Is There a Role for Vascular Surgery in the Contemporary Management of Erectile Dysfunction?

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KEYWORDS

• ED • Bypass • Impotence • Penis • Vascular

KEY POINTS

- Young men with focal vascular disease are thought to benefit most from vascular surgery for erectile dysfunction, although exact criteria have not been agreed upon.
- Current microvascular artery bypass techniques for penile revascularization consist of an anastomosis between the inferior epigastric artery and the dorsal artery or the deep dorsal vein of the penis.
- Venous vascular surgery or embolization procedures for the treatment of veno-occulsive erectile dysfunction are not recommended.

INTRODUCTION

Michal and colleagues[1] reported the first penile microvascular artery bypass surgery (MABS) for erectile dysfunction (ED) in 1973. He and his collaborators directly anastomosed the inferior epigastric artery (IEA) to the corpus cavernosum (Michal I), which resulted in intraoperative erections and excellent flow rates (>100 mL/min). This approach was also associated with close to 100% anastomotic stenosis/thrombosis, and thus the results were not durable. Subsequently, Michal's team anastomosed the IEA with the dorsal penile artery using an end-to-side anastomosis technique in an attempt to improve patency rates. The documented success rate using nonvalidated instruments of this Michal II procedure was 56%.[2]

Eight years later, Virag and colleagues[3] reported 92 cases with 54 MABS using an IEA to deep dorsal vein technique. The goal was to increase penile perfusion in a retrograde fashion. The reported success rate was 49% with an additional 20% of men reporting improvement in ED.[3] This artery-to-vein technique unfortunately also resulted in glans hyperemia in most patients, which was minimized by ligation of the circumflex branches. Furlow and Fisher[4] reported a 62% success rate using an artery-to-vein technique with ligation of the circumflex branches. Hauri[5] continued to modify the penile arterial bypass technique by performing a complicated side-to-side anastomosis between the dorsal artery (DA) and vein covered by a spatulated IEA in an attempt to improve outcomes and satisfaction rates.

In the modern era, penile revascularization procedures are rarely performed for a variety of reasons, principle among them being the availability of safe and efficacious oral therapy for ED. However, in select young, healthy men with vasculogenic ED secondary to arterial insufficiency, MABS has

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the potential to reverse the pathophysiology of ED and restore normal erectile function.

Venous vascular surgery was a common procedure for ED in the 1980s and 1990s. Current guidelines on ED recommend against these procedures owing to poor long-term surgical outcomes. In select patients, venous ligation surgery by an experienced surgeon may be an option.[6]

MICROARTERIAL BYPASS SURGERY
Ideal Surgical Candidate

Patient selection is crucial for optimal outcomes after vascular interventions for ED. In general, young healthy men with focal vascular disease are thought to benefit the most from vascular surgery. In the 2015 International Consultation on Sexual Medicine Report, the authors recommend considering vascular interventions for men younger than 55 years old, with "recently acquired ED from focal arterial occlusive disease in the absence of other risk factors."[7] Although exact criteria have not been agreed upon, we have expanded the patient criteria based on the limited available literature and our institutional experience.[7–10]

1. Age: Trost and colleagues [7]reported that age less than 55 may be a predictor of better outcomes, but also that "data was insufficient to define a specific cut-off point" (Evidence Grade C). However, we believe the ideal candidate should be less than 50 years of age or even younger (<40 years old).
2. Absence of vascular risk factors (diabetes, hypertension, tobacco use, hypercholesterolemia, etc).
3. Absence of neurologic ED (eg, multiple sclerosis, pelvic surgery, lumbosacral radiculopathies).
4. Absence of untreated hormonal abnormalities.
5. Absence of active or significant psychiatric disorders (severe depression, bipolar disease, or schizophrenia) or the use of psychotropic drugs owing to their documented sexual side effects.
6. Absence of Peyronie's disease.
7. Absence of untreated premature ejaculation.
8. Absence of acute or chronic perineal or pelvic trauma.
9. Absence of corporo-occlusive dysfunction by duplex Doppler ultrasound examination and cavernosometry.
10. Focal occlusive disease of the common penile or cavernosal arteries documented by penile duplex Doppler ultrasound examination with

or without cavernosometry and confirmed by selective internal pudendal arteriography.

Vascular Anatomy

The blood supply to the penis is derived mainly from the internal pudendal artery and enters the perineum at the level of Alcock's canal. The internal pudendal artery's 3 terminal branches are the bulbourethral, the scrotal, and the common penile artery, which in turn divides into the dorsal and cavernosal arteries (Fig. 1A). The accessory pudendal arteries frequently provide additional blood to the corpora cavernosa and may play a critical role in men who undergo pelvic surgery.

The IEA is a branch of the external iliac artery and travels cephalad underneath the rectus muscle above the peritoneum ending near the umbilicus (Fig. 2A). It gives several small branches that feed the rectus muscle, which have to be carefully clipped or cauterized using bipolar electrocautery during IEA harvesting. Occasionally, the IEA and the obturator artery have a common trunk. If so, it is advisable to harvest the contralateral IEA if there is no common trunk to avoid a penile artery shunt syndrome in which blood flow preferentially flows to the obturator artery rather than the penile artery (see Fig. 2B).[11]

Hemodynamic Evaluation

Penile duplex Doppler ultrasound examination and dynamic infusion cavernosometry
We recommend a screening penile duplex Doppler ultrasound examination with redosing erectogenic agent if necessary.[12] Peak systolic velocities (PSV) of less than 25 cm/s are considered diagnostic for arterial insufficiency, with velocities between 25 and 30 cm/s considered borderline.[13] Chung and colleagues have reported that PSV are age dependent.[14] Thus, in young patients with a PSV of greater than 25 cm/s, cavernosometry documenting arterial gradients of greater than 20 mm of Hg between the brachial and cavernosal arteries may be helpful to confirm the diagnosis of arterial insufficiency. Ultimately, a pudendal arteriogram may be needed to document focal arterial occlusion.

