values, and the rest experienced a decrease in symptom severity (Table V).

Finally, once shock wave therapy was completed and while still on PDE5i treatment, patients in the responder population successfully completed intercourse in 70% of their sexual encounters as shown in figure 2 (SEP 2, 3). This figure is similar to the one exhibited by different PDE5i efficacy reports (25-27).

Our study has several limitations. First, its lack of a placebo group prevents a proper comparison of the effects of shock wave therapy.

Another limitation of this study is the short follow-up phase (three months after treatment), which added to the lack of a placebo group, prevents us from knowing whether the changes are temporary or permanent, or derived from a placebo effect.

Importantly, each patient was compared with himself before and after shock wave therapy concurrently with PDE5 inhibitors. These were patients that had remained unresponsive to oral therapy even after the introduction of optimization measures.

Whenever independent pilot studies are conducted, the number of patients included tends to be small, and the results cannot be generalized. Nevertheless, we believe that, however limited the

experiences reported in the literature so far allow us to take these preliminary data into consideration, while being cautious about its interpretation. We hope that these data will be to be confirmed by multicenter sham control studies on a larger group of patients and involving a longer follow-up phase.

In our group of patients, neither age nor ED duration had an influence on the results (Table II). However, and although changes in the IIEF were directly proportional to ED severity, the group of VRFs and severe ED patients responded less in percentage terms (25%) (Table III). This observation is consistent with the importance of defining whether the number of sessions or shock waves should be increased or repeated over time depending on ED severity. Gruenwald et al report that a second round of L-ESWT was beneficial in 25 patients with partial or unsatisfactory results after the first session (28).

CONCLUSIONS

According to our results, low-intensity extracorporeal shock wave therapy for patients with ED and vascular risk associated who are poor PDE5i responders, was safe and effective. This approach will thus enable the optimization and restoration of PDE5i response in more than 50% of patients. A large-scale multicentric study is required to determine the benefits of this new line of treatment for ED.

REFERENCES AND RECOMMENDED READINGS (*of special interest, **of outstanding interest)

1. Gruenwald I, Shenfeld O, Chen J, Raviv G, Richter S, Cohen A, Vardi Y. Positive effect of counseling and dose adjustment in patients with erectile dysfunction who failed treatment with sildenafil. *Eur Urol* 2006; 50:134-140
2. Hatzimouratidis K, Moysidis K, Bekos A, Tsimtsiou Z, Ioannidis E, Hatzichristou D. Treatment strategy for “nonresponders” to tadalafil and vardenafil: A real-life study. *Eur Urol* 2006; 50:126–32.
3. Eardley I, Donatucci C, Corbin J, El-Meliegy A, Hatzimouratidis K, McVary K, Munarriz R, Lee SW. Pharmacotherapy for erectile dysfunction. *J Sex Med* 2010;7:524-40
4. Sommer F, Engelmann U. Future options for combination therapy in the management of erectile dysfunction in older men. *Drugs Aging* 2004; 21: 555–64
5. Dhir R, Lin HCh, Canfield SE, Wang R. Combination therapy for erectile dysfunction: an update review *Asian J Androl* 2011; 13: 382–390

6. Vardi Y, Appel B, Jacob G, Massarwi O, Gruenwald I. Can low-intensity extracorporeal shockwave therapy improve erectile function? A 6-month follow-up pilot study in patients with organic erectile dysfunction. *Eur Urol* 2010; 58:243–8.
7. Gruenwald I, Appel B, and Vardi Y. Low-intensity extracorporeal shock wave therapy—A novel effective treatment for erectile dysfunction in severe ED patients who respond poorly to PDE5 inhibitor therapy. *J Sex Med* 2012; 9:259–264
- **8. Vardi Y, Appel B, Kilchevsky A, Gruenwald I. Does Low Intensity Extracorporeal Shock Wave Therapy Have a Physiological Effect on Erectile Function? Short-Term Results of a Randomized, Double-Blind, Sham Controlled Study. *J Urol* 2012, 187, 1769:1775.
- **9. Young SR and Dyson M: The effect of therapeutic ultrasound on angiogenesis. *Ultrasound Med Biol* 1990; 16: 261-269.
- *10. Nurzynska D, Di Meglio F, Castaldo C, Arcucci A, Marlinghaus E, Russo S, Corrado B, de Santo L, Baldascino F, Cotrufo M, Montagnani S. Shock waves activate in vitro cultured progenitors and precursors of cardiac cell lineages from the human heart. *Ultrasound Med Biol* 2008; 34:334-342.
11. Nishida T, Shimokawa H, Oi K, Tatewaki H, Uwatoku T, Abe K, Matsumoto Y, Kajihara N, Eto M, Matsuda T, Yasui H, Takeshita A, Sunagawa K. Extracorporeal cardiac shock wave therapy markedly ameliorates ischemia-induced myocardial dysfunction in pigs in vivo. *Circulation* 2004, 110:3055-3061.
12. Aicher A, Heeschen C, Sasaki K, Urbich C, Zeiher A, Dimmeler S. Lowenergy shock wave for enhancing recruitment of endothelial progenitor cells: a new modality to increase efficacy of cell therapy in chronic hind limb ischemia. *Circulation* 2006;114: 2823–30.
13. Kikuchi Y, Ito K, Ito Y, Shiroto T, Tsuburaya R, Aizawa K, Hao K, Fukumoto Y, Takahashi J, Takeda M, Nakayama M, Yasuda S, Kuriyama S, Tsuji I, Shimokawa H.. Double-blind and placebo-controlled study of the effectiveness and safety of extracorporeal cardiac shock wave therapy for severe angina pectoris. *Circ J* 2010; 74: 589–91.
14. Wang CJ, Kuo YR, Wu RW, Liu RT, Hsu CS, Wang FS, Yang KD. Extracorporeal shockwave treatment for chronic diabetic foot ulcers. *J Surg Res* 2009; 152:96–103.
15. Dumfarth J, Zimpfer D, Vögele-Kadletz M, Holfeld J, Sihorsch F, Schaden W, Czerny M, Aharijad S, Wolner E, Grimm M.. Prophylactic low energy shock wave therapy improves wound healing after vein harvesting for coronary artery bypass graft surgery: a prospective, randomized trial. *Ann Thorac Surg* 2008;86:1909–13
- **16. Gotte G, Amelio E, Russo S, Marlinghaus E, Musci G, Suzuki H. Short time non-enzymatic nitric oxide synthesis from L-arginine and hydrogen peroxide induced by shock waves treatment. *FEBS Lett* 2002; 520:153–5.
17. Cappelleri J., Rosen R, Smith M, Mishra A, Osterloh I. Diagnostic evaluation of the erectile function domain of the International Index of Erectile Function. *Urology* 1999; 54:346-51.
18. McMahon, C; Smith, C, Shabsigh, R. Treating erectile dysfunction when PDE5 inhibitors fail. *BMJ* 2006 ; 11; 332 (7541): 589:592
19. Kloner R. Erectile dysfunction and cardiovascular risk factors. *Urol Clin N Am.* 2005; 32:397-402.
20. Gandaglia G, Briganti A, Jackson G, Kloner RA, Montorsi F, Montorsi V, Vlachopoulos C. A Systematic Review of the Association Between Erectile Dysfunction and Cardiovascular Disease. *Eur Urol.* 2014; 65:968-978
21. Seftel AD, Sun P, Swindle R. The prevalence of hypertension, hyperlipidemia, diabetes mellitus and depression in men with erectile dysfunction *J Urol.* 2004; 171 (6 Pt 1):2341-5.
22. Eardley I, Donatucci C, Corbin J, El-Meliegy A, Hatzimouratidis K, McVary K, Munarriz R, Lee SW. Pharmacotherapy for erectile dysfunction *J Sex Med.* 2010 7(1 Pt 2):524-40.
- *23. Qiu X, Lin G, Xin Z, Ferretti L, Zhang H, Lue TF, Lin CS. Effects of low-energy shockwave therapy on the erectile function and tissue of a diabetic rat model. *J Sex Med.* 2013, 10:738-46.
24. Reisman, Y; Hind, A; Varanekas, A; Motil, I. Efficacy and safety of linear focused shockwaves for erectile dysfunction (Renova) – a second generation technology XII Congress of The Latin American Society for Sexual Medicine <http://www.slams2013.org/slams2013-programa-final.pdf> O-15
25. Brock G, McMahon C, Chen K, Costigan T, Shen W, Watkins V, Anglin G, Whitaker S. Efficacy and safety of tadalafil for the treatment of Erectile dysfunction: results of integrated analyses. *J Urol* 2002, 168, 1332–1336.
26. Goldstein I, Lue TF, Padma-Nathan H, Rosen RC, Steers WD, Wicker PA. Oral sildenafil in the treatment of erectile dysfunction. *N Engl J Med* 1998; 338: 1397–1404.
27. Donatucci C, Eardley I, Buvat J, Gittelman M, Kell P, Segerson T, Homering M, Montorsi F; Vardenafil Study Group. Vardenafil improves erectile function in men with erectile dysfunction irrespective of disease severity and disease classification. *J Sex Med.* 2004, 1:301-9.
28. Gruenwald, I. E.; Appel, B2; Vardi, Y The effect of a second course of low intensity shock waves for ED in partial or non-responders to one treatment course *J Sex Med* 2012;9 (suppl 5):303–335 (Abs PS-05-005)



