

Audiovisual Sexual Stimulation and RigiScan Test for the Diagnosis of Erectile Dysfunction

Tao Wang^{1,2}, Li Zhuan^{1,2,3}, Zhuo Liu^{1,2}, Ming-Chao Li^{1,2}, Jun Yang^{1,2}, Shao-Gang Wang^{1,2}, Ji-Hong Liu^{1,2}, Qing Ling^{1,2}, Wei-Min Yang^{1,2}, Zhang-Qun Ye^{1,2}

¹Department of Urology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei 430030, China

²Institute of Urology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei 430030, China

³Department of Reproductive Medicine, The First People's Hospital of Yunnan Province, Kunming, Yunnan 650032, China

Abstract

Background: Currently available evaluation criteria for penile tumescence and rigidity have been fraught with controversy. In this study, we sought to establish normative Chinese evaluation criteria for penile tumescence and rigidity by utilizing audiovisual sexual stimulation and RigiScan™ test (AVSS-Rigiscan test) with the administration of phosphodiesterase-5 inhibitor.

Methods: A total of 1169 patients (aged 18–67 years) complained of erectile dysfunction (ED) underwent AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor. A total of 1078 patients whose final etiological diagnosis was accurate by means of history, endocrine, vascular, and neurological diagnosis, International Index of Erectile Function 5 questionnaire, and erection hardness score were included in the research. Logistic regression model and receiver operating characteristic curve analysis were performed to determine the cutoff value of the RigiScan™ data. Then, the multivariable logistic analysis was used in the selected variables.

Results: A normal result is defined as one erection with basal rigidity over 60% sustained for at least 8.75 min, average event rigidity of tip at least 43.5% and base at least 50.5%, average maximum rigidity of tip at least 62.5% and base at least 67.5%, Δ tumescence (increase of tumescence or maximum–minimum tumescence) of tip at least 1.75 cm and base at least 1.95 cm, total tumescence time at least 29.75 min, and times of total tumescence at least once. Most importantly, basal rigidity over 60% sustained for at least 8.75 min, average event rigidity of tip at least 43.5%, and base at least 50.5% would be the new normative Chinese evaluation criteria for penile tumescence and rigidity. By multivariable logistic regression analysis, six significant RigiScan™ parameters including times of total tumescence, duration of erectile episodes over 60%, average event rigidity of tip, Δ tumescence of tip, average event rigidity of base, and Δ tumescence of base contribute to the risk model of ED. In logistic regression equation, predict value $P < 0.303$ was considered as psychogenic ED. The sensitivity and specificity of the AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor in discriminating psychogenic from organic ED was 87.7% and 93.4%, respectively.

Conclusions: This study suggests that AVSS-RigiScan test with oral phosphodiesterase-5 inhibitors can objectively assess penile tumescence and rigidity and seems to be a better modality in differentiating psychogenic from organic ED. However, due to the limited sample size, bias cannot be totally excluded.

Key words: Audiovisual Sexual Stimulation-RigiScan Test; Erectile Dysfunction; Phosphodiesterase-5 Inhibitor

INTRODUCTION

Penile erection is a complex event controlled by vascular, hormonal, and neurological systems.^[1] Depending on the context in which penile erection occurs, it is generally accepted that different central and peripheral neural and/or humoral endocrine mechanisms may participate in the regulation of this sexual response, often in a very complex fashion.^[2–4] Erectile dysfunction (ED) is a men's health issue that is receiving overwhelming attention in recent years. Although studies have shown that up to 52% of the male population aged 40–70 years had different

degrees of ED, data from the National Health and Social Life Survey had found that only about 1 in 10 men with ED

Address for correspondence: Prof. Ji-Hong Liu,

Department of Urology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei 430030, China
Institute of Urology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei 430030, China
E-Mail: jhliu@tjh.tjmu.edu.cn

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

© 2018 Chinese Medical Journal | Produced by Wolters Kluwer - Medknow

Received: 26-12-2017 **Edited by:** Qiang Shi

How to cite this article: Wang T, Zhuan L, Liu Z, Li MC, Yang J, Wang SG, Liu JH, Ling Q, Yang WM, Ye ZQ. Audiovisual Sexual Stimulation and RigiScan Test for the Diagnosis of Erectile Dysfunction. Chin Med J 2018;131:1465-71.

Access this article online

Quick Response Code:



Website:
www.cmj.org

DOI:
10.4103/0366-6999.233945

between 18 and 59 years of age actually went to a physician for consultation regarding their sexual dysfunction.^[5-7] Currently, the diagnostic application of RigiScan™ in nocturnal penile tumescence and rigidity (NPTR) is well recognized as an available powerful means to discriminate between psychogenic and organic ED,^[8-11] and it takes a time- and money-consuming effort to obtain the nocturnal erectile activity.^[12] In addition, normal values of NPTR parameters are controversial for researchers and normative data for RigiScan™ are in urgent need.^[11,13] Therefore, currently available evaluation criteria for NPTR test should be revised, and a brand new approach for RigiScan™ test needs developing.