The penile duplex Doppler ultrasound examination should reveal end-diastolic velocities and resistive index consistent with normal corporo-occlusive function. Teloken and colleagues[15] reported that penile duplex Doppler ultrasound examination has the propensity to inaccurately diagnose venous leak. Thus, in cases of borderline PSV in young men or unclear veno-occlusive function, cavernosometry may be a more accurate assessment for veno-occlusive ED.[15,16] We
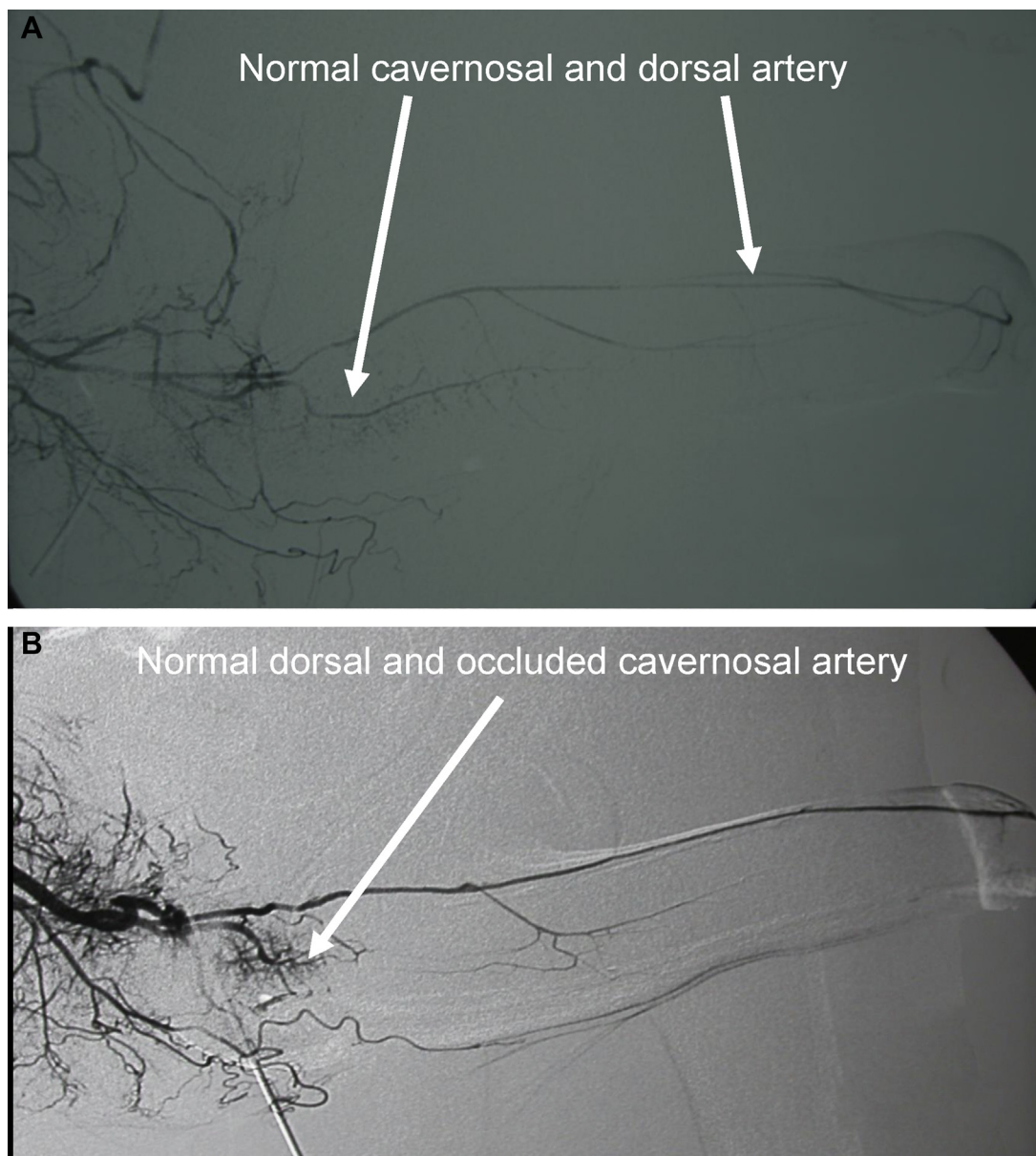
Fig. 1. Selective internal pudendal arteriography documenting patent dorsal artery with perforating cavernosal branch (*A*) and occluded cavernosal artery (*B*).

routinely perform dynamic infusion cavernosometry to further document arterial occlusive disease and normal corporo-occlusive function. Flows to maintain of less than 5 mL/min and pressure decays of less than 45 mm of Hg over 30 seconds effectively rules out the possibility of venous leak.[10]
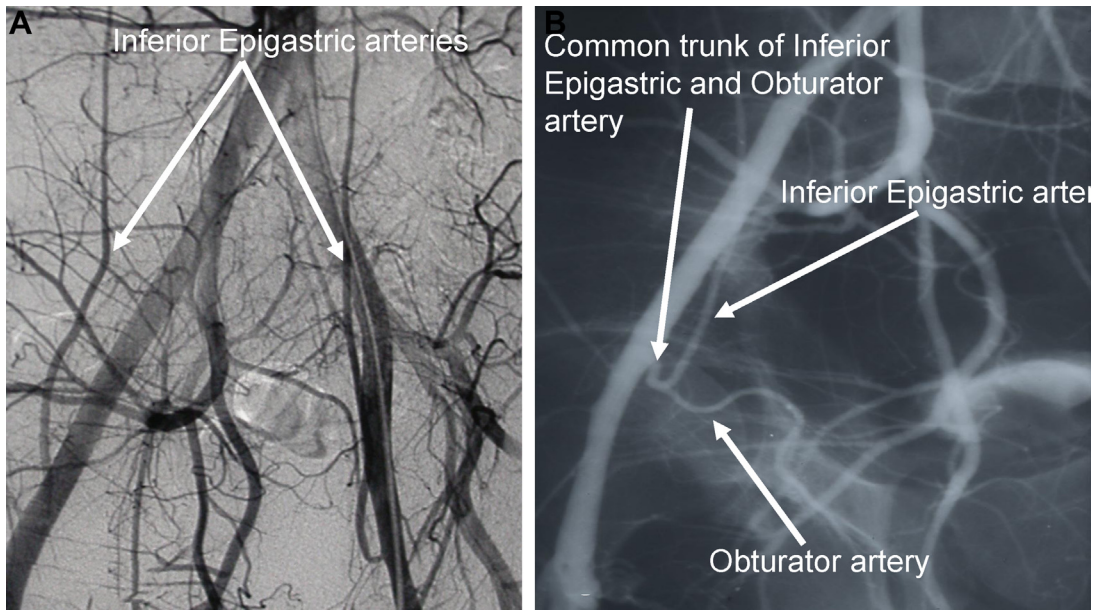
Selective internal pudendal arteriography