ORIGINAL ARTICLE

Initial experience with linear focused shockwave treatment for erectile dysfunction: a 6-month follow-up pilot study

Y Reisman¹, A Hind², A Varaneckas³ and I Motil⁴

Low-intensity shockwaves (LISW) are known to produce revascularization and have been in evaluation and in use to treat erectile dysfunction (ED). The present single-arm pilot study is aimed to assess the safety and efficacy of a dedicated shockwave device (Renova) on vasculogenic ED patients. Fifty-eight patients with mild to severe ED were treated by LISW and their erectile function was evaluated by the International Index of Erectile Function–Erectile Function Domain (IIEF–EF), Sexual Encounter Profile and Global Assessment Questions questionnaires, at baseline and at 1, 3 and 6 months post treatment. The average IIEF–EF increased significantly from 14.78 at baseline to 21.93 at 3 months post treatment and stabilized at 22.26 at 6 months post treatment. Out of 58 patients, 47 (81%) had a successful treatment. No adverse events were reported during the treatment and the follow-up duration. In conclusion, it suggests that the performance of LISW could add a new advanced treatment for ED.

International Journal of Impotence Research advance online publication, 4 December 2014; doi:10.1038/ijir.2014.41

INTRODUCTION

Vasculogenic erectile dysfunction (ED) is defined as inability to get or keep an erection firm enough for satisfying sexual intercourse and is maybe originated by diseases, such as diabetes mellitus (DM) and atherosclerotic vascular occlusive disease. Current methods for treating vasculogenic ED aim at reducing symptoms instead of reversing the source of the dysfunction, which in the majority of the patients is due to arterial or inflow disorders.¹ It has been demonstrated that shockwaves can enhance intrinsic angiogenesis and are used to treat ischemic heart disease.² Low-intensity shockwaves (LISW) have been evaluated for treating ED in both pilot and randomized sham-controlled studies. The encouraging results that were seen in these studies were the first to show the effect of LISW on ED symptoms,^{3–4} but have never been evaluated elsewhere. Recently published study conducted on rats with DM-associated ED showed that low-energy shockwave therapy (LESWT) significantly restored erectile function to levels almost similar to normal levels of controls. The therapeutic efficacy of LESWT is possibly mediated by increased recruitment of mesenchymal stem cells (MSCs) that promote the regeneration of DM-damaged erectile tissues.⁵

The present study was aimed to assess the safety and efficacy of a new dedicated shockwave device, 'Renova', which was designed to achieve substantially superior organ coverage, compared with the existing devices and hence produces positive results with a shorter protocol in a multicenter study.

SUBJECTS AND METHODS

Study protocol

This study was a multicenter open-label prospective pilot study, conducted at four sites. It was conducted in accordance with the principles of the Declaration of Helsinki of World Medical Association. Patients gave their written informed consent before participation in the study. This study consisted of a screening phase, treatment phase and a 6-month follow-up

phase. At screening phase, patients had an extensive medical and sexological history evaluation, as well as a physical examination. Inclusion criteria were heterosexual men in stable heterosexual relationship for at least 3 months, aged 20–80 years, with vascular ED (according to physician judgment) for at least 6 months, International Index of Erectile Function–Erectile Function Domain (IIEF–EF)⁶ score of 6–25 points. Recruited patients were both responders and nonresponders to phosphodiesterase type 5 inhibitors (PDE5-i). The exclusion criteria were hormonal, neurological or psychological pathology, past radical prostatectomy, any unstable medical or psychiatric condition, spinal cord injury, penile anatomical abnormalities, clinically significant chronic hematological disease, usage of antiandrogens, recovering from cancer in the past 5 years or radiotherapy in pelvic region.

At baseline and follow-up visits IIEF–EF and Sexual Encounter Profile (SEP)—questions 2 and 3 questionnaires were used.^{7–8} Global Assessment Questions⁹ (GAQ) were used at follow-ups as well. The IIEF–EF questionnaire is widely accepted as the best method to verify ED progress. It includes six questions regarding erectile function and its score range is 1–30 points. Safety was assessed at each treatment and follow-up visits, by answering questions regarding side effects and pain as part of the case report form (CRF). Patients were instructed to inform the investigators if any side effects occur.

Almost all of the patients were using PDE5-i during baseline evaluation. No PDE5-i were used 3 weeks prior to treatment, during shockwave treatment, and until the first follow-up, 1 month post treatments. Answering the questionnaires at the 3 and 6 months post-treatment follow-ups was made, whereas the patients were using PDE5-i, as was done in previously done studies.³ At all follow-up sessions, patients were instructed to return to the exact PDE5-i consumption as at baseline, as shown in Figure 1. Patients committed to avoid using any ED treatment other than PDE5-i oral medication throughout the study duration.

The treatment consisted of 4 weekly treatment sessions. During each session 3600 shocks of 0.09 mJ mm² were applied. Shocks were applied at the penis shaft at right corpus cavernosum and left corpus cavernosum, and at the crura at right crus and left crus, 900 shocks at each area. The treatment areas were the same for each session, so that at the end of the full treatment (four sessions) each area has received 3600 shocks of 0.09 mJ mm².

¹Men's Health Clinic, Amstelland Hospital, Amsterdam, The Netherlands; ²Urology and Andrology Center, Red Crescent Hospital (RCH), Ramallah, Palestine; ³Amber Clinic, Klaipėda, Lithuania and ⁴Urologická ambulance, Brno, Czech Republic. Correspondence: Dr Y Reisman, Urology, Amstelland Hospital, Laan van de Helende Meesters 8, 1187NR Amsterdam, The Netherlands.

E-mail: creisman@planet.nl

Received 28 December 2013; revised 10 July 2014; accepted 18 October 2014

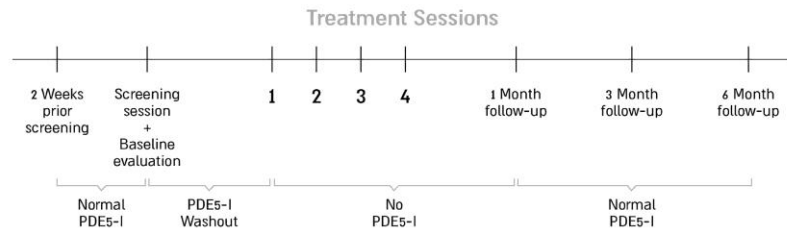


Figure 1. The use of PDE5-I throughout the study.

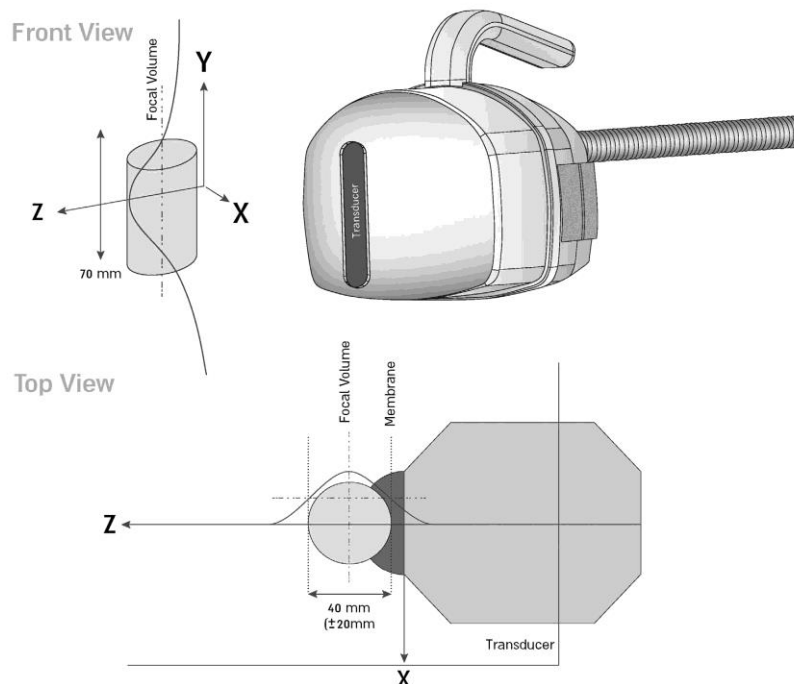


Figure 2. Qualitative view of the shockwave intensity changes.