Nowadays, audiovisual sexual stimulation and RigiScan™ (AVSS-RigiScan) is widely regarded as a more useful tool than NPT-RigiScan for diagnosis and antidiastole of ED.^[12,14,15] Sexually induced erections and sleep erections are not the same. Sexually induced erections are a combination of erotic and reflex erection activity, whereas the mechanism initiating and maintaining sleep erections still remains unknown.^[16] The difference between sleep and sexually induced erections is primarily neurological. Both erections involve the same vascular and penile structural components. In addition, AVSS-RigiScan test is relatively simple, cost-effective, and less time-consuming. There have been remarkably few studies evaluating AVSS-RigiScan in healthy aging men. This study aimed not only to establish normative Chinese evaluation criteria for future studies of men with ED, but also to reevaluate the significance of RigiScan™ Plus in the diagnosis of ED by utilizing AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor.

METHODS

Ethical approval

All methods were carried out in accordance with the guidelines, and study protocol approved by the Institutional Review Board and written informed consent was obtained from all participants that participated in the study.

Participants

Between 2008 and 2012, a total of 1169 patients aged 18–67 years (mean ± standard deviation, 30.3 ± 7.9 years) complained of ED for at least 6 months who were not excessively exposed to AVSS, or not super-suppressed, or not easily affected by the test circumstances, or had no contraindications for phosphodiesterase-5 inhibitors underwent AVSS-RigiScan test with administration of 20 mg of vardenafil. A total of 1078 patients whose final etiological diagnosis was accurate were included in the research, whereas 91 patients who were resistant to the test ($n = 16$) or failed to be followed up ($n = 75$) were excluded from the study.

Baseline evaluation

Our clinical guideline for the evaluation of ED is as follows: sexual history, physical examination, and analysis of serum glucose level. Each participant completed a self-reported

assessment of erectile function using the erectile domain section of the International Index of Erectile Function 5 (IIEF-5) questionnaire and erection hardness score. Laboratory data (biochemical profile, complete blood count, and urinalysis) and serum concentrations of total testosterone, luteinizing hormone, follicle-stimulating hormone, prolactin, and estradiol were taken (data not shown).

Audiovisual sexual stimulation test

Twenty milligrams of vardenafil was administered to all patients. One hour after administration of 20 mg of vardenafil, patients were then asked to lie in a supine position on a comfortable examination table. The examination room was dimly lit for comfort. The penis of the patient was connected to the RigiScan™ Plus device according to the instruction manual, and the device automatically determined the baseline penile rigidity and tumescence for the first 15 min. An audiovisual headset was placed on the participant's head and adjusted to a comfortable volume. The 60 min erotic video was shown individually to each patient in a dark and silent room and then stimulated rigidity and tumescence for the next 60 min. In this study, manual stimulation of the penis was prohibited during the session.

Etiological diagnosis of erectile dysfunction

In the following day, all patients were evaluated with intracavernous injection (ICI). If this result is abnormal, we continue evaluation with penile color flow Doppler ultrasonography (PDU) and cavernosometry-cavernosography and neurological tests in selected cases to differentiate psychogenic ED from vascular ED. Psychogenic ED is defined as IIEF-5 <21 and no evidence of endocrine, vascular, and neurological system disorders and erectile angle >90° after ICI sustained for at least 30 min. Organic ED is defined as IIEF-5 <21 and erectile angle <90° after ICI sustained for <30 min or evidence of endocrine, penile vascular, and neurological system disorders or diabetes mellitus. All the methods utilized to make etiological diagnosis of ED are routine and authorized methods for ED diagnosis, and the experimental protocols are also conventional ones.

Statistical analysis

Data analysis was performed with SPSS version 17.0 for Windows (SPSS Inc., Chicago, IL, USA). Wilcoxon rank sum test was performed on parameters between psychogenic and organic ED; Kruskal-Wallis *H*-test was used in parameters with regard to etiological groups and age groups. Logistic regression model and receiver operating characteristic (ROC) curve analysis were performed on the RigiScan™ data with final etiological diagnosis as the outcome. Then, multivariable logistic analysis was used in the selected variables. Two-sided $P < 0.05$ was considered to be statistically significant.

RESULTS

Participants' profile

All patients were evaluated with ICI, PDU, and cavernosometry-cavernosography and neurological tests in

selected cases. The final diagnosis was psychogenic ED in 743 patients (68.9%), whereas 335 patients (31.1%) were found to have organic ED. In the 743 patients diagnosed with psychogenic ED, 17 patients were false positives. Of the 335 patients diagnosed with organic ED, two patients were false negatives, 242 patients (72.2%) were diagnosed with vascular ED, and 45 patients (13.4%) were diagnosed with endocrine ED. AVSS-RigiScan parameters with regard to etiology and age are shown in Tables 1–3. Parameters except for times of total tumescence between psychogenic and organic ED were statistically significant ($P < 0.05$). Parameters with regard to etiological groups, average event rigidity of tip (%), duration of erectile episodes over 60% (min), and average event rigidity of base (%) were statistically significant ($P < 0.05$). Parameters with regard to age groups, average maximum rigidity of tip (%), and average maximum rigidity of base (%) were statistically significant ($P < 0.05$).

