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Modern methods of diagnosis and treatment of vasculogenic erectile dysfunction

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ABSTRACT

A review of modern methods of diagnosis and treatment of vasculogenic erectile dysfunction is presented. Data regarding the diagnostic value of noninvasive and invasive diagnostic techniques are displayed: stamp test, Snap-Gauge test, use of the RigiScan and Androscan-MIT systems, intracavernous injections of vasoactive drugs, Doppler ultrasound of penile vessels, penile angiography, and magnetic resonance arteriography. The advantages and disadvantages of each of these tests are shown. The main directions of conservative and surgical treatment of vasculogenic erectile dysfunction are presented. Notably, early detection of erectile dysfunction with the prescription of appropriate treatment can improve the quality of life of patients and prevent life-threatening complications of cardiovascular conditions.

Keywords: erectile dysfunction; Doppler ultrasound; Androscan-MIT; nocturnal penile tumescence test.

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Современные методы диагностики и лечения васкулогенной эректильной дисфункции

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АННОТАЦИЯ

Представлен обзор современных методов диагностики и лечения васкулогенной эректильной дисфункции. Приведены данные относительно диагностической ценности неинвазивных и инвазивных диагностических методик: марочного теста, Снэп-Гэйдж-теста, систем RigiScan и Андроскан-МИТ, внутрикавернозных инъекций вазоактивных препаратов, ультразвуковой допплерографии сосудов полового члена, ангиографии полового члена, магнитно-резонансной артериографии. Показаны преимущества и недостатки каждого из этих тестов. Представлены основные направления лечения пациентов с васкулогенной эректильной дисфункцией как консервативные, так и хирургические. Подчеркнуто, что раннее выявление нарушений эректильной функции с назначением соответствующего лечения может не только улучшить качество жизни пациентов, но и предотвратить жизнеугрожающие осложнения со стороны сердечно-сосудистой системы.

Ключевые слова: эректильная дисфункция; ультразвуковая допплерография; Андроскан-МИТ; тест ночных пенильных тумесценций.

Как цитировать

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INTRODUCTION

Erectile dysfunction (ED) refers to the inability to achieve or maintain an adequate erection of the penis for satisfactory sexual intercourse [1]. The prevalence of ED is high and increases with age, rising from 13.8% in men aged 30–40 years to nearly 100% in men aged >70 years [2, 3].

The most common causes of ED are neurogenic and vascular factors, which worsen with age and are often associated with conditions such as hypertension, diabetes, atherosclerosis, dyslipidemia, and metabolic syndrome. Vascular factors primarily affect local erectile function, whereas neurogenic factors can impair all levels of the nervous system [4, 5].

This review aims to examine modern diagnostic methods for vasculogenic (vascular) ED.

NONINVASIVE METHODS FOR ASSESSING ERECTILE DYSFUNCTION

Postage stamp test

Developed in 1980, the postage stamp test is a simple method for evaluating erectile strength [6]. Four postage stamps with a combined width of 5 inches (12.7 cm) are wrapped around the penis. The overlapping part is sealed by folding the stamps to half their width. During the test, tearing of the stamps is considered a sign of an erection. This method is still used clinically to differentiate psychogenic ED from organic ED [7]. The method is simple, inexpensive, and safe. However, because the stamps are torn during the measurement, it does not allow for continuous monitoring of nocturnal penile tumescence (NPT), limiting its use. Moreover, because the test requires sufficient erection strength to tear the stamps, the results can vary based on the degree of erection achieved [8].

Snap-Gauge test

The Snap-Gauge test uses an adjustable band with three snap fasteners that can be secured around the penis. The fasteners have release strengths of 0.2, 0.34, and 0.45 kg, which correspond to intracavernous pressures ranging from 90 to 160 mmHg. The test evaluates the strength of an erection based on the release of fasteners. However, erroneous results are observed in 15.5% of healthy young men, limiting the test's reliability for continuous monitoring [9]. Furthermore, a previous study reported a weak correlation between Snap-Gauge test results and NPT monitoring [10].

The analog measurement methods mentioned above have limitations in terms of data quantification. Furthermore, they can only capture one or at most a single instance of erection, lacking the capability for continuous or repetitive measurements.

Digital measurements

The advent of digital measurement methods using computers and electronic sensors has enabled continuous monitoring of penile conditions. The RigiScan system, introduced in 1985, is a device capable of monitoring NPT and penile rigidity simultaneously [11]. The device comprises two inelastic loops fitted around the penis and connected to a microcomputer for data processing, facilitating real-time measurement of penile rigidity. Although extensively used in clinical research and regarded as effective and accurate [12–18], the size and weight of the device — along with the requirement to attach it to the hip — can disrupt sleep and affect test outcomes.

The Russian equivalent device Androscan-MIT, introduced in 2019, evaluates NPT by tracking changes in penile diameter and rigidity. This device comprises a sensor capable of obtaining 20 measurements and software installed on a personal computer. The device is activated contactless after the patient is registered in the program, indicating the start and end times of the test. Upon completion, digital data are transferred to a computer and visualized as graphs [19]. The duration of the analyzed period is defined as 8 h of good-quality sleep. The device allows the recording of changes in penile diameter and the duration of each tumescence, with the results displayed in a diagrammatic form. The findings of the study are highly informative, as they used both quantitative and qualitative methods to identify the vasculogenic forms of ED. The device can be easily operated by patients with minimal skills, making it suitable for home use.