Follow-ups were conducted at 1, 3 and 6 months post treatment and were consisted of adverse events report, IIEF-EF, SEP and GAQ questionnaires. The primary success criterion, regarding to efficacy, was defined as an increase of IIEF-EF score from baseline to the third follow-up (6 months post treatment) according to the initial ED severity: > 2-point increase for mild symptoms; > 5 points for moderate symptoms; and > 7 points for severe symptoms.⁶

Treatment device

Renova (Direx Group) is the first dedicated shockwave system for ED. Instead of generating shockwaves that converge on a single focal point and require moving the shockwave source to multiple positions along the penis, Renova is based on linear shockwave therapy (LSWT) that enables focusing shockwaves on a 70 mm long and 10 mm width treatment area along the target organ. The shockwaves penetrate into the treated organ to a 40 mm depth and therefore their focal volume is 9.4 cm³. Figure 2 described qualitatively how shockwaves intensity changes in z axis. The prolonged shape of the transducer (Figure 3) enables effective positioning when applying to the crura by its direct contact to the groin. Renova's electromagnetic generator delivers shockwaves with a maximum energy density of 0.09 mJ mm², meaning, they deliver 10% of the pressure used for disintegrating kidney stones. Shocks are delivered at a maximum rate of 300 pulses min⁻¹ (PPM; 5 Hz), therefore, the net treatment time of a session of 3600 shocks lasts ~ 15 min.

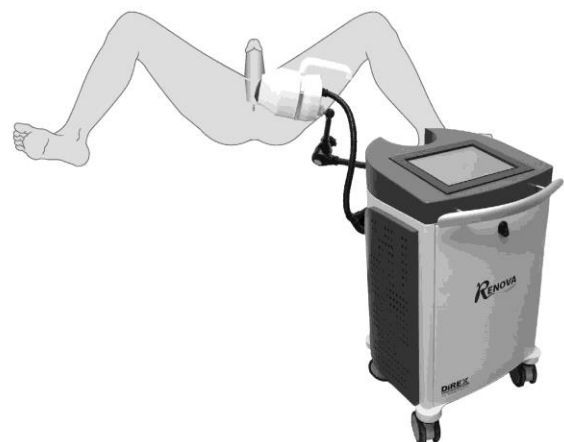


Figure 3. Renova's transducer: its prolonged shape enables effective positioning when applied to the crura.

Statistical analysis

Patients' demographic variables were summarized by descriptive statistics. The average score of each questionnaire and its s.d. was calculated at baseline and at 1-, 3- and 6-month follow-up. Student's *t*-test were used at significance level of < 0.05 .

RESULTS

Fifty-eight middle-aged men (mean: 56.75 ± 9.91 years, range: 33–84 years) with vasculogenic ED were recruited for this study: 20 patients were treated at Men's Health Clinic, Amstelland Hospital, Amsterdam; 17 were treated at the Urology and Andrology Center,

Red Crescent Hospital, Ramallah; 11 were treated at Amber Clinic, Klaipėda; and 10 were treated in Urologickaambulance.cz, Brno. Patients' characteristics were similar in all sites, excluding the patients in Brno, who had a longer duration of ED and a lower success rate than the rest of the sites. The selection of patients in the Lithuanian site was made with patients who had a milder average of clinical signs.

Twenty-five patients (43.1%) suffered from cardiovascular disease, 41.4% (24 patients) had diabetes, 39.7% (23 patients) suffered from hypertension and 46.6% (27) had high cholesterol level. Fifty patients (86.2%) were PDE5-i responders. In all, 37.9% of patients were smokers, 19.0% were past smokers and 43.1% have never smoked. Table 1 describes patients' background diseases with an emphasis on some of the main risk factors for vasculogenic ED.

Patients' baseline IIEF-EF score ranged between 6 and 25 points with an average of 14.8. Table 2 summarizes the effect of low-intensity extracorporeal shockwave therapy on the IIEF-EF scores, according to the baseline ED severity.

A moderate negative Pearson correlation coefficient of -0.62 was found between the duration of ED and success of treatment. Figure 4 describes the change in the IIEF-EF score between baseline and the follow-ups at 1, 3 and 6 months post treatment, according to the duration of ED. The percentage of patients who have answered 'Yes' to questions 2 and 3 of the SEP was calculated at baseline and at 1-, 3- and 6-month follow-up and is presented in Figure 5.

The percentage of patients who have answered 'Yes' to questions 1 and 2 of the GAQ was calculated at 1-, 3- and 6-month follow-up; for question 1, the percentages were 74.14%, 82.76% and 89.66%, respectively. For question 2, the percentages at 1-, 3- and 6-month follow-up were 63.79%, 68.97% and 75.86%, respectively.

Table 1. Patients' comorbidities with an emphasis on some of the main risk factors for vasculogenic ED: cardiovascular diseases; diabetes; hypertension; and high cholesterol

Disease	Cardiovascular disease	Diabetes	Hypertension	High cholesterol
Prevalence (%)				
27.6				
19.0	✓	✓	✓	✓
10.3				✓
10.3	✓	✓		
8.6		✓		
8.6		✓		✓
6.9		✓	✓	✓
1.7	✓	✓	✓	
1.7	✓			✓
1.7		✓	✓	
1.7	✓	✓		
1.7	✓			

Table 2. The results of the IIEF-EF, before and at 6 months following low-intensity extracorporeal shockwave therapy

Baseline ED severity	Number of patients	PDE5-i responders	Baseline IIEF-EF AVG \pm s.d.	IIEF-EF improvement points AVG \pm s.d.	% Success	P-value
Severe	13	69.23%	8.5 ± 1.2	8.5 ± 6.3	61.54	< 0.001
Moderate	22	86.36%	13.3 ± 1.8	8.3 ± 5.1	77.27	< 0.001
Mild to moderate	18	94.44%	18.6 ± 1.5	6.8 ± 3.0	94.44	< 0.001
Mild	5	100.00%	23.6 ± 1.3	3.6 ± 0.5	100.00	< 0.001
Total	58	86.2%	14.8 ± 4.8	7.5 ± 4.7	81.03	< 0.001

Abbreviations: ED, erectile dysfunction; IIEF-EF, International Index of Erectile Function-Erectile Function Domain; PDE5-i, phosphodiesterase type 5 inhibitors. Two-tailed *t*-test was performed on the IIEF-EF scores of each group of ED severity before Renova treatment and at 6-month follow-up.

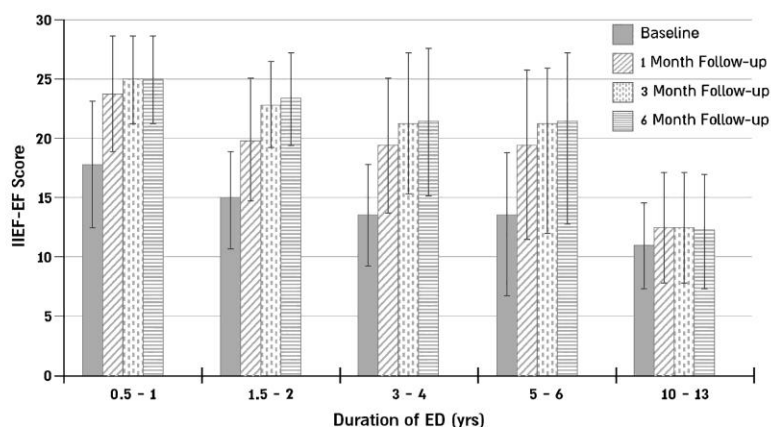


Figure 4. The change in the IIEF-EF score between baseline and the follow-ups at 1, 3 and 6 months post treatment, in accordance with the ranges of ED duration. The error bars indicate the s.d. of each group.