Relationship between parameters and the diagnosis of erectile dysfunction

Area under the curve (AUC) of RigiScan™ parameters screened by logistic regression analysis were listed as the following order: average event rigidity of tip (AUC = 0.943, $P = 0.001$) > duration of erectile episodes over 60% (AUC = 0.942, $P = 0.001$) > average event rigidity

of base (AUC = 0.933, $P = 0.001$) > average maximum rigidity of tip (AUC = 0.876, $P = 0.001$) > average maximum rigidity of base (AUC = 0.862, $P = 0.001$) > Δ tumescence (increase of tumescence or maximum–minimum tumescence) of tip (AUC = 0.804, $P = 0.001$) > Δ tumescence of base (AUC = 0.773, $P = 0.001$) > times of erectile episodes over 60% (AUC = 0.749, $P = 0.001$) > total tumescence time (AUC = 0.743, $P = 0.001$) > times of total tumescence (AUC = 0.526, $P = 0.335$) [Table 4 and Figure 1].

Normative values for penile rigidity

According to AUC and $\text{Max}_{(\text{Sensitivity} + \text{Specificity})}$, normative AVSS-RigiScan parameters (duration of erectile episodes over 60%, average event rigidity of tip, average event rigidity of base, average maximum rigidity of tip, average maximum rigidity of base, Δ tumescence of tip, Δ tumescence of base, and total tumescence time) are summarized in Table 5.

Establishment of risk model of erectile dysfunction

By multivariable logistic regression analysis, it was revealed that there were six significant AVSS-RigiScan parameters ($P < 0.05$) for differentiating psychogenic ED from organic ED as times of total tumescence, duration of erectile episodes over 60%, average event rigidity of tip, Δ tumescence of tip, average event rigidity of base, and Δ tumescence of base [Table 6]. Logistic regression equation (area

Table 1: Parameters of AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor between psychogenic and organic erectile dysfunction patients

Parameters	Psychogenic ED ($n = 743$)	Organic ED ($n = 335$)	Wilcoxon W	P
Average event rigidity of tip (%)	52.00 (9.00)	27.00 (16.00)	16,571.50	<0.001
Duration of erectile episodes over 60% (min)	21.00 (20.00)	0.00 (5.00)	16,601.00	<0.001
Average event rigidity of base (%)	58.00 (9.00)	35.00 (17.00)	17,156.00	<0.001
Average maximum rigidity of tip (%)	71.00 (9.00)	53.00 (21.00)	20,517.00	<0.001
Average maximum rigidity of base (%)	75.00 (9.00)	58.00 (18.00)	21,308.00	<0.001
Δ Tumescence of tip (cm)	2.00 (0.60)	1.60 (0.70)	24,709.50	<0.001
Δ Tumescence of base (cm)	2.30 (0.60)	1.80 (0.63)	26,525.50	<0.001
Times of erectile episodes over 60%	1.00 (0.00)	0.00 (1.00)	27,958.50	<0.001
Total tumescence time (min)	40.75 (20.00)	22.75 (25.50)	28,316.50	<0.001
Times of total tumescence	1.00 (0.00)	1.00 (0.00)	41,059.00	0.172

Data are shown as median (interquartile range). Δ Tumescence: increase of tumescence or maximum–minimum tumescence. ED: Erectile dysfunction; AVSS: Audiovisual sexual stimulation.

Table 2: AVSS-RigiScan test parameters with regard to etiological groups of organic erectile dysfunction

Parameters	Neurogenic ED ($n = 25$)	Vascular ED ($n = 242$)	Endocrine ED ($n = 45$)	Others ($n = 23$)	Kruskal-Wallis H	P
Average event rigidity of tip (%)	40.50 (31.00)	29.00 (24.00)	45.00 (27.00)	29.00 (8.00)	12.13	0.007
Duration of erectile episodes over 60% (min)	10.75 (25.00)	2.00 (54.00)	5.75 (33.00)	2.00 (7.00)	13.25	0.004
Average event rigidity of base (%)	46.50 (27.00)	39.00 (22.00)	50.50 (29.00)	39.00 (14.00)	12.73	0.005
Average maximum rigidity of tip (%)	63.00 (25.00)	55.00 (25.00)	62.00 (23.75)	62.00 (23.00)	6.81	0.078
Average maximum rigidity of base (%)	69.00 (20.75)	62.00 (22.00)	70.00 (21.00)	64.00 (17.00)	7.51	0.057
Δ Tumescence of tip (cm)	1.85 (0.85)	1.70 (0.80)	1.70 (0.65)	1.60 (0.70)	5.46	0.141
Δ Tumescence of base (cm)	2.10 (0.67)	2.00 (0.70)	2.05 (0.70)	2.00 (0.60)	0.95	0.815
Times of erectile episodes over 60%	10.75 (25.00)	2.00 (9.00)	5.75 (33.00)	2.00 (7.00)	4.28	0.233
Total tumescence time (min)	31.00 (34.25)	28.00 (28.00)	32.50 (33.38)	22.00 (18.50)	3.10	0.377
Times of total tumescence	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (1.00)	2.93	0.403