INVASIVE EXAMINATION TECHNIQUES

Intracavernous administration of vasoactive drugs was the first proposed method for diagnosing vascular ED, laying the foundation for further advances in this field [20]. In 1982, Virag [21] reported that papaverine injection into the corpora cavernosa induced an erection lasting for 2–15 min. Since then, papaverine, along with phentolamine and alprostadil, has been widely used for diagnosing and treating vascular ED [22–24]. Intracavernous injections of vasoactive drugs were initially considered as the first-line treatment for ED before the introduction of oral phosphodiesterase type 5 (PDE5) inhibitors. However, these injections are still relevant in certain clinical situations. Moreover, they play a crucial role in diagnosing vascular ED [24]. Ten minutes after the injection, the penis length, circumference, and angle relative to the thigh (while standing) are measured. An angle >90° with an erection lasting >30 min indicates normal vascular function, whereas an angle <60° indicates possible vascular ED. If the angle is between 60° and 90°, further diagnostic evaluation is required.

Additionally, insufficient erection 15 min after injection indicates impaired arterial inflow, whereas rapid erection followed by quick subsidence indicates venous occlusion issues [25].

Despite their diagnostic utility, intracavernous injections have side effects, including pain, priapism, penile fibrosis, and long-term refractoriness, limiting their clinical use [26]. Therefore, most researchers recommend combining these injections with other diagnostic methods [27–31].

METHODS OF DIAGNOSIS OF ARTERIAL ERECTILE DYSFUNCTION

Doppler ultrasound

Doppler ultrasound was used for the first time to diagnose vasculogenic ED in 1980 [32]. In 1985, Lue et al. [33] introduced a combination of Doppler ultrasound with intracavernosal injection of vasoactive drugs to evaluate penile hemodynamics. Subsequently, several studies have optimized this method. Currently, this procedure is the first-line diagnostic method for diagnosing vascular ED to determine its subtype and severity [34, 35].

The International Society for Sexual Medicine recommends three primary indicators for assessing blood flow in patients with ED: peak systolic velocity, terminal diastolic velocity, and resistive index. A peak systolic blood flow rate <25 cm/s indicates arterial vasculogenic ED [36].

Despite its diagnostic value, Doppler ultrasound has limitations. The procedure is complex, labor-intensive, expensive, and requires highly skilled specialists [37, 38]. Moreover, Doppler ultrasound requires maximum relaxation of the penile smooth muscles to reflect the actual state of vascular function during the study, which can be challenging under stress [39, 40]. These limitations can lead to false positives, necessitating repeated administration of vasoactive drugs. However, there is no consensus on the optimal drug and dosages [41–43]. Audiovisual sexual stimulation has also been reported to enhance erection before Doppler ultrasound or after intracavernous injections [35]. Doppler ultrasound is a widely recognized first-line method for diagnosing vascular ED. However, differences in the qualifications of specialists, the absence of standardized protocols, reliance on medications, and the use of audiovisual sexual stimulation during the procedure contribute to significant variability in the results.

Selective penile angiography

While Doppler ultrasound is effective for the preliminary assessment of vascular function, its results are variable and limited to the evaluation of blood flow without providing anatomical information about the penis [44]. Selective penile angiography, considered the gold standard for diagnosing vasculogenic ED [45], overcomes these limitations. This method accurately visualizes the penile vascular network, facilitating the identification of traumatic arterial injuries, anatomical abnormalities, occlusive diseases, and collateral circulation [46]. It is typically used in younger patients with suspected arterial ED when revascularization surgery is considered [47].

Despite its diagnostic advantages, penile angiography has several drawbacks, including its invasiveness, high costs, and need for postoperative monitoring. The procedure also requires skilled endovascular surgeons to cannulate small internal arteries, further limiting its routine application.

Magnetic resonance arteriography

Magnetic resonance arteriography (MRA) is a relatively new diagnostic tool that provides both anatomical and functional assessments of penile blood flow [48, 49]. MRA is particularly useful for evaluating penile vascular health in patients with post-traumatic ED, penile fractures, and Peyronie's disease, particularly when planning for penile prosthetics [49, 50].

According to Armenakas et al. [50], MRA offers better visualization of the proximal iliac and genital arteries but is less effective for distal genital and penile arteries. Consequently, traditional selective angiography remains superior to three-dimensional (3D-MRA) in assessing distal arterial function, and 3D-MRA is not recommended for routine preoperative planning for revascularization. Nonetheless, MRA's noninvasive nature and ability to generate high-resolution, multivariate evaluations make it a viable alternative for patients with contraindications to angiography.