Digital subtraction angiography is the gold standard for diagnosing arterial insufficiency. Digital subtraction angiography confirms the presence and location of focal occlusions (see Fig. 1B). Digital subtraction angiography also provides vascular anatomic information on the donor (IEA; see Fig. 2) and recipient vessels (DA; see Fig. 2) (eg, size, length, branches) that is critical for surgical planning.[9,10]

Surgical Technique

Current MABS techniques consist of an anastomosis between the IEA to the DA or the deep dorsal vein of the penis. Although an IEA to deep

Fig. 2. Selective internal pudendal arteriography of the inferior epigastric arteries.

dorsal vein anastomosis is technically easier than IEA to DA, we favor IEA to DA MABS for several reasons. The use of a valvulotome to facilitate flow through the valves of the dorsal vein may cause endothelial injury, which may activate the intrinsic pathway of the clotting system and lead to thrombosis of the anastomosis. An IEA to DA MABS anastomosis also eliminates the possibility of glans hyperemia, a devastating complication.[17–19] Although there are no definitive data regarding the best technique, IEA to DA studies by Munarriz and colleagues[20] (the largest series to date) and Jarow and DeFranzo[21] show superior outcomes to those reported using artery-to-vein techniques.

Dorsal artery dissection
A 4- to 5-cm semilunar scrotal incision 2 finger-breadths below the penoscrotal junction on the opposite side from the planned abdominal incision for IEA harvesting provides excellent surgical exposure. Finger blunt dissection along Buck's fascia toward the glans is carried out and the penis is then inverted. The fundiform ligament is mobilized and preserved to minimize penile shortening. At this point, the selected DA is isolated and mobilized while avoiding injury to the dorsal nerves. The neurovascular bundle is irrigated with papaverine to prevent vasospasm. The scrotal wound is temporarily closed with staples (Fig. 3).

Harvesting of the inferior epigastric artery
Traditionally, open abdominal incisions are used to harvest the IEA. Robot-assisted laparoscopic

harvesting of the IEA has been described and may result in shorter hospitalization times and faster recoveries.[22] If an open procedure is chosen, a 5- to 7-cm transverse incision three-quarters of the distance between the umbilicus and pubis is created with a scalpel (Fig. 4). Dissection is carried down through Scarpa's fascia and the rectus fascia is divided vertically. The rectus muscle is mobilized medially to allow exposure of the IEA, which is mobilized from its origin (the common external iliac artery) to the umbilicus. Papaverine is used to prevent vasospasm during the mobilization of the IEA. The distal end of the IEA is clipped and divided as high as possible.

Inferior epigastric artery transfer
The scrotal staples are removed and blunt dissection between the fundiform ligament and the neurovascular bundle is carried out until the lateral aspect of the pubic tubercle is palpated. At this point, the abdominal fascia is perforated bluntly using a technique similar to that used for the insertion of a penile prosthesis reservoir into the retroperitoneal space. A Schnitt clamp is advanced from the penis into the preperitoneal space where the IEA lies. The distal clip of the IEA is grasped with the clamp and the IEA is transferred to the dorsal aspect of the penis by pulling out the clamp(see Fig. 4). The abdomen is closed in a multilayer fashion using a running technique with 0 polyglycolic acid suture for the rectus fascia, a 2-0 polyglycolic acid suture for Scarpa's fascia, and a 4-0 poliglecaprone suture for the skin.
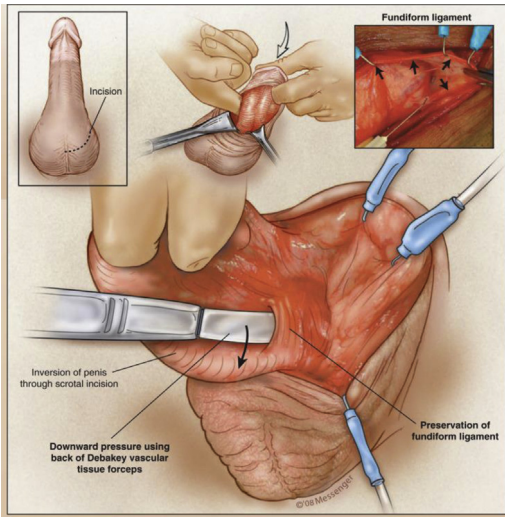
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Fig. 3. Dorsal artery dissection technique.

Microvascular anastomosis

The penis is inverted again and a retractor with surgical hooks is used to accommodate the penis for microsurgery. The operating microscope is brought to the surgical field and the DA is mobilized proximally and divided. The proximal end is cauterized using bipolar electrocautery and aneurysmal clips are placed on the DA and IEA. The adventitia of the distal end of the IEA and proximal end of the DA are sharply excised with microscissors to prevent thrombosis of the anastomosis (see **Fig. 4**). A microsurgical anastomosis is performed using a simple interrupted technique with 10-0 nylon suture (**Figs. 5** and **6**). The aneurysmal clips are removed and blood flow is observed,

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Fig. 4. IEA transfer technique.

documenting anastomotic patency. The penis is placed back on its normal anatomic position and the dartos and skin are reapproximated with 2-0 polyglactin and 4-0 poliglecaprone sutures, respectively. The patency of the anastomosis is confirmed again by Doppler ultrasound examination.

VENOUS VASCULAR SURGERY

The 2018 American Urological Association guideline on ED states that "for men with ED, penile venous surgery is not recommended." This recommendation is derived from poor long-term surgical outcomes.[8] However, in select cases, venous ligation surgery may be beneficial.