Data are shown as median (interquartile range). Δ Tumescence: increase of tumescence or maximum–minimum tumescence. ED: Erectile dysfunction; AVSS: Audiovisual sexual stimulation.

Table 3: AVSS-RigiScan test parameters with regard to age groups of erectile dysfunction patients

Parameters	≤29 years (n = 634)	30–39 years (n = 306)	40–49 years (n = 107)	≥50 years (n = 31)	Kruskal- Wallis H	P
Average event rigidity of tip (%)	48.00 (20.00)	47.00 (18.00)	40.00 (30.00)	47.00 (24.00)	5.87	0.118
Duration of erectile episodes over 60% (min)	15.00 (24.00)	13.00 (21.00)	7.75 (24.00)	15.00 (36.00)	3.64	0.303
Average event rigidity of base (%)	55.00 (16.00)	53.00 (17.00)	49.50 (24.00)	53.00 (29.00)	5.21	0.157
Average maximum rigidity of tip (%)	69.00 (15.00)	67.00 (14.00)	67.00 (27.00)	65.00 (26.00)	9.95	0.019
Average maximum rigidity of base (%)	73.00 (15.00)	73.00 (14.00)	69.50 (17.00)	69.00 (25.00)	8.18	0.042
ΔTumescence of tip (cm)	1.90 (0.65)	1.90 (0.75)	1.90 (0.58)	1.70 (0.55)	4.91	0.179
ΔTumescence of base (cm)	2.20 (0.70)	2.20 (0.70)	2.20 (0.75)	2.20 (0.55)	2.46	0.482
Times of erectile episodes over 60%	1.00 (0.00)	1.00 (0.00)	1.00 (1.00)	1.00 (1.00)	6.16	0.104
Total tumescence time (min)	37.00 (22.13)	36.00 (27.75)	33.50 (30.25)	38.00 (40.13)	0.83	0.841
Times of total tumescence	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	2.49	0.477

Data are shown as median (interquartile range). ΔTumescence: increase of tumescence or maximum–minimum tumescence. AVSS: Audiovisual sexual stimulation.

Table 4: Area under the curves for different parameters of AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor

Parameters	AUC	SE	95% confidence interval	P
Average event rigidity of tip (%)	0.943	0.010	0.923-0.963	<0.001
Duration of erectile episodes over 60% (min)	0.942	0.010	0.922-0.963	<0.001
Average event rigidity of base (%)	0.933	0.011	0.910-0.955	<0.001
Average maximum rigidity of tip (%)	0.876	0.018	0.840-0.912	<0.001
Average maximum rigidity of base (%)	0.862	0.019	0.825-0.900	<0.001
ΔTumescence of tip (cm)	0.804	0.022	0.762-0.847	<0.001
ΔTumescence of base (cm)	0.773	0.023	0.728-0.819	<0.001
Times of erectile episodes over 60%	0.749	0.026	0.697-0.801	<0.001
Total tumescence time (min)	0.743	0.024	0.695-0.791	<0.001
Times of total tumescence	0.526	0.027	0.474-0.579	0.335

ΔTumescence: increase of tumescence or maximum–minimum tumescence. AUC: Area under the curve; SE: Standard error; AVSS: Audiovisual sexual stimulation.

Table 5: Normative value for parameters of AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor

Parameters	Value	Sensitivity	Specificity	Max _(Sensitivity + Specificity)
Average event rigidity of tip (%)	43.500	0.938	0.840	1.778
Duration of erectile episodes over 60% (min)	8.750	0.926	0.848	1.774
Average event rigidity of base (%)	50.500	0.938	0.818	1.756
Average maximum rigidity of tip (%)	62.500	0.778	0.851	1.629
Average maximum rigidity of base (%)	67.500	0.778	0.837	1.615
ΔTumescence of tip (cm)	1.750	0.698	0.796	1.494
ΔTumescence of base (cm)	1.950	0.580	0.862	1.442
Times of erectile episodes over 60%	1.000	0.119	0.882	0.938
Total tumescence time (min)	29.750	0.636	0.780	1.416
Times of total tumescence	1.000	0.827	0.223	1.050

ΔTumescence: increase of tumescence or maximum–minimum tumescence; AVSS: Audiovisual sexual stimulation.

under the curve=0.967) was as following: $P = 1/1 + \text{Exp}(-[3.457 + 0.052X_3 - 0.309X_5 - 0.212X_7 + 1.059X_8 + 0.149X_9 - 1.944X_{10}])$. ROC analysis produced a cutoff value (0.303) with a sensitivity of 87.7% and a specificity of 93.4% for ED diagnosis, that is, organic ED was considered with a predict value of $P \geq 0.303$, whereas the predict value of $P < 0.303$ was considered as psychogenic ED [Figure 2].