TREATMENT OF PATIENTS WITH ERECTILE DYSFUNCTION

Clinical guidelines recommend PDE5 inhibitors as the first-line therapy for ED [51]. PDE5 inhibitors block the enzyme responsible for reducing cyclic guanosine monophosphate levels, promoting smooth muscle relaxation, and improving blood flow during sexual stimulation [52]. These drugs are effective for both organic and psychogenic ED, but side effects, such as headaches, facial flushing, nasal congestion, visual impairment, and indigestion, may occur.

Intracavernous injections of vasoactive drugs are considered second-line treatment for ED. This treatment is indicated when oral therapy proves ineffective or intolerable or when a patient prefers a more reliable and predictable erection. Alprostadil injections are effective in cases where sildenafil has failed. The effectiveness of intracavernous administration of prostaglandin E1 is reported to be between 70% and 80%,

with the primary side effect being pain during injection [29]. Contraindications for this treatment include significant anatomical defects of the penis or cavernous bodies, diseases predisposing to priapism (e.g., sickle cell anemia and myeloid leukemia), and mental health disorders.

NONPHARMACOLOGICAL METHODS OF TREATMENT OF ERECTILE DYSFUNCTION

Low-intensity extracorporeal shockwave therapy

Low-intensity extracorporeal shockwave therapy (Li-ESWT) involves the transfer of low-intensity acoustic energy (<0.2 MJ/mm^2) to differentiate tissue types, similar to traditional extracorporeal shockwave lithotripsy used for treating urolithiasis. The first study on the use of this method for treating ED was published in 2010 [53]. The authors reported improved hemodynamics in the corpus cavernosum without side effects under the influence of Li-ESWT. Clinical application was preceded by experimental studies showing improved blood flow in soft tissues. Since then, Li-ESWT has been widely used to treat ED, particularly of vascular and neurogenic origins.

Most studies have shown a long-term positive effect of Li-ESWT on erectile function, as confirmed by improvements in the International Index of Erectile Function and the Erection Hardness Scale [54, 55]. Li-ESWT is believed to promote neovascularization, tissue regeneration (including nerve regeneration), and inflammation reduction [56], potentially improving erectile function. However, some researchers have reported only a moderate effect of Li-ESWT on erectile function, noting that treatment efficacy decreases as the severity of ED increases [57–59]. Due to conflicting results and a lack of standardized treatment protocols regarding intensity, frequency, and duration, Li-ESWT remains an experimental approach, requiring further clinical trials and standardization.

Vacuum erectile devices

Vacuum erectile devices are a nonsurgical treatment option for patients with ED. These devices consist of a vacuum cylinder and a local negative pressure pump, which draws blood into the cavernous bodies to induce an erection. The first vacuum pump for enhancing erections was patented in 1917 [60]; however, it was only in 1989 that the Food and Drug Administration in the United States registered it as a medical device for treating ED [61]. Since then, many similar devices have been developed and are used as primary therapy for challenging organic ED. The efficacy of vacuum erection devices has been validated in several experimental and clinical studies [62–64].

SURGICAL TREATMENT OF ERECTILE DYSFUNCTION

Achieving an erection suitable for successful sexual intercourse requires adequate arterial blood flow and a functional venous occlusion mechanism in the cavernous bodies of the penis. Disruptions in blood supply or venous occlusion mechanisms are common causes of ED and can result from conditions such as hypertension, diabetes, atherosclerosis, and dyslipidemia as well as surgical interventions, particularly radical prostatectomy, which can impair penile innervation [65, 66]. Surgical treatment is a viable option for patients with ED caused by arterial insufficiency.

Penile prosthetics

Penile prosthesis implantation has been a surgical option for ED treatment since 1973 [67]. This procedure is typically performed in patients in whom other ED treatments have failed. Various types of implants are continuously improved to make them more reliable, safe, and durable. The three-component inflatable penile implants closely mimic the natural erection process, allowing the penis to become erect and then return to a flaccid state when deactivated. These prostheses are associated with one of the highest patient satisfaction rates among implantable medical devices (85%–90%) [68], and over 90% of patients achieve normal sexual activity following phalloprosthesis [69]. Penile prosthetics have also proven highly effective in patients with ED secondary to Peyronie's disease [70] and those who have undergone radical prostatectomy [71].

CONCLUSION

This review discusses the primary methods of diagnosing and treating vasculogenic ED. Current clinical guidelines recommend Doppler ultrasound of the penile vessels as an instrumental diagnostic method although its recommendation is classified as level C with level 5 evidence) [51]. Other diagnostic tests have yet to be incorporated into clinical guidelines and require further validation of their effectiveness. The interpretation and significance of the NPT test in men with various forms of ED remain unclear.

Effective treatment of ED requires identifying its cause. The vasculogenic form is the most prevalent and is considered a predictor of cardiovascular disease. Consequently, early detection and treatment of ED can not only enhance patients' quality of life but also potentially prevent life-threatening cardiovascular complications.

ADDITIONAL INFORMATION

Authors' contribution. All authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to

be accountable for all aspects of the study. Personal contribution of each author: R.R. Aliev — search and analysis of literary data, writing the text of the manuscript; A.I. Neymark, A.V. Davydov — concept of the study, analysis of literary data, editing the text of the manuscript.

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