Ideal Surgical Candidate

1. Normal cavernous arteries on color duplex Doppler studies and/or cavernosometry. However, there are no definitive data.[10]
2. Abnormal, but limited veno-occlusion dysfunction demonstrated by penile Duplex Doppler ultrasound examination and/or cavernosometry.
3. Localization of the site of venous leakage on pharmacocavernosography to a discrete area of the corporal crura.
4. No medical contraindication to surgery.
5. No vascular risk factors.
6. Highly motivated patient who understands that venous ligation surgery has poor long-term outcomes, but may be effective in select cases.

Surgical Technique

Positioning and surgical approach

Penile degloving using a subcoronal or an inversion technique (**Fig. 6**) are excellent approaches for venous dissection and ligation surgery because they provide access to all important venous channels along the shaft of the penis. The dorsal lithotomy position is preferred if crural banding or ligation is necessary. A combination of blunt and sharp dissection is used to expose the venous system from the glans to the pubic area. Some surgeons dissect and divide the fundiform and suspensory ligaments to maximize vascular exposure to the more proximal deep dorsal penile vein and the cavernosal veins. There are concerns, however, that these maneuvers may result in penile shortening and instability.[20] As a result, we recommend mobilization of the fundiform ligament and reconstruction of the suspensory ligament if divided. In addition, we recommend loupe magnification and the use of bipolar electrocautery to avoid mechanical or thermal injury to the dorsal arteries and nerves.
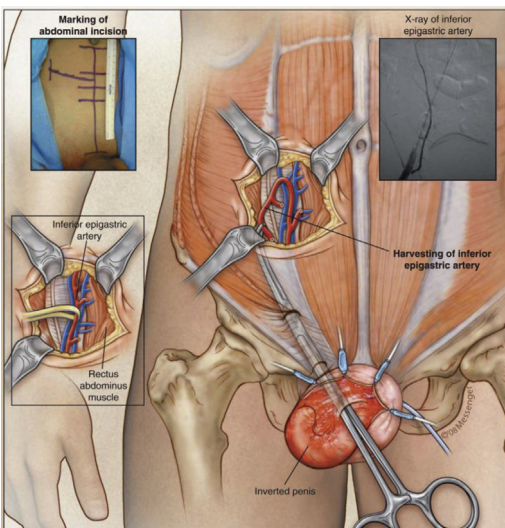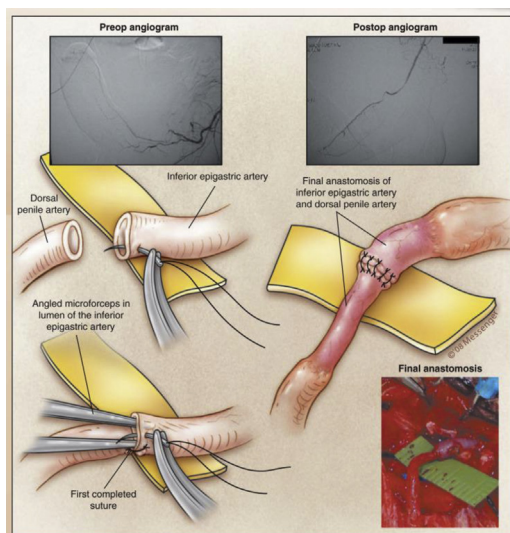
Fig. 5. Inferior epigastric to doral artery anstomosis technique.

Venous vascular ligation

A nonretractable butterfly needle is placed into one of the corpora cavernosa and fixed in place with a purse-string ligature in the tunical albuginea. Indigo carmine or methylene blue is administered to demarcate the vascular system.

Distally, the deep dorsal vein is mobilized and ligated as closed to the glanular sulcus as possible. Along the penile shaft, communicating circumflex veins near the corpora cavernosa and the spongiosum are identified, exposed under Buck's fascia, and ligated.

Communicating veins to the perineal side wall and the pubic regions are isolated and divided to maximize exposure to the deeper venous drainage system. The deep dorsal and cavernosal veins are dissected proximally under the pubic bone and ligated. Communicating veins between the deep and the superficial system are also ligated. We recommend the use of absorbable sutures (2-0 polyglactin) to avoid the patient or partner feeling permanent suture material during sexual activity. Other surgeons have promulgated the use of permanent sutures to ligate the deep dorsal and cavernosal veins under the pubis.

If crural ligation is elected, the crura are identified and carefully isolated from the corpus spongiosum. A right-angle clamp can be used to pass two 5-mm-wide cotton tape ligatures 1 cm apart around the crus (Fig. 7).

A closed suction drain is placed in the infrapubic region and withdrawn through a separate stab wound where it is affixed to the skin. The drain is usually removed in 24 to 48 hours if drainage is minimal. The skin is approximated with reabsorbable suture (chromic 3-0 or 3-0 poliglecaprone) and a loose circumferential elastic dressing is placed to decrease postoperative edema and swelling.
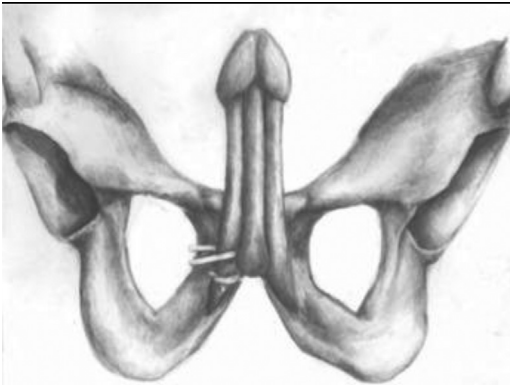
DISCUSSION
MABS Surgical Outcomes