DISCUSSION

In the era of pharmacotherapy for ED, it is important for the

clinician to differentiate psychogenic ED from organic ED in planning treatment modalities. Recently, AVSS is more commonly used than NPT because the tumescence during AVSS is more similar to that during sexual intercourse.^[14-17] In addition, the test is relatively simple, cost-effective, less time-consuming, and more physiologic than the NPT. However, the test for erection relies on psychogenic stimulation, if a subject with normal erection who is excessively exposed to AVSS, or super-suppressed, or easily affected by the test circumstances would fail to respond and measurement value would lose.^[12,14] Thereby the method

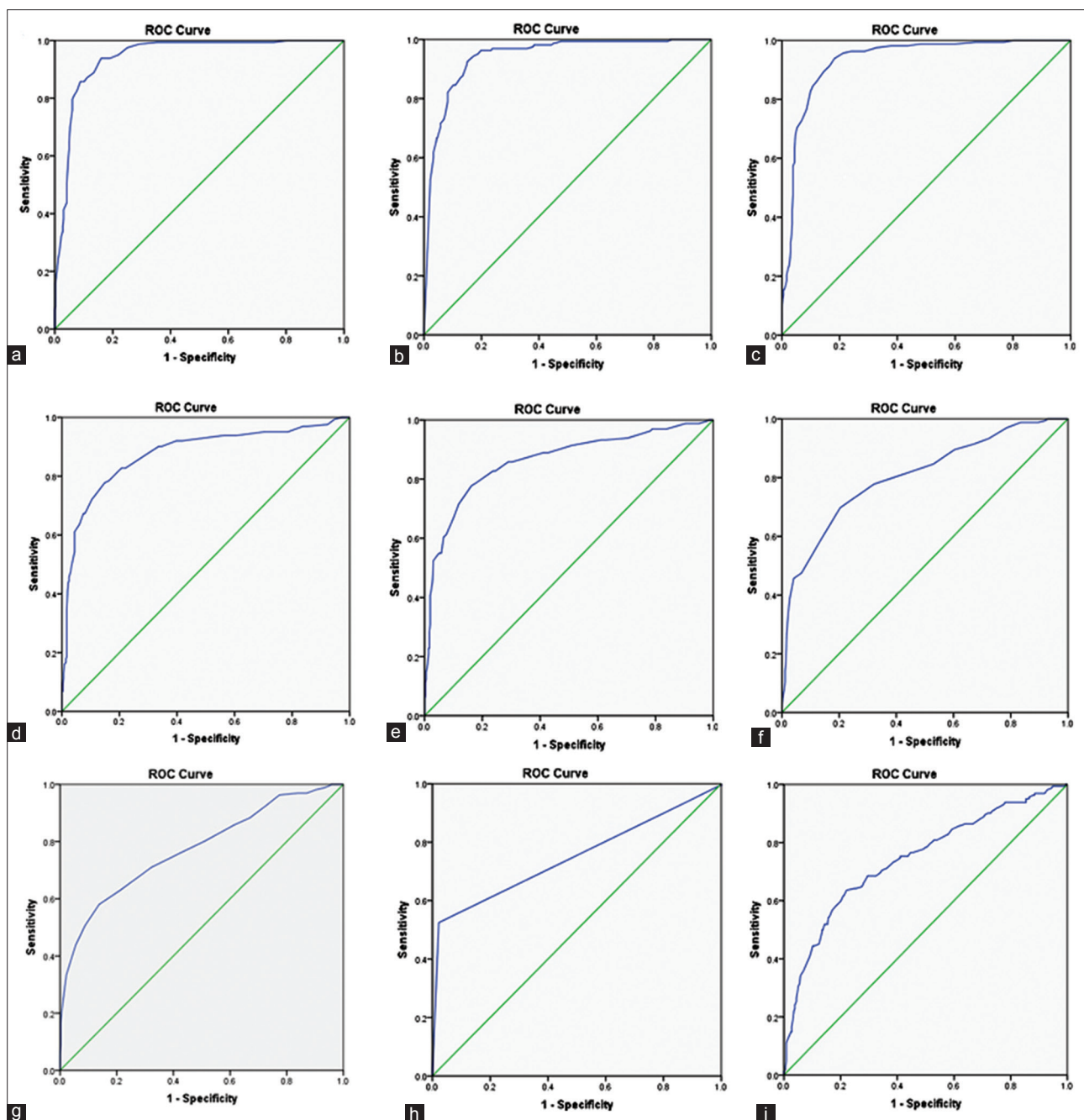


Figure 1: Receiver operating characteristic analyses for different parameters of AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor in erectile dysfunction patients. (a) Average event rigidity of tip (%). (b) Duration of erectile episodes over 60% (min). (c) Average event rigidity of base (%). (d) Average maximum rigidity of tip (%). (e) Average maximum rigidity of base (%). (f) Δ Tumescence of tip (cm). (g) Δ Tumescence of base (cm). (h) Times of erectile episodes over 60%. (i) Total tumescence time (min). Δ Tumescence: increase of tumescence or maximum – minimum tumescence. AVSS: Audiovisual sexual stimulation.