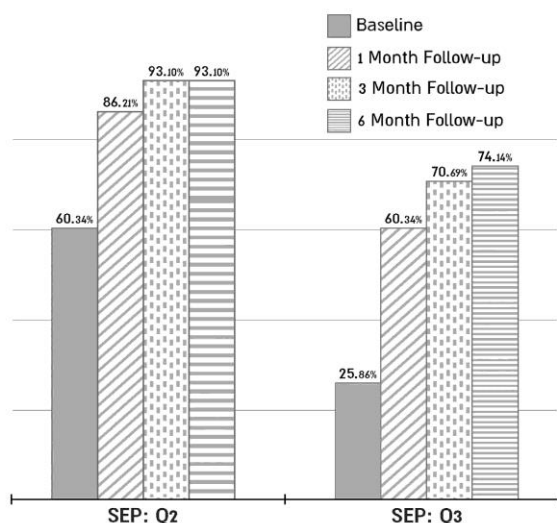


Figure 5. the average results of SEP questions 2 and 3 at the baseline and at each follow-up. The percentages represent the fraction of patients who have answered 'Yes' to each of these questions.

The difference between the IIEF-EF scores and the SEP answers, from baseline to the third follow-up was remarkable and has a statistical significance, with a *P*-value of < 0.001 .

LISW treatment has succeeded in $>80\%$ of the cases (47 patients). Among the successful patients, the average IIEF-EF score increase was nine points.

When comparing diabetic patients and nondiabetic patients, the success rate of the latter group was 25% higher (70.83% and 88.24%, respectively). In all, 41.4% of patients in this study were diabetic (24 patients) and there was no significant difference between age and ED duration of the diabetic and nondiabetic patients (57.45 and 56.25 years, 2.90 and 2.96 years, respectively). This may indicate on better suitability of this treatment to nondiabetic patients.

Among the 58 patients, 4 patients stopped using PDE5-i during follow-up as they had no need for it.

No adverse events or complications were reported during and following treatment.

During the treatment period and thereafter, no use of analgesics was needed.

DISCUSSION

This study is the first study that shows a successful treatment with LISW for vascular ED in a multicenter manner, which is not connected to the previous publications and from different sites than the previous publications.³⁻⁴

When compared with previously described studies, in which PDE5-i were used, the results of this study are in line, with similar success rates.³⁻⁴

This study included patients with mild to severe ED symptoms, whereas 22.4% of patients had severe symptoms, 37.9% moderate, 31.0% mild to moderate and 8.6% mild. The average baseline IIEF-EF was 14.8 points, which represents moderate ED symptoms.

When comparing the success rate between groups of other comorbidities, no strong correlation was found. Owing to the small sample size, more research is required.

Almost 28% of the patients didn't have any of the following vascular ED risk factors: cardiovascular disease; diabetes; hypertension; and high cholesterol. The success rate of patients who

had at least one of the diseases listed above was 76.2%, whereas the success rate of patients without any of these diseases was 93.7%. There were no significant differences between the age, duration of ED and percentage of PDE5-i responders between patients with at least one of the listed disease and patients without any of these diseases (57.3 and 55.3 years, 3.0 and 2.7 years, 85.7% and 87.5%, respectively). The percentage of smokers was higher in the group of patients without any of the listed diseases (62.5%) compared with the second group (54.8%). Out of the first group, all patients who were nonsmokers (10.3% of all patients) succeeded in the treatment.

The ED duration of failed patients was on average longer than the ED duration of the whole group, with 6.4 and 2.9 years, respectively. As seen in Figure 3, the increase in IIEF-EF score decreases as the ED duration rises. Satisfactory success rates were shown in cases of ED that started up to 10 years previously, and even higher success rates were demonstrated on patients who recently noticed a decrease in erectile function. The average results are very disappointing for patients with ED for > 10 years, so it seems this treatment is not adequate for such patients whereas average results are satisfactory for patients with ED for 5–6 years or less.

A comprehensive research is required for designing a modified protocol that would be suitable for cases of longtime ED.

When considering the numerical change in IIEF-EF, only six patients (10%) have not experienced any change in their erectile function.

When reviewing the change in SEP scores, a significant increase between baseline and follow-up is noticeable. These questions can indicate directly on the patients erectile function condition, as they are referring directly to the patient's ability to perform successful intercourse.

When reviewing the individual answers for the GAQ questionnaires, it appears that 75% of the patients (44 patients) have answered 'Yes' to both questions. As these questions are intended to evaluate the treatment, these results indicate a successful treatment and support the results found with the IIEF-EF scores.

When looking at the percentage of almost 7% of patients who stopped using PDE5-i after the treatment, this could perhaps be one of the next steps in the development of this treatment option, and might be a viable option for patients who are not satisfied with the effect of PDE5-i or that these drugs are contraindicated for them.

The specifically designed device, which has a specialized transducer that is configured to reach the exact treated areas, is able to treat a bigger area than other previously used devices and therefore enables a better adjustment to the patient's body, a shorter duration of treatment and a better coverage.

This pilot study on a small number of ED patients with a relatively short follow-up shows encouraging results. Large multicenter, long-term, randomized and sham-controlled studies are needed to be able to evaluate and define those patients who respond to this type of treatment. More data are also needed with regard to the possible long-term impact of shockwaves on penile tissue. More basic research is needed to be able to understand the mechanism of action of LISW on tissues.

CONCLUSIONS

The initial results of this pilot study suggest positive outcomes of this second generation technology for treating ED with linear low-intensity shockwaves. This study with 6 months follow-up from almost 60 patients is suggestive of a positive therapeutic efficiency in the majority of the patients. Pain is tolerated by 100% of the treated patients and no side effects have been recorded, demonstrating the potential of this technology, as a treatment option for men who are not satisfied by the currently available solutions.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

Direx Group provided the treatment device (Renova), which generates linear focused shockwave.

REFERENCES

- 1 Stief C *et al*. Physiology and pathophysiology of men's sexual arousal and penile erection. In: Montorsi F *et al*. (eds). *Sexual Medicine Sexual Dysfunctions in Men and Women. 3rd International Consultation on Sexual Medicine*. Health Publication Ltd: Paris, 2010, pp 605–680.
- 2 Ito K, Fukumoto Y, Shimokawa H. Extracorporeal shock wave therapy as a new and non-invasive angiogenic strategy. *Tohoku J Exp Med* 2009; **219**: 1–9.
- 3 Vardi Y, Appel B, Jacob G, Massarwi O, Gruenwald I. Can low-intensity extracorporeal shockwave therapy improve erectile function? A 6-month follow-up pilot study in patients with organic erectile dysfunction. *Eur Urol* 2010; **58**: 243–248.
- 4 Vardi Y, Appel B, Kilchevsky A, Gruenwald I. Does low intensity extracorporeal shock wave therapy have a physiological effect on erectile function? Short-term results of a randomized, double-blind, sham controlled study. *J Urol* 2012; **187**: 1769–1775.
- 5 Qiu X. Effects of low-energy shockwave therapy on the erectile function and tissue of a diabetic rat model. *J Sex Med* 2013; **10**: 738–746.
- 6 Rosen RC, Allen KR, Ni X, Araujo AB. Minimal clinically important differences in the erectile function domain of the International Index of Erectile Function scale. *Eur Urol* 2011; **60**: 1010–1016.
- 7 Rosen RC, Cappelleri JC, Gendrano N 3rd. The International Index of Erectile Function (IIEF): a state-of-the-science review. *Int J Impot Res* 2002; **14**: 226–244.
- 8 Hatzichristou D *et al*. Clinical evaluation and symptoms scales in men and women with sexual dysfunction. In: Montorsi F *et al*. (eds). *Sexual Medicine Sexual Dysfunctions in Men and Women. 3rd International Consultation on Sexual Medicine*. Health Publication Ltd: Paris, 2010, pp 229–280.
- 9 Porst H *et al*. Standards for clinical trials in male sexual dysfunctions. In: Montorsi F *et al*. (eds). *Sexual Medicine Sexual Dysfunctions in Men and Women. 3rd International Consultation on Sexual Medicine*. Health Publication Ltd: Paris, 2010, pp 567–603.



Safety and Efficient Duration of Linear Focused Shockwave Treatment for Erectile Dysfunction – A 12 months Follow-up Pilot Study

Y. Reisman

Men's Health Clinic, Bovenij Hospital, Amsterdam, The Netherlands

Objective

The aim of this pilot study was to assess the safety, effectiveness and sustainable results of the Linear Focused Shockwave system Renova, for the treatment of Vascular Erectile Dysfunction patients.