Assessing outcomes after vascular interventions is challenging. Although vascular interventions for ED have been described as early as the 1970s,
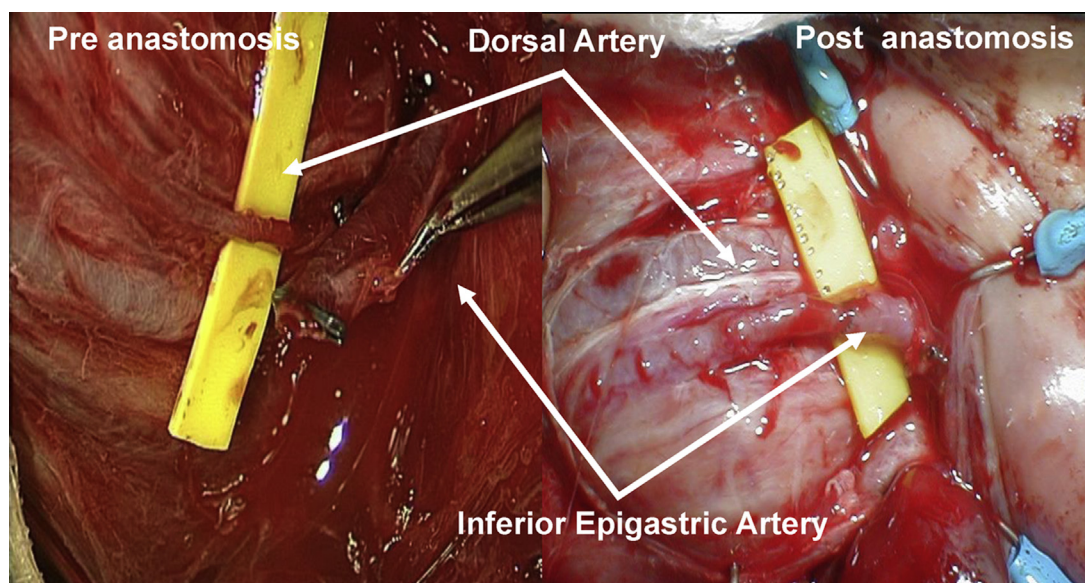
Fig. 6. Photography before and after the anastomosis between the inferior epigastric and dorsal arteries.

Fig. 7. A right-angle clamp can be used to pass two 5-mm-wide cotton tape ligatures 1 cm apart around the crus.

standardized validated questionnaires such as the International Index of Erectile Function (IIEF) were not developed until 1997.[23] Much of the available literature used subjective outcomes like nonvalidated questionnaires, imaging assessments (penile Doppler ultrasound examination, angiogram, nocturnal penile tumescence) or need for phosphodiesterase type 5 inhibitors. These nonstandard measures add to the heterogeneity of the literature, making it difficult to draw conclusions regarding therapeutic efficacy. **Table 1** summarizes most of the available publications and clearly shows a tremendous variation in treatment outcomes.

The American Urologic Association Erectile Dysfunction Guideline Panel attempted to analyze available literature regarding arterial insufficiency by using a defined "index patient"—a healthy man no older than 55 years with recently acquired ED from focal arterial occlusive disease and without other vascular risk factors such as smoking or diabetes. In trying to achieve homogeneity in their approach, the authors found that, at the time of their evaluation, only 4 articles met this definition.[8] The total studied population was 50 men with reported successful outcomes of 36% to 80% for IEA to dorsal vein and 91% for IEA-to-DA MABS, respectively.[21,24–26] **Table 2** summarizes the available studies that met the Erectile Dysfunction Update panel criteria.

Munarriz and colleagues[20] published the largest long-term outcome MABS study to date using validated questionnaires (71 men; aged 30.5 ± 9.2 years; mean follow-up of 34.5 ± 18 months). The mean preoperative and postoperative penile rigidity using analog scale (with and without phosphodiesterase type 5 inhibitors), total IIEF score (35.5 ± 14.8 and 56.2 ± 16.6), and Center for Epidemiologic Studies Depression Scale score (42.0 ± 10.0 33.7 ± 6.1) improved significantly. Treatment satisfaction according to the Erectile Dysfunction Inventory of Treatment Satisfaction scale was high; 62 of the 71 patients (87.3%) stated they would recommend the surgery to someone else[20] (**Table 3**).

The 2015 International Consultation for Sexual Medicine suggested that age less than 55 years may be a predictor of better outcomes, but also that "data was insufficient to define a specific cut-off point (Evidence Grade C)."[6] In our experience, the optimal patient should be 50 years of age or younger.

Munarriz and colleagues[20] evaluated MABS effectiveness by age using IIEF data and divided patients into 4 age groups (18–29, 30–39, 40–49, and 50–59 years) and found statistically significant improvements for all age groups except for the 50- to 59-year-old group, which had only 1 patient Interestingly, 77.46% of patients were younger than 40 years of age.[20]

Other work focusing on older men (>50 years old; mean age, 59.7 years old) has found an approximately 60.5% success rate in men undergoing deep dorsal vein arterialization. This series included carefully selected men without a history of major trauma, diabetes, nicotine use, hyperlipidemia, coronary artery disease, or hypertension. The mean follow-up was 22.1 months and the mean IIEF 15 improved from 19.2 to 25.5 (P<.05).[27]

Microvascular Artery Bypass Surgery Complications

There are few data regarding complications of penile MABS. With few exceptions, most complications (infection, bleeding, fevers, nausea, penile pain, anesthesia problems, etc) are rare (0%–3%) and short term.[20] The exception to this is penile hyperemia, a devastating complication associated with dorsal vein arterialization characterized by severe penile pain, glans vascular congestion, and ulcerations.[17–19]

Complications that are particularly bothersome to patients include decreased penile sensation, loss of penile length, and hernias. Munarriz and colleagues[20] reported that 3 (4%), 17 (24%), and 20 (28%) of 71 patients reported incisional hernias, loss of penile sensation and loss of penile length, respectively. The mean postoperative IIEF Orgasmic Function domain scores documented an improvement in orgasmic function (preoperative 5.71 ± 3.04 and postoperative 7.97 ± 2.58), suggesting that sensation is generally at least partially preserved. Despite these reports, the overall postoperative satisfaction was high and