that patients were given with three-dimensional AVSS and phosphodiesterase-5 inhibitor will not just avoid or reduce the defects of the conventional AVSS and but improve the diagnostic performance of AVSS.^[12,14,15,18-20]

There have been remarkably few studies that have evaluated AVSS-RigiScan in healthy aging men. However, currently available evaluation criteria for penile tumescence and rigidity have been very controversial.^[13,21] In this study, we sought not only to establish normative Chinese evaluation criteria

for future studies of men with ED but also to reevaluate the significance of RigiScan™ Plus in the diagnosis of ED by utilizing AVSS-RigiScan test with the administration of 20 mg of vardenafil. All the patients whose final etiological diagnosis was accurate by means of history, endocrine, vascular, and neurological diagnostic techniques were included in the study. The final diagnosis was psychogenic ED in 68.9%, whereas 31.1% patients were found to have organic ED. Of the patients diagnosed with organic ED, most patients (72.2%) were diagnosed with vascular ED.

Table 6: Multivariable logistic analysis for parameters of AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor

Variables	Regression coefficient (β_1)	P	OR
Age (X_1)	0.016	0.530	1.016
Marital status (X_2)	0.393	0.319	1.481
Total tumescence time (X_3)	0.052	0.001	1.053
Times of total tumescence (X_4)	-0.610	0.068	0.543
Duration of erectile episodes over 60% (X_5)	-0.309	<0.001	0.734
Times of erectile episodes over 60% (X_6)	-0.254	0.484	0.776
Average event rigidity of base (X_7)	-0.212	0.000	0.809
Δ Tumescence of tip (X_8)	1.059	0.032	2.884
Average maximum rigidity of base (X_9)	0.149	0.001	1.161
Δ Tumescence of base (X_{10})	-1.944	0.000	0.143
Average maximum rigidity of tip (X_{11})	0.029	0.424	1.029
Average maximum rigidity of base (X_{12})	-0.015	0.678	0.985
Constant	3.457	0.015	31.718

Δ Tumescence: increase of tumescence or maximum–minimum tumescence. OR: Odds ratio; AVSS: Audiovisual sexual stimulation.

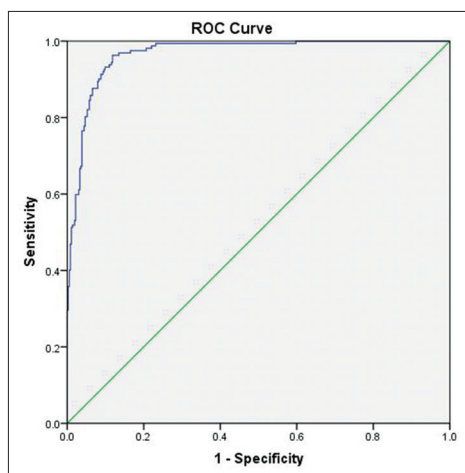


Figure 2: Receiver operating characteristic analysis for logistic regression equation (AUC=0.967). The regression equation was composed of total tumescence time (X_3), duration of erectile episodes over 60% (X_5), average event rigidity of base (X_7), Δ tumescence of tip (X_8), average maximum rigidity of base (X_9), and Δ tumescence of base (X_{10}) by AVSS-RigiScan test in erectile dysfunction patients: $P = 1/1 + \text{Exp}(-[3.457 + 0.052X_3 - 0.309X_5 - 0.212X_7 + 1.059X_8 + 0.149X_9 - 1.944X_{10}])$. Δ Tumescence: increase of tumescence or maximum–minimum tumescence; AVSS: Audiovisual sexual stimulation; AUC: Area under the curve.