Material and methods

Renova is a system that uses a Linear Low Intensity Shockwave technology. We have treated 20 patients with Vasculogenic ED; with an averaged International Index of Erectile Function (IIEF-EF) score of 12.35 ± 3.16 (Range 7-18). The protocol consisted of 4 weekly sessions, in which a total of 3600 shockwaves were applied, divided into 4 areas; right and left crura, and right and left corpus cavernosum, 900 shockwaves in each site. The following questionnaires were used: IIEF-EF, Sexual Encounter Profile (SEP) and Global Assessment Question (GAQ), at baseline visit and 1, 3, 6 and 12 months post treatment. Success was defined as an increase in score from baseline to the 6 months post treatment follow-up, according to Minimal Clinical Improvement Criteria (Rosen et al.).

Results

At the 6 months follow-up, 18 patients out of 20 showed success (90%). Out of these 90%, **83.3% (15 patients) sustained the positive outcome for a period longer than 12 months** after the end of treatment. The average IIEF-EF increased significantly from 12.35 ± 3.16 at baseline to 20.65 ± 2.64 at 6 months post treatment, and was 18.65 ± 2.56 at the 12 month follow-up. Four patients (20%) who were non-responsive to Phosphodiesterase type 5

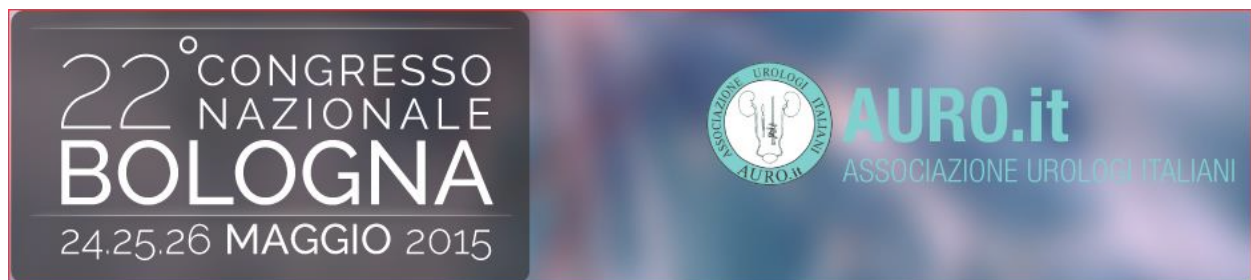
LSWT – CLINICAL DATA AND REPORTS

Inhibitors (PDE5i) at baseline became responsive after the treatment, and 2 patients (10%) successfully stopped using PDE5i. All 20 patients completed the last follow-up with an average of 14.5 ± 1.08 months duration from the end of treatment. Among the successful patients, the average IIEF-EF score increase was 8.3 points. No side effects were reported.

Conclusions

With a success rate of 90% after 6 months, and an 83.3% sustainable positive effect after 1 year, the results of this pilot study suggest that this treatment is probably effective for at least 1 year. No anaesthesia or analgesia was needed, and no adverse effects were recorded, making it a potential good alternative for current available treatments.

The above paper abstract was presented at the *16th World Meeting on Sexual Medicine*, on October 11th 2014, Sao-Paulo, Brazil.



Long Term Efficacy of Low Intensity Linear Focused Shockwave Therapy for Vascular Erectile Dysfunction Patients: 20 months follow-up

A. Casarico, P. Puppo

Montallegro Clinic, Genova, Italy

Objective

Erectile dysfunction is a common medical disorder that primarily affects men older than 40 years of age [1]. Phosphodiesterase type 5 inhibitors (PDE5i) are considered as first-line therapy as they increase arterial blood flow leading to smooth muscle relaxation, vasodilatation and penile erection [2]. The limitation in the efficacy of PDE5i is that a 'critical amount' of NO is necessary for these drugs to work. Therefore, in cases of impairment in NO synthesis or release or in cases of destruction of NO, PDE5i cannot cure erectile dysfunction (ED) symptoms [3].

Lately, studies have started to evaluate the effect of low intensity shockwave (LISW) to treat ED on PDE5i responders and non-responders patients [4-8].

The current study evaluated how the therapy by a new device ('RENOVA', Direx Group) using low-intensity linear focused shockwave, exerts effective and sustainable results at long term follow-up on patients who suffer from ED of vascular origin and experience full, partial or no response at all to PDE5i.

Materials and Methods

This study was conducted in an outpatient clinic from March to December 2013. Eligible patients were those suffering from Vasculogenic ED for at least 6 months, and their International Index of Erectile Function score (IIEF-EF, [9]) was between 9 and 25 (while on

PDE5i). Patients who had hormonal, neurological or psychological pathology or had undergone radical prostatectomy were excluded.

During the treatment period and 3 weeks prior to it, no PDE5i were used.

The treatment consisted of 4 weekly sessions. Shockwaves were delivered with a maximum energy of 0.09mJ/mm²; therefore, no anesthesia was required. At the end of the full treatment a total of 20000 SW had been delivered (6400 shocks at each crura, 3600 shocks at each corpus).

Erectile function was evaluated by means of IIEF-EF, questions 2-3 of the Sexual Encounter Profile (SEP), questions 1-2 of the Global Assessment Questions (GAQ) and the Erection Hardness Score (EHS), at baseline and at 1, 3 and 6 months post treatment. Success was defined as positive answer to both SEP questions and both GAQ questions, EHS of 3 or higher and an increase of IIEF-EF score from baseline to the third follow up (6 months post treatment) according to the severity of the symptoms [10].

Out of 25 patients enrolled to this study, 24 finished the full treatment series. The mean age of these patients was 62.58 ± 8.32 (45-74) years and the mean duration of their ED was 4.84 ± 4.46 (1-20) years. 52% were smokers, 26% had diabetes, 58% had high cholesterol levels, 37% had a cardiovascular disease and 47% had hypertension. 75% of the patients had a positive response to PDE5i.

At the end of the treatment and during the follow-up period patients were using PDE5i as needed.

14 patients out of 19 patients who had a successful result in all evaluation parameters at 6 months follow-up were evaluable for long-term follow up (15-21 months; mean 19.8 months) They completed again all the questionnaires.

Results

At 6 months follow-up the overall percentage of patients who achieved positive outcomes at all 4 evaluation questionnaires was 79%.

33% of the PDE5i non-responders (2/6) and 94% of the responders (17/18) achieved positive outcomes at all 4 evaluation questionnaires.

44.4% of the responders stopped using PDE5i at 6 month follow-up. None of the patients have reported on pain during or after treatment. No adverse events were reported.

11/14 patients (78.5%) who had a successful result at 6 months FU, and were evaluable for long-term FU, maintained the advantage gained.

2 patients, PDE5i non responders, continued to respond to PDE5i. Their IIEF at long term FU was respectively 19 (+1) and 23 (-2).

9 patients, PDE5i responders, lost 4 points combined at IIEF-6 (5 patients with unchanged scores, 1 patient dropped from 29 to 27, 1 patient gained 1 point from 26 to 27, 1 patient dropped from 25 to 23 and the last patient dropped from 27 to 26); SEP and GAQ were unchanged; EHS was reduced from 4 to 3 in only 1 patient and was maintained at 4 in 4 patients.

5 out of these 9 patients had successful intercours without PDE5i or used them occasionally. 3/14 patients (21.4%) did not maintain the advantage gained at the long term FU. IIEF (while on PDE5i), was 20/24/21, 15 points lower (-9/-2/-4) than at 6 months FU; SEP was unchanged (2); EHS was 1 point lower (from 4 to 3) in 1 patient; GAQ dropped from 2 to 0 in all 3 patients.

Discussion

This pilot study was designed for assessing the long term efficacy of a novel device for the treatment of erectile dysfunction, based on an original technology that enables the delivery of low-intensity shockwaves onto a long focal area. The subjects in this study included also patients with multiple co-morbidities, different degrees of response to PDE5i and wide range of ED severities. The results of this study demonstrate a possible alternative treatment for some of the patients who did not respond to first-line oral pharmacotherapy and thanks to this treatment may avoid turning to other therapy options which are less convenient to use. In parallel, these data imply on a potential mean to eliminate the need for PDE5i which may significantly improve patients' quality of life.

At 6 months FU, an overall success in 79% of the patients was shown, that was maintained by 78.5% of these at longer FU (19.8 months mean). 55% of PDE5i responders (at baseline evaluation) continued to have successful intercours without use of PDE5i or using them occasionally.

Conclusion

A growing number of men develop vascular erectile dysfunction because of multiple comorbidities such as diabetes, hypertension, heart disease, dyslipidemia or smoke. PDE5i, alprostadil injections, vacuum constriction devices and surgical treatment are symptomatic therapies and do not help patients to achieve spontaneous erections. Moreover medications are contraindicated in some conditions and may have side effects. LISWT, is a promising, minimally invasive therapy without side-effects that induce the release of endothelial nitric oxide synthase, vascular endothelial growth factors and proliferating cell nuclear antigen and thus enhance neovascularization of the penis.

The long-term follow up shows that the vast majority of patients who achieved a positive result from treatment with 20000 low intensity linear shock waves, delivered in 4 weekly sessions, continues to maintain the advantage gained after 19.8 months.

The effect of treatment wanes gradually only in 21.4% of the patients.

There is a need for further research to determine if modifications in the treatment protocol (number and intensity) of low-intensity linear focused shockwave could make the positive effect last longer and if an additional treatment could be useful for patients who did not have or lost a successful result from the treatment.

References

1. Rany Shamloul, Hussein Ghanem. Erectile dysfunction. *Lancet* 2013; 381: 153–65.
2. Eric Wespes, Edouard Amar, Dimitrios Hatzichristou, Kosta Hatzimouratidis, Francesco Montorsi, John Pryor, Yoram Vardi. EAU Guidelines on Erectile Dysfunction: An Update. *European Urology* 49 (2006) 806–815.
3. Inigo Sáenz de Tejada. Therapeutic strategies for optimizing PDE-5 inhibitor therapy in patients with erectile dysfunction considered difficult or challenging to treat. *International Journal of Impotence Research* (2004) 16, S40–S42.
4. Ilan Gruenwald, Boaz Appel and Yoram Vardi. Low-Intensity Extracorporeal Shock Wave Therapy—A Novel Effective Treatment for Erectile Dysfunction in Severe ED Patients Who Respond Poorly to PDE5 Inhibitor Therapy. *J Sex Med* 2012;9:259–264.
5. Yoram Vardi, Boaz Appel, Giris Jacob, Omar Massarwi, Ilan Gruenwald. Can Low-Intensity Extracorporeal Shockwave Therapy Improve Erectile Function? A 6-Month Follow-up Pilot Study in Patients with Organic Erectile Dysfunction. *European Urology* 58 (2010) 243–248.
6. Yoram Vardi, Boaz Appel, Amichai Kilchevsky and Ilan Gruenwald. Does Low Intensity Extracorporeal Shock Wave Therapy Have a Physiological Effect on Erectile Function? Short-Term Results of a Randomized, Double-Blind, Sham Controlled Study. *The Journal of Urology* 187 (2012) 1769–1775.
7. Ilan Gruenwald, Noam D Kitrey, Boaz Appel, and Yoram Vardi. Lowintensity extracorporeal shock wave therapy in vascular disease and erectile dysfunction: Theory and outcomes. *Sex Med Rev* 2013; 1: 83–90.
8. Anne B Olsen, Marie Persiani, Sidesel Boie, Milad Hanna, Lars Lund. Can low-intensity extracorporeal shockwave therapy improve erectile dysfunction? A prospective, randomized, double-blind, placebo-controlled study. *Scand J Urol* 2014 Dec 3:1-5. [Epub ahead of print]
9. Rosen RC, Cappelleri JC, Gendrano N 3rd. The International Index of Erectile Function (IIEF): a state-of-the-science review. *Int J Impot Res.* 2002 Aug; 14(4): 226-44.

10. Rosen RC, Allen KR, Ni X, Araujo AB. Minimal clinically important differences in the erectile function domain of the International Index of Erectile Function scale. Eur Urol. 2011 Nov; 60(5): 1010-6.

The above paper abstract was presented at the 22nd National Congress of the Italian Urological Association, on May 24th 2015, Bologna, Italy.



Initial Clinical Experience of Linear Focused, Low Intensity Shockwave for Treatment of ED Patients with Different Severity Symptoms

N. Cruz¹, A. Morales²

¹Clinica Andromedi Sevilla, ²Instituto de Urología Málaga

Objective

The aim of this clinical experience was to assess the feasibility of the application of Linear Focused Low Intensity Shockwaves (Renova Direx Group) as an alternative or complementary treatment for Vascular ED patients with different degrees of symptom severity.

Material and methods

The treatment was offered in a routine natural way in 2 medical centers: 46 patients in Malaga (series A), and 35 in Sevilla (Series B). The treatment was composed of 4 weekly sessions, in which shockwaves were applied into 4 areas: right and left crura, and right and left corpus cavernosum, with 900 shockwaves in each site (Total 14400). No need for anesthesia, sedation or painkillers and each session's treatment time was 20 minutes. The evaluation was done using the IIEF-EF, SEP and GAQ questionnaires, at baseline visit, 1 month and 3 months post treatment.

Results

The average IIEF-EF increased significantly from 19.94 and 14.03 at baseline to 23.92 and 18.53 at 3 months post treatment. A number of patients stopped using PDE5-i; 30.77% and 23.53% respectively. SEP 2 increased from 88.89% and 43.48% to 100% and 66.67%. The SEP 3 increased from 38.89% and 27.59% to 78.75% and 57.89%.

LSWT – CLINICAL DATA AND REPORTS

At baseline, the use of PDE5-i for sexual intercourses was needed by 77.78% and 85.19% of patients, and was reduced to 53.85% and 35.29% at 3 months post treatment. No side effects were recorded.

Conclusions

The results of both series at 3 months show a consistent and global improvement in IIEF-EF, SEP 2 and SEP 3 parameters. Since the baseline symptoms severity of patients in series B was much higher compared to series A, the end results obtained in series B are consistently lower compared to series A.

This would imply that the outcome of the treatment is related to the baseline symptoms severity, meaning that in average, patients with more severe ED symptoms will improve, but will not reach the final level of improvement that can be obtained by mild to moderate patients. In our experience the Linear-Focused Low Intensity Shockwave treatment is a valid alternative or complement to current available treatments.

The above paper abstract was presented at the 16th World Meeting on Sexual Medicine, on October 11th 2014, Sao-Paulo, Brazil.



Efficacy and Safety of Linear Focused Shockwaves for Erectile Dysfunction (RENOVA) – A Second Generation Technology

Y. Reisman¹, A. Hind², A. Varaneckas³, I. Motil⁴

¹Men's Health Clinic, Bovenij Hospital, Amsterdam, The Netherlands, ²Urology and Andrology Center, Red Crescent Hospital (RCH), Ramallah, Palestine, ³Amber Clinic, Klaipėda, Lithuania, ⁴Uroclinic Brno, Brno, Czech Republic

Introduction

Recent studies have demonstrated that low intensity shockwaves have a therapeutic effect on ED of vascular origin.

Objective

The present study was aimed to assess the efficacy and safety of a dedicated shockwave device, Renova, which was designed to achieve substantially superior organ coverage.

Material and Methods

52 patients with mild to severe ED were treated by Renova as part of a multi-center, open-label, prospective pilot study, conducted at 4 sites. Patients underwent 4 weekly treatment sessions by a Renova that generates line focused shockwaves. Patients' erectile function was assessed by the IIEF-EF, SEP and GAQ questionnaires at baseline and at 1 and 3 months post treatment. Success was defined as an increase of IIEF-EF score from baseline to the second follow up according to the severity of the symptoms at baseline.

Results

The average IIEF-EF greatly increased from 14.7 at baseline to 21.4 at 1 month and 3 months post treatment. **Out of 52 patients, 41 (79%) had a successful treatment.** No adverse events

LSWT – CLINICAL DATA AND REPORTS

were reported during the treatment and the follow-up duration. Main outcomes are presented in the following table:

Age	Baseline IIEF-EF	Improvement in IIEF-EF	P value	% Success
57.2 ± 10.1	14.7 ± 4.9	6.8	<0.0001	78.8%

Conclusions

The results of this study indicate success of the second generation technology for treating ED with linear low-intensity shockwaves. Initial follow up data demonstrate a therapeutic success in almost 80% of patients. No side effects have been recorded, demonstrating the suitability of this treatment in an office setting.

The above paper abstract was presented at the 12th Congress of the Latin American Society for Sexual Medicine, on August 29th 2013, Cancun, Mexico.



Low intensity shock wave (LISW) treatment (Renova) to improve male sexual function: A preliminary data on 42 patients

F. Iacono, A. Ruffo, D. Prezioso, G. Romeo, E. Illiano, L. Romis, G. Di Lauro
Centro Urolab, Napoli, Italy

Objective

The aim of our study is to investigate the safety and efficacy of Low intensity Extracorporeal shock wave therapy LI-ESWT (Renova) in the treatment of erectile dysfunction.

Methods

We enrolled 47 patients with erectile dysfunction (ED). They underwent four weekly sessions using a dedicated device (Renova) for the management of erectile dysfunction. The treatment included four weekly sessions. During each treatment session, LI-ESWT was applied at four different anatomical areas, right and left corpus cavernosum and right and left crus penis (900 shocks, 0.09 mJ/mm² intensity at 240 shocks/min at each site for a total of 3600 shocks). Patients were followed at one month after treatment. Two self-administered questionnaires: International Index of Erectile Function-Erectile Function (IIEF-ED), Sexual Encounter Profile (SEP- Questions 2 and 3) were given to patients to assess their sexual function pre and post treatment.

Results

Five patients dropped out of treatment, so forty-two patients (mean age was 59.2 years) were evaluated. At one month follow-up, we noticed a statistically significant improvement in IIEF-ED domain scores in treated patients (from a mean of 12+/- 4.8 at baseline to 23.5+/- 5.3, p<0.05). **SEP-Q2 and SEP-Q3 success rates improved from 57% to 84% and from 24% to 76% respectively.** No side effects were reported.

Conclusion

(LI) ESWT improves male sexual function inducing neovascularization in the treated tissues by stimulating the expression of angiogenesis-related growth factors, such as endothelial nitric oxide synthase, vascular endothelial growth factor, and endothelial cell proliferation factors, such as proliferating cell nuclear antigen. This therapy shows a statistically significant clinical improvement of erectile function without any side effect or contraindication. In our opinion further studies are needed even to assess the possibility to repeat the treatment cyclically or in association with PDE5-i or with nutraceutical composite.

The above paper abstract was presented at the 16th Congress of the European Society for Sexual Medicine (ESSM), on February 1st 2014, Istanbul.



Low Intensity Linear Focused Shockwave Therapy: a New Treatment to Improve the Quality of Life of Vascular Erectile Dysfunction Patients

P. Puppo, A. Casarico

Montallegro Clinic, Genova, Italy

Objective

Erectile dysfunction is a common medical disorder that primarily affects men older than 40 years of age. Phosphodiesterase type 5 inhibitors (PDE5i) are considered as first-line therapy as they increase arterial blood flow leading to smooth muscle relaxation, vasodilatation and penile erection. The limitation in the efficacy of PDE5 inhibitors is that a 'critical amount' of NO is necessary for these drugs to work. Therefore, in cases of impairment in NO synthesis or release or in cases of destruction of NO, PDE5 inhibitors cannot cure erectile dysfunction (ED) symptoms.

The correlation between potency and quality of life was established by a study on 1680 men seeking medical attention in a free screening program at three different locations in the USA. Unsurprisingly, it was reported that potent men have a better quality of life than impotent men.

Lately, studies have started to evaluate the effect of low intensity shockwave (LISW) to treat ED on PDE5i responders and non-responders patients.

The current study evaluated how the therapy by a new device ('RENOVA', Direx Group) using low-intensity linear focused shockwave affects the quality of life of patients who suffer from ED of vascular origin and experience full, partial or no response at all to PDE5 inhibitors.

Methods and results

This study was conducted in an outpatient clinic over a period of 10 months. Eligible patients were those who have been suffering from Vasculogenic ED for at least 6 months, and their International Index of Erectile Function score in the erectile function domain (IIEF-EF) was

between 9 and 25. Patients who had hormonal, neurological or psychological pathology or have undergone radical prostatectomy were excluded.

The treatment consisted of 4 weekly sessions; in each session 4 areas were treated consecutively: left and right sides of the Crura and the Corpora Cavernosa. Shockwaves were delivered with a maximum energy of 0.09mJ/mm²; therefore, no anesthesia was required. During the treatment period (22 days) and 3 weeks prior it, no phosphodiesterase type 5 inhibitors (PDE5-I) were used.

Erectile function was evaluated by means of IIEF-EF, questions 2-3 of the Sexual Encounter Profile (SEP), questions 1-2 of the Global Assessment Questions (GAQ) and the Erection Hardness Score (EHS), at baseline and at 1, 3 and 6 months post treatment. Success was defined as positive answer to both SEP and GAQ questions, EHS of 3 or higher and an increase of IIEF-EF score from baseline to the third follow up (6 months post treatment) according to the severity of the symptoms.

Out of 25 patients who were enrolled to this study, 24 have finished the full treatment series. The mean age of these patients was 62.58 ± 8.32 (45-74) years and the mean duration of their ED was 4.84 ± 4.46 (1-20) years. 52% were smokers, 26% had diabetes, 58% had high cholesterol levels, 37% had a cardiovascular disease and 47% had hypertension. 74% of the patients had a positive response to PDE5 inhibitors.

All patients were instructed to use PDE5 inhibitors during the 4 weeks prior baseline evaluation. At the end of the treatment and during the follow-up period patients were using PDE5 inhibitors as needed.

At the most recent follow-up of each patient, 40% of the PDE5i non-responders and 78% of the responders achieved positive outcomes at all 4 evaluation questionnaires. 42.8% of the responders stopped using PDE5 inhibitors at 6 month follow-up. Out of these patients, 83% achieved positive outcomes at all 4 evaluation questionnaires. **The overall percentage of patients who achieved positive outcomes at all 4 evaluation questionnaires was 70%.** None of the patients have reported on pain during or after treatment. No adverse events were reported.

Discussion

This pilot study was designed for assessing the efficacy of a novel device dedicated for the treatment of erectile dysfunction and based on an original technology that enables the delivery of low-intensity shockwaves onto a long focal area. The subjects in this study included also patients with multiple co-morbidities, different degrees of response to PDE5 inhibitors and wide range of ED severities. The results of this study demonstrate a possible alternative

LSWT – CLINICAL DATA AND REPORTS

treatment for some of the patients who did not respond to first-line oral pharmacotherapy and thanks to this treatment may avoid turning to other therapy options which are less convenient to use. In parallel, these data imply on a potential mean to eliminate the need for PDE5 inhibitors which may significantly improve patients' quality of life. In order to establish the overall effect of this treatment on the quality of life of ED patients, a larger study with longer follow-up duration is required.

The above paper abstract was presented at the 21st National Congress of the Italian Urology Association, on June 2014, Rome, Italy.



Linear Low Intensity Shockwaves Treatment of Vasculogenic ED – First Results

Motil¹, T. Šramkova²

¹Urology Ajem, Brno, Czech Republic, ²Department of Sexology, Brno University Hospital, Czech Republic

Introduction and Objectives

ED is significantly associated with: increased age, diabetes, cardiovascular disease, hypertension, depression, smoking, medications, and has a multifactorial etiology with physical and psychological factors.

The treatment options currently offered to patients are: drugs that reversibly inhibit penile-specific PDE5 and enhance the nitric oxide–cyclic GMP pathways of cavernous smooth muscle relaxation, vacuum constriction device, intraurethral and intracorporeal alprostadil, or surgical treatment-implantation of penile prosthesis.

Our aim was to assess the safety and efficacy of a unique Linear Shockwave Therapy for Vasculogenic ED patients in a prospective trial (PT).

Materials and Methods

22 men with vasculogenic ED completed this open-label, prospective pilot study. In order to compare our own results (22 men) we included the outputs of 3 other European LSWT centers. Finally, an overall of 69 (22+47) patients with mild to severe ED were treated using the Renova device and were evaluated.

The evaluation of success was made according to the IIEF-EF questionnaire, which was filled at baseline, and 1, 3 and 6 months post treatment.

Results

The average IIEF-EF increased significantly from 14.7 at baseline to 21.6 at 1 month and 3 months post treatment. **82% of patients had a successful treatment.** No adverse events were reported during the treatment and the follow-up duration.

Conclusions

We have been able to prove that Linear SWT is an effective therapeutic option for men with erectile dysfunction of vasculogenic origin. Moreover the efficacy of linear application of low-intensity extracorporeal shock waves is superior to former non-linear methods.

The above paper abstract was presented at the *102nd Annual Meeting of the Japanese Urological Association (JUA)*, on April 21st 2014, Kobe, Japan.



Efficacy and Safety of Linear Focused Shockwaves for Erectile Dysfunction (RENOVA) – A Second Generation Technology

Y. Reisman¹, A. Hind², A. Varaneckas³, I. Motil⁴

¹Men's Health Clinic, Bovenij Hospital, Amsterdam, The Netherlands, ²Urology and Andrology Center, Red Crescent Hospital (RCH), Ramallah, Palestine, ³Amber Clinic, Klaipėda, Lithuania, ⁴Uroclinic Brno, Brno, Czech Republic

Introduction

Vasculogenic erectile dysfunction (ED) which is caused by arteriosclerosis can be treated by a variety of therapies that aim at reducing ED symptoms. Low-intensity shockwaves (LISW) were discovered as an enhancing factor to angiogenesis for treating ischemic heart disease. In addition, LISW therapy demonstrated significantly the restoration of erectile function in diabetic rats. The present study evaluates the therapeutic effect of LISW produced by an innovative device on patients with erectile dysfunction.

Objective

The present study was aimed to assess the safety and efficacy of a dedicated shockwave device, 'Renova', which was designed to achieve substantially superior organ coverage.

Material and Methods

57 patients with mild to severe ED were treated by Renova as part of a multi-center, open-label, prospective pilot study, conducted at 4 sites. Patients underwent 4 weekly treatment sessions by a novel machine (Renova) that generates line focused shockwaves at 4 treated areas: right and left crus and right and left corpus cavernosum. Each treatment session lasted approximately 15 minutes, did not require anesthesia and did not cause any pain or adverse effects. Patients' erectile function was assessed by the IIEF-EF, SEP and GAQ questionnaires

LSWT – CLINICAL DATA AND REPORTS

at baseline and at 1 and 3 months post treatment. Success was defined as an increase of IIEF-EF score from baseline to the second follow up according to the severity of ED symptoms at baseline.

Results

The average IIEF-EF score has greatly increased from 14.7 at baseline to 21.6 at 1 month and 3 months post treatment. **Out of 57 patients, 47 (82%) had a successful treatment.** Among the successful patients, the average IIEF-EF score increase was 8 points. No adverse events were reported during the treatment and the follow-up duration.

Conclusions

The results of this study indicate success of the second generation technology for treating ED with linear low-intensity shockwaves. Initial follow up data from almost 60 patients demonstrate a clear therapeutic success in 82% of patients.

The above paper abstract was presented at the 2nd Biennial Meeting of the Middle East Society for Sexual Medicine, on November 2013, Dubai.



Line Focused Shockwave for Erectile Dysfunction – A Different Technological Approach

A. Hind, O. Saleh, Y. Abu Asbeh

Urology and Andrology Center, Red Crescent Hospital (RCH), Ramallah, Palestine

Introduction

During the last 2 years a new technology was introduced to treat Erectile Dysfunction. The treatment uses Low Intensity Shockwave which was shown to produce angiogenesis in order to improve the patient erectile function for patients of Vasculogenic origin ED. The initial treatments were done with conventional orthopedic treatment shockwave devices, and although results were encouraging, they have a series of limitations.

We are presenting our initial results with a new type of Low Intensity shockwave system that was specifically developed to treat ED.

Patients and Methods

Instead of focusing the shockwave into a focal point, like in any conventional lithotripter, Renova system (DirexGroup) shockwaves focalize along a 70mm line, with a dept of 40mm. This allows a perfect coverage of the full penis shaft and the crura. We use a short protocol of 4 weekly sessions, applying 900 shocks in each of the 4 following areas: right Crus, left Crus, right Corpus Cavernosum, left Corpus Cavernosum.

We have treated 20 patients and we have a follow up of the first 12 patients, both PDE5-I Responders and non Responders.

Results

IIEF-EF: International Index of Erectile Function – Erectile Function Domain

LSWT – CLINICAL DATA AND REPORTS

	Patient Initials	Baseline IIEF-EF	IIEF-EF at 1 month	IIEF Difference	Success /Failure
1	M I M	9	18	9	Success
2	H I S	8	8	0	Failure
3	N M M	8	8	0	Failure
4	J H S	17	24	7	Success
5	M N S	14	25	11	Success
6	O I S	19	25	6	Success
7	M M K	11	24	13	Success
8	A A D	6	19	13	Success
9	I H A	19	28	9	Success
10	A H	19	28	9	Success
11	S A	12	20	8	Success
12	A M H	17	24	7	Success
Average		13.25	20.92	7.67	84%

SEP- Sexual Encounter Profile

	Patient Initials	Baseline		Follow-up	
		SEP 2	SEP 3	SEP 2	SEP 3
1	M I M	NO	NO	YES	YES
2	H I S	NO	NO	NO	NO
3	N M M	NO	NO	NO	NO
4	J H S	YES	YES	YES	YES
5	M N S	YES	NO	YES	YES
6	O I S	YES	YES	YES	YES
7	M M K	NO	NO	YES	YES
8	A A D	NO	NO	YES	YES
9	I H A	YES	NO	YES	YES
10	A H	YES	YES	YES	YES
11	S A	NO	NO	YES	YES
12	A M H	YES	YES	YES	YES
Average		50%	33%	83%	83%

LSWT – CLINICAL DATA AND REPORTS

Comparative follow up: 1 and 3 months

	Patients Initials	Response to PDE5-I	IIEF Score			Results Comparison	Delta	Success
			Baseline	1month	3 months			
1	M I M	YES	9	18	18	Same	9	Yes
2	H I S	NO	9	8	8	Same	-1	No
3	N M M	NO	8	8	8	Same	0	No
4	J H S	YES	17	24	24	Same	6	Yes
5	M N S	YES	14	25	30	Improvement	16	Yes
6	O I S	YES	19	25	25	Same	6	Yes
7	M M K	YES	11	24	24	Same	13	Yes
8	A A D	NO	6	19	19	Same	13	Yes
9	I H A	YES	19	28	28	Same	7	Yes
10	A H	YES	19	28	28	Same	7	Yes
11	S A I	YES	12	20	20	Same	8	Yes
12	A M H	YES	17	24	24	Same	7	Yes

- Results at 1 and 3 month follow-up are essentially the same.
- Successful results are seen at 1 month post treatment.

Conclusions

- Initial results at 1 and 3 months show great progress in erectile function.
- Average IIEF-EF increased from 13.25 to 20.92 (57.86 % improvement).
- **84% Success according to success criteria.**
- All mild to moderate cases have succeeded.
- One severe case has improved while 2 severe cases failed.
- SEP and GAQ results have improved.
- No pain and no complications were reported.

The above paper abstract was presented at the 5th *Pan Arab Congress of Sexual Health*, on April 20th 2013, Dubai.



The Effect of Low Intensity Shockwave Therapy on the Erectile Function of Smokers and Non-smokers - Initial Report with a Dedicated System

P. Puppo, A. Casarico

Montallegro Clinic, Genova, Italy

Introduction and Objective

The association between cigarettes smoking and erectile dysfunction (ED) was researched in many studies so far. The strongest relationship found was an adjusted odds ratio of 1.97 for incident ED in smokers compared with nonsmokers. Smoking appears to decrease pelvic and penile vascular flow. Moreover, atherosclerosis is possibly the most important vascular consequence of cigarette smoking. It was established that the effect of smoking on erectile function is related to impairment of endothelium dependent smooth muscle relaxation which is a key process leading to the dilation of vessels in the erectile tissue and an increased blood flow required for erection.

10 years ago, a study that examined the beneficial effects of Shockwaves on ischemia-induced myocardial dysfunction was published and revealed that shockwaves at energy level of 0.09mJ/mm² enhance coronary angiogenesis.

The present study examines the effect of a treatment by a new dedicated device delivering shockwaves at the same energy level and a long focal area adjusted to the male sexual organ, on patients suffering from vascular origin ED, both smokers and non-smokers.

Materials and Methods

25 patients with Vasculogenic ED were treated by the shockwave device, 4 times, once a week. 1600 shocks were applied to each Crus and 900 shocks were applied to each Corpus Cavernosum. No PDE5 inhibitors were used during the treatment and 3 weeks prior treatment. Erectile function was evaluated at baseline and at 1, 3 and 6 months post treatment by 4 self administered questionnaires: IIEF-6, SEP, GAQ and EHS. Success was defined as

positive answers to SEP and GAQ questions, EHS \geq 3 and a significant increase of IIEF-6 score according to the baseline ED severity.

Results

24 men with a mean age of 62.6 have finished treatment. 53% of them were smokers. There was no significant difference between ED duration, age and baseline IIEF-6 of smokers and non-smokers. Co-morbidities rates were higher in smokers than in non-smokers. The increase in IIEF-6 from baseline to the last follow-up was twice as large in the smokers than the non-smokers. **The overall success rate was 70% and 84% of patients answered "Yes" to both GAQ questions.** No adverse events were reported.

Conclusions

This pilot study shows that eventually this new treatment for vascular ED could be suitable to smoking patients and patients with vascular risk factors. More research is required for confirming the efficacy of this treatment on different populations.

The above paper abstract was presented at the 30th Italian society of Andrology Congress (SIA), on May 2014, Maratea, Italy.