Table 1
Microarterial bypass surgery outcomes

Study	Year	No. of Patients	Result
Virag	1981	36	41.6% good, 33.3% fair
Michal et al	1986	73	60% success
Balko et al	1986	11	73% significantly improved
Society for Study of Impotence (Belker and Bennett)	1988	50	78% success
Lizza and Zorgniotti	1988	13	77% success
Sharlip	1990	30	20% success, 27% improved
Virag and Bennett	1991	100	38% good, 30% improved
Furlow et al	1990	95	78%
Sohn	1992	65	31% success, 54% good or improved
Bock and Lewis	1992	36	53% success, 28% improved
Löbelenz et al	1992	19	58% success, 40% improved
Schramek et al	1992	35	60% success, 23% improved 54% excellent postoperative Doppler 23% good postoperative Doppler
Melman and Riccardi	1993	18	33% success
Janssen et al	1994	21	62% success, 5% improved
Lizza and Zorgiotti	1994	36 32 26	53% success, 31% improved 41% success, 34% improved 54% success, 19% improved
Jarow and DeFranzo	1996	11	64% success, 27% improved
Benet et al	1997	36	46% success, 14% improved
Mannine et al	1998	62	34% success, 20% improved
Munarriz et al 2009	2009	71	EF domains of IIEF significantly improved Question 3 IIEF significantly improved Question 4 IIEF significantly improved SDS significantly improved CES-D significantly improved Treatment satisfaction significantly improved

Abbreviations: CES-D, Center for Epidemiologic Studies Depression Scale and Treatment Satisfaction; IIEF, International Index of Erectile Function; SDS, Sexual Distress Scale.

Data from Ronald Lewis and Ricardo Munarriz. Vascular Surgery for Erectile dysfunction. Campbell's Urology. Walsh, Retik, Vaughan& Wein. Nine Edition, Chapter 24, 802-817.

87.7% of patients reported they would recommend or undergo surgery again.

Venous vascular surgery outcomes

Venous ligation surgery for ED was very popular in the 1980s and 1990s, but poor long-term success rates resulted in discontinuation of these procedures (**Table 4**).[28–33] The 2018 American Urological Association Guideline on Erectile Dysfunction recommends against penile venous surgery.[8]

Despite the American Urological Association recommendation, a number of studies have suggested that venous vascular surgery may be helpful in very carefully selected patients.[34–36] Rahman and colleagues[34] reported statistically significant improvements in mean IIEF scores (8.9 ± 4.5 and 17.5 ± 5.0) in 11 men who underwent crural ligation for ED and congenital venous leakage. Cayan[35] also reported significant improvement in mean IIEF scores at 1 year postoperatively in patients undergoing resection of the deep and superficial dorsal and the cavernous veins. Flores and colleagues[36] also documented statistically significant improvements in mean IIEF scores (6.7 ± 3.61–16.3 ± 6.4) in men undergoing crural ligation surgery for isolated crural venous leak.

A variety of endovascular procedures to manage veno-occlusive ED have been reported;

Table 2

Microarterial bypass surgery outcomes that met the criteria for the arterial occlusive disease index patient[8]

Investigators	Year	Patients	Outcome (%)	Success Criteria
Grasso et al[26]	1992	22	68 36	NPT Doppler
DePalma et al[25]	1995	11	60	Doppler
Jarow and DeFranzo[21]	1996	11	91	Doppler
Ang and Lim.[24]	1997	6	66	NPT, Doppler
Munarriz et al.[20]	2009	71	Preoperative: 40.03 ± 20.19 and 18.70 ± 12.99 Postoperative: 64.15 ± 23.35 and 32.06 ± 16.48	IIEF overall IIEF EF domain

Abbreviations: Doppler, penile duplex Doppler ultrasound examination; IIEF EF domain, erectile function domain of the IIEF; IIEF, International Index of Erectile Function; NPT, nocturnal tumescence testing.

Data from Ronald Lewis and Ricardo Munarriz. Vascular Surgery for Erectile dysfunction. Campbell's Urology. Walsh, Retik, Vaughan & Wein. Nine Edition, Chapter 24, 802-817.

outcomes seem to be generally similar to surgical series, although there are no head-to-head comparison studies.[37–43]

Venous vascular surgery complications

There are limited data on the frequency of venous vascular complications and how they were managed. The most commonly reported complications include penile pain and numbness, skin necrosis, painful erections, penile curvature, and wound and tape infections[28–33] (**Table 5**).

LIMITATIONS IN STUDIES OF VASCULAR INTERVENTIONS

Although there are data showing a potential benefit of penile arterial revascularization or venous vascular surgery for select patient with vasculogenic ED, the procedures are not mainstream for a number of reasons. The lack of standardization in patient selection, hemodynamic evaluation, surgical technique, and limited long-term outcome data using validated instruments has marginalized these surgical procedures.

With the incidence of obesity, metabolic syndrome, and cardiovascular disease increasing over the past few decades, especially in younger patients, the index patient is becoming rarer.[43] Most men who present with ED are found to have concomitant subclinical cardiovascular disease, of which ED is merely the initial presenting symptom.[44] As such, even young patients may have vascular risk factors such as high blood pressure, high cholesterol, or diabetes. In addition, MABS requires significant microsurgical expertise, a skill not possessed by the majority of those who treat ED. The learning curve would be significant for the surgeon who does not perform microsurgery routinely. The equipment costs associated with microsurgery may also be prohibitive. The procedure takes experienced surgeons approximately 4 hours to complete, and reimbursement does not accurately reflect the complexity of the procedure.

Table 3

Microarterial bypass surgery outcomes using validated questionnaires.[20]

	Preoperatively	Postoperatively
IIEF		
Total score	35.5 ± 14.8	56.2 ± 16.6
EF of IIEF	13.7 ± 6.7	23.8 ± 6.6
Question 3	2.2 ± 1.4	4.1 ± 1.4
Question 4	2.1 ± 1.3	3.9 ± 1.5
SDS	37.7 ± 11.1	17.5 ± 12.5
CES-D	42.0 ± 10.0	33.7 ± 7.1
Edits		72%–81%
Penile rigidity (%)		
Without PDE % inhibitors	41	71
With PDE 5 inhibitors	77	90

Abbreviations: CES, Center for Epidemiologic Studies Depression Scale and Treatment Satisfaction; IIEF EF domain, erectile function domain of the IIEF; IIEF, International Index of Erectile Function; Rigidity, Penile rigidity using analog scale; SDS, Sexual Distress Scale.

Data from Munarriz, R., Uberoi, J., Fantini, G., Martinez, D., and Lee, C. (2009) Microvascular arterial bypass surgery: long-term outcomes using validated instruments. J. Urol. 182(2), 643–648.

Table 4
Penile venous ligation surgery for veno-occlusive ED

Investigator	Mean Age (y)	Technique	Outcome
Sasso et al,[28] 1999 N = 23 Follow-up: 12 mo	41	Superficial DDV Circumflex Emissary	Spontaneous erections at 12 mo: 74% Long term: 55%
Popken et al,[29] 1999 N = 122 Follow-up: 70 mo	49	Superficial DDV Circumflex	Spontaneous erections 14% ICI 9%
Al Assal et al,[30] 1998 N = 325 Follow-up: 1–13 mo	45		Cured <40 years 76% > 40 years 58%
Lukkarinen et al,[31] 1998 N = 21 Follow-up: >12 mo			Good 29% ICI 52%
Basar[33] N = 26 Follow-up: 25 mo			Complete erection 15% Partial erection 23%
Schultheiss[32] N = 147 Follow-up: 6–76 mo	48 ± 11.7	DDV	Complete spontaneous erection 11.2% Postop response to pharmacotherapy 19.0% No satisfactory improvement 69.8%
Rahmal et al,[34] 2005 N = 12	28	Crural ligation	IIEF EF domain 8.9–15.5 9/11 reported significant improvement
Cayan,[35] 2008 N = 24 Follow-up: 1 y	34.6	Superficial DDV Cavernous V Crural ligation	IIEF EF domain 6.7 ± 3.61–16.3 ± 6.4 73% reported some degree of improvement 42.3% reported complete EF improvement 30.8% reported partial improvement
Flores et al,[36] 2011 N = 14 Follow-up: 12 mo	29 ± 7	Crural ligation	Statistical improvement in IIEF EF scores No patients needed intracavernosal therapy 4 of 14 patients needed DE5s.

Abbreviations: Cavernous V, cavernous vein; DDV, deep dorsal vein; IIEF EF domain, erectile function domain of the IIEF; IIEF, International Index of Erectile Function.

From a patient perspective, MABS procedures are invasive and require both an abdominal and scrotal incision, with a recovery time of a few weeks. This time is in addition to complex testing for those pursuing this option, such as dynamic infusion cavernosometry and selective internal pudendal arteriography. For young men with mild ED, an oral medication that provides satisfactory results is obviously much less invasive and potentially more appealing. In the past, cost considerations for the chronic use of phosphodiesterase type 5 inhibitors may have been exorbitant, but cost reductions and the availability of generic and compounded medications have made this less of an issue.[45]

For men who are not responsive to oral therapies for ED, less invasive options like intracavernosal injections may have more appeal. To our knowledge, no formal cost-effectiveness analysis of vascular surgery compared with other treatment modalities for ED has been performed to date, although it has been performed for phosphodiesterase type 5 inhibitors, injections, and penile implants.[46] Despite these considerations, a therapy

Table 5
Venous embolization for veno-occlusive ED

	Age	Technique	Agent	Follow-up (mo)	Outcome (%)
Fernandez et al,[37] 2001 N = 23	63	Transfemoral	Balloon ETOH	22	Complete 26 Patient report
Miwa et al,[38] 2001 N = 10	67	Open DDV canalization	ETOH	32	Complete 50 Patient report
Peskircioglu et al,[39] 2000 N = 32	46	Open DDV canalization	*N*-Butyl cyanoacrylate	25	Complete 69 Patient report
Malossini et al,[40] 1998 N = 17	36	Open DDV canalization	Coils	34	Good 73% Patient report
Rebonato et al,[41] 2014 N = 18	51	US guided DDV canalization	N-butyl cyanoacrylate Coils	13.3 ± 7.5	IIEF End diastolic V

Abbreviations: DDV, deep dorsal vein; US, ultrasound examination.
  Data from Hellstrom JG, Montague DK, Moncada I, Carson C, Minhas S, Faria G, Krishnamurti S. J Sex Med 2010 Jan;7(1 Pt 2):501-23. Implants, mechanical devices, and vascular surgery for erectile dysfunction.

that can reverse ED is appealing for patients and surgeons alike and interest in vascular surgery options for ED is likely to continue.

SUMMARY

The current treatment of ED is aimed at managing the condition but none of the current treatments approved by the US Food and Drug Administration can cure or reverse the pathophysiology of vasculogenic ED. Penile MABS may be the only treatment capable of restoring erectile function without the need for the chronic use of vasoactive medications or placement of a penile prosthesis. Similarly, in select cases, penile venous ligation surgery may beneficial. However, current guidelines do not support penile venous surgery. The lack of standardization in patient selection, hemodynamic evaluation, surgical technique, and limited long-term outcome data using validated instruments has resulted in these surgeries being considered experimental and rarely performed.

CLINICS CARE POINTS

- Young healthy men presenting with suspected vasculogenic ED may benefit from hemodynamic testing (penile duplex Doppler ultrasound examination, cavernosometry and confirmatory selective internal pudendal arteriography).
- Young healthy men with ED secondary to confirmed vascular insufficiency may be considered for penile revascularization procedures.
- Venous vascular surgery or embolization procedures for the treatment of veno-occlusive ED are not recommended. However, these surgeries or procedures may be performed in select cases or in the setting of research studies.
- The lack of standardization in patient selection, hemodynamic evaluation, surgical technique, and deficiency of long-term outcome data using validated instruments has limited the use of these surgeries.

DISCLOSURE

Dr R. Munarriz and M.S. Gross are consultants for Coloplast.

REFERENCES

1. Michal V, Kramar R, Pospichal J, et al. Direct arterial anastomosis to the cavernous body in the treatment of erectile impotence. Czech Rozhledy Chir 1973; 52:587–93.
2. Michal V, Kramer R, Hejhal L. Revascularization procedures of the cavernous bodies. In: Zorgniotti AW,

Ross G, editors. Vasculogenic Impotence: Proceedings of the first International Conference on corpus cavernosum revascularization. Springfield, IL: Charles C Thomas; 1980. p. 239–55.

3. Virag R, Zwang G, Dermange H, et al. Vasculogenic impotence: a review of 92 cases with 54 surgical operations. Vasc Surg 1981;15:9–16.

4. Furlow WL, Fisher J. Deep dorsal vein arterialization: clinical experience with a new technique for penile revascularization. J Urol 1988;139:298A. Abstr. 543.

5. Hauri D. Therapiemoglichkeitem bei der vascular bedingten erectilei n impotenz. Akt Urol 1984;15:350.

6. Burnett AL, Nehra A, Breau RH, et al. Erectile dysfunction: AUA guideline. J Urol 2018;200(3): 633–41.

7. Trost LW, Munarriz R, Wang R, et al. External mechanical devices and vascular surgery for erectile dysfunction. J Sex Med 2016;13(11):1579–617.

8. Montague DK, Jarow JP, Broderick GA, et al. The management of erectile dysfunction: an update. Baltimore: American Urological Association; 2007.

9. Munarriz R, Mulhall J, Goldstein I. Penile arterial reconstruction. In: Graham Jr SD, Keane TE, Glenn JF, editors. Glenn's urologic surgery. 6th edition. Philadelphia: Lippincott Williams & Wilkins; 2004. p. 573–81.

10. Lewis R, Munarriz R. Vascular surgery for erectile dysfunction. Campbell's urology. 9th edition. Saunders, Philadelphia PA: Walsh, Retik, Vaughan & Wein; 2007. p. 802–17. Chapter 24.

11. Pavlinec JG, Hakky TS, Yang C, et al. Penile artery shunt syndrome: a novel cause of erectile dysfunction after penile revascularization surgery. J Sex Med 2014;11(9):2338–41.

12. Mulhall JP, Abdel-Moneim A, Abobakr R, et al. Improving the accuracy of vascular testing in impotent men: correcting hemodynamic alterations using a vasoactive medication re-dosing schedule. J Urol 2001;166(3):923–6.

13. Quam JP, King BF, James EM, et al. Duplex or color Doppler sonographic evaluation of vasculogenic impotence. Am J Roentgenol 1989;153:1141–7.

14. Chung WS, Park YY, Kwon SW. The impact of aging on penile hemodynamics in normal responders to pharmacologic injection: a Doppler sonographic study. J Urol 1997;157:2129–31.

15. Teloken PE, Kelly P, Parker M, et al. The false diagnosis of venous leak: prevalence and predictors. J Sex Med 2011;8(8):2344–9.

16. Vardi Y, Glina S, Mulhall JP, et al. Cavernosometry: is it a dinosaur? J Sex Med 2008;5(4):760–4.

17. Eichmann A, Krähenbühl A, Hauri D. Postoperative hyperemia of the glans penis with ulcers following revascularization surgery for vascular impotence. Dermatology 1992;184(4):291–3.

18. Claes H, Van Poppel H, Baert L. Hypervascularization of the glans penis after a venous leakage and revascularisation procedure: a case report. Acta Urol Belg 1993;61(3):17–9.

19. Wilms G, Oyen R, Claes L, et al. Glans ischemia after penis revascularization: therapeutic embolization. Cardiovasc Intervent Radiol 1990;13(5):304–5.

20. Munarriz R, Uberoi J, Fantini G, et al. Microvascular arterial bypass surgery: long-term outcomes using validated instruments. J Urol 2009;182(2):643–8.

21. Jarow JP, DeFranzo AJ. Long-term results of arterial bypass surgery for impotence secondary to segmental vascular disease. J Urol 1996;156:982.

22. Raynor MC, Davis R, Hellstrom WJG. Robot-assisted vessel harvesting for penile revascularization. J Sex Med 2010;7(1 Pt 1):293–7.

23. Rosen RC, Riley A, Wagner G, et al. The International Index of Erectile Function (IIEF): a multidimensional scale for assessment of erectile dysfunction. Urology 1997;49(6):822–30.

24. Ang LP, Lim PH. Penile revascularisation for vascular impotence. Singapore Med J 1997;38:285.

25. DePalma RG, Olding M, Yu GW, et al. Vascular interventions for impotence: lessons learned. J Vasc Surg 1995;21:576.

26. Grasso M, Lania C, Castelli M, et al. Deep dorsal vein arterialization in vasculogenic impotence: our experience. Arch Ital Urol Nefrol Androl 1992;64:309.

27. Kayigil O, Agras K, Okulu E. Is deep dorsal vein arterialization effective in elderly patients? Int Urol Nephrol 2008;40(1):125–31.

28. Sasso F, Gulino G, Weir J, et al. Patient selection criteria in the surgical treatment of veno-occlusive dysfunction. J Urol 1999;161:1145–7.

29. Popken G, Katzenwadel A, Wetterauer U. Long-term results of dorsal penile vein ligation for symptomatic treatment of erectile dysfunction. Andrologia 1999; 31(Suppl. 1):77–82.

30. Al Assal F, Delgado A, Al Assal R. Venous surgery for veno-occlusive dysfunction. Long-term results. Int J Impot Res 1998;10S:31.

31. Lukkarinen O, Tonttila P, Hellstrom P, et al. Non-prosthetic surgery in the treatment of erectile dysfunction. A retrospective study of 45 impotent patients in the University of Oulu. Scand J Urol Nephrol 1998;32:42–6.

32. Basar MM, Atan A, Yildiz M. Long-term results of venous ligation in patients with veno-occlusive dysfunction. Int J Impot Res 1998;10S:21.

33. Schultheiss D, Truss MC, Becker AJ, et al. Long-term results following dorsal penile vein ligation in 126 patients with veno-occlusive dysfunction. Int J Impot Res 1997;9:205–9.

34. Rahman NU, Dean RC, Carrion R, et al. Crural ligation for primary erectile dysfunction: a case series. J Urol 2005;173(6):2064–6.

35. Cayan S. Primary penile venous leakage surgery with crural ligation in men with erectile dysfunction. J Urol 2008;180(3):1056–9.

36. Flores S, Tal R, O'Brien K, et al. Outcomes of crural ligation surgery for isolated crural venous leak. J Sex Med 2011;8:3495–9.

37. Fernández Arjona M, Oteros R, Zarca M, et al. Percutaneous embolization for erectile dysfunction due to venous leakage: prognostic factors for a good therapeutic result. Eur Urol 2001;39:15–9.

38. Miwa Y, Shioyama R, Itou