Among all RigiScan™ parameters, other than times of total tumescence, these parameters (average event rigidity of tip [%], duration of erectile episodes over 60% [min], average event rigidity of base [%], average maximum rigidity of tip [%], average maximum rigidity of base [%], Δ tumescence of tip [cm], Δ tumescence of base [cm], times of erectile episodes over 60%, and total tumescence time [min]) were observed statistically significant difference. AUC of RigiScan™ parameters screened by logistic regression analysis revealed the following order: average event rigidity of tip > duration of erectile episodes over 60% > average event rigidity of base > average maximum rigidity of tip > average maximum rigidity of base > Δ tumescence

of tip > Δ tumescence of base > times of erectile episodes over 60% > total tumescence time > times of total tumescence. A normal result is defined as one erection with base rigidity over 60% sustained for at least 8.75 min, average event rigidity of tip at least 43.5% and base at least 50.5%, average maximum rigidity of tip at least 62.5% and base at least 67.5%, Δ tumescence of tip at least 1.75 cm and base at least 1.95 cm, total tumescence time at least 29.75 min, and times of total tumescence at least once. Most importantly, base rigidity over 60% sustained for at least 8.75 min, average event rigidity of tip at least 43.5%, and base at least 50.5% would be the new normative Chinese evaluation criteria for penile tumescence and rigidity.

By multivariable logistic regression analysis, six significant RigiScan™ parameters including times of total tumescence, duration of erectile episodes over 60%, average event rigidity of tip, Δ tumescence of tip, average event rigidity of base, and Δ tumescence of base contribute to the risk model of ED. It was revealed that the sensitivity and specificity of the AVSS-RigiScan test with the administration of phosphodiesterase-5 inhibitor in discriminating psychogenic from organic ED was 87.7% and 93.4%, respectively.

This study suggests that AVSS-RigiScan test with oral phosphodiesterase-5 inhibitors can objectively assess penile tumescence and rigidity and seems to be a better modality in differentiating psychogenic from organic ED. We anticipate that application of these criteria for AVSS-RigiScan will improve the diagnostic validity of ED. Since the size of this study and the population of ED patients were limited, bias cannot be totally excluded. Future research will determine whether these criteria are too strict for the evaluation of ED. Thereby, a multicenter clinical study on the diagnostic criteria for ED is urgently needed in China.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Jeon SW, Yoo KH, Kim TH, Kim JI, Lee CH. Correlation of the erectile dysfunction with lesions of cerebrovascular accidents. *J Sex Med* 2009;6:251-6. doi: 10.1111/j.1743-6109.2008.00923.x.
2. McKenna KE. Some proposals regarding the organization of the central nervous system control of penile erection. *Neurosci Biobehav Rev* 2000;24:535-40. doi: 10.1016/S0149-7634(00)00021-X.
3. Jung JH, Kam SC, Choi SM, Jae SU, Lee SH, Hyun JS, *et al.* Sexual dysfunction in male stroke patients: Correlation between brain lesions and sexual function. *Urology* 2008;71:99-103. doi: 10.1016/j.urology.2007.08.045.
4. Miyagawa Y, Tsujimura A, Fujita K, Matsuoka Y, Takahashi T, Takao T, *et al.* Differential brain processing of audiovisual sexual stimuli in men: Comparative positron emission tomography study of the initiation and maintenance of penile erection during sexual arousal. *Neuroimage* 2007;36:830-42. doi: 10.1016/j.neuroimage.2007.03.055.
5. Shamloul R, Ghanem H. Erectile dysfunction. *Lancet* 2013;381:153-65. doi: 10.1016/S0140-6736(12)60520-0.
6. Derogatis LR, Burnett AL. The epidemiology of sexual dysfunctions. *J Sex Med* 2008;5:289-300. doi: 10.1111/j.1743-6109.2007.00668.x.
7. Albersen M, Orabi H, Lue TF. Evaluation and treatment of erectile dysfunction in the aging male: A mini-review. *Gerontology* 2012;58:3-14. doi: 10.1159/000329598.
8. Burris AS, Banks SM, Sherins RJ. Quantitative assessment of nocturnal penile tumescence and rigidity in normal men using a home monitor. *J Androl* 1989;10:492-7. doi: 10.1002/j.1939-4640.1989.tb00148.x.
9. Levine LA, Lenting EL. Use of nocturnal penile tumescence and rigidity in the evaluation of male erectile dysfunction. *Urol Clin North Am* 1995;22:775-88.
10. Hatzichristou DG, Hatzimouratidis K, Ioannides E, Yannakoyorgos K, Dimitriadis G, Kalinderis A, *et al.* Nocturnal penile tumescence and rigidity monitoring in young potent volunteers: Reproducibility, evaluation criteria and the effect of sexual intercourse. *J Urol* 1998;159:1921-6. doi: 10.1016/S0022-5347(01)63197-5.
11. Yaman O, Tokatli Z, Ozdiler E, Anafarta K. Effect of aging on quality of nocturnal erections: Evaluation with NPTR testing. *Int J Impot Res* 2004;16:150-3. doi: 10.1038/sj.ijir.3901199.
12. Moon KH, Song PH, Park TC. Using a three-dimension head mounted displayer in audio-visual sexual stimulation aids in differential diagnosis of psychogenic from organic erectile dysfunction. *Int J Impot Res* 2005;17:519-22. doi: 10.1038/sj.ijir.3901349.
13. Basar MM, Atan A, Tekdogan UY. New concept parameters of RigiScan in differentiation of vascular erectile dysfunction: Is it a useful test? *Int J Urol* 2001;8:686-91. doi: 10.1046/j.1442-2042.2001.00398.x.
14. Mizuno I, Fuse H, Fujiuchi Y, Nakagawa O, Akashi T. Comparative study between audiovisual sexual stimulation test and nocturnal penile tumescence test using RigiScan Plus in the evaluation of erectile dysfunction. *Urol Int* 2004;72:221-4. doi: 10.1159/000077119.
15. Soh J, Naya Y, Ushijima S, Naitoh Y, Ochiai A, Mizutani Y, *et al.* Efficacy of sildenafil for Japanese patients with audio-visual sexual stimulation (AVSS) test by the RigiScan plus. *Arch Androl* 2006;52:163-8. doi: 10.1080/01485010500379889.
16. Cera N, Di Piero ED, Ferretti A, Tartaro A, Romani GL, Perrucci MG, *et al.* Brain networks during free viewing of complex erotic movie: New insights on psychogenic erectile dysfunction. *PLoS One* 2014;9:e105336. doi: 10.1371/journal.pone.0105336.
17. Hagemann JH, Berding G, Bergh S, Sleep DJ, Knapp WH, Jonas U, *et al.* Effects of visual sexual stimuli and apomorphine SL on cerebral activity in men with erectile dysfunction. *Eur Urol* 2003;43:412-20. doi: 10.1016/S0302-2838(03)00002-2.
18. Mathers MJ, Klotz T, Brandt AS, Roth S, Sommer F. Long-term treatment of erectile dysfunction with a phosphodiesterase-5 inhibitor and dose optimization based on nocturnal penile tumescence. *BJU Int* 2008;101:1129-34. doi: 10.1111/j.1464-410X.2007.07376.x.
19. Gökçe A, Demirtas A, Halis F, Ekmekcioglu O. The effects of phosphodiesterase type 5 inhibitors on penile rigidity variables during a period with no sexual stimulation: A laboratory setting double-blind study. *BJU Int* 2011;107:264-7. doi: 10.1111/j.1464-410X.2010.09390.x.
20. Greenstein A, Chen J, Salonia A, Sofer M, Matzkin H, Montorsi F, *et al.* Does sildenafil enhance quality of nocturnal erections in healthy young men? A NPT-RigiScan study. *J Sex Med* 2004;1:314-7. doi: 10.1111/j.1743-6109.04045.x.
21. Jannini EA, Granata AM, Hatzimouratidis K, Goldstein I. Use and abuse of RigiScan in the diagnosis of erectile dysfunction. *J Sex Med* 2009;6:1820-9. doi: 10.1111/j.1743-6109.2009.01343.x.

视听觉性刺激Rigiscan诊断勃起功能障碍

摘要

背景：目前现有的勃起硬度评价标准仍存在较大的争议，本研究旨通过口服PDE5抑制剂联合视听觉性刺激Rigiscan（AVSS-Rigiscan）建立中国人群勃起硬度的正常参考值。

方法：1169例18–67岁的勃起功能障碍（ED）患者予口服磷酸二酯酶-5（PDE5）抑制剂并行AVSS-RigiScan实时监测阴茎勃起情况，并通过病史采集、内分泌学、血管功能和神经系统检测、国际勃起功能指数5（IIEF-5）问卷以及勃起硬度评分（EHS）作出病因学诊断。Logistic回归模型和受试者工作特征曲线（ROC）分析用于确定RigiScan™各参数的截断值，选择变量采用多因素Logistic回归分析。

结果：RigiScan™各参数的正常参考值下限分别为：阴茎基底部充分勃起（平均勃起硬度>60%）持续时间8.75min、冠状沟部平均硬度43.5%、基底部平均硬度50.5%、冠状沟平均最大硬度62.5%、基底部平均最大硬度67.5%、冠状沟部肿胀增加值1.75cm、基底部肿胀增加值1.95cm、总勃起时间29.75min、勃起次数1次，其中基底部充分勃起（平均勃起硬度>60%）时间8.75min、冠状沟部平均硬度43.5%和基底部平均硬度50.5%可作为中国人群勃起硬度的新的正常参考值。通过多因素Logistic回归分析显示，基底部充分勃起持续时间、冠状沟部平均硬度、冠状沟部肿胀增加值、基底部平均硬度及基底部肿胀增加值等6个RigiScan™参数可作为ED风险预测模型的重要指标，即当Logistic回归方程的预测值 $P < 0.303$ 时诊断为心理性ED，反之为器质性ED。口服PDE5抑制剂联合AVSS-Rigiscan鉴别诊断心理性和器质性ED的灵敏度和特异度分别为87.7%和93.4%。

结论：本研究表明，通过口服PDE5抑制剂联合AVSS-Rigiscan能更好、更客观地鉴别诊断心理性和器质性ED，但由于本研究样本量有限，偏倚仍不能完全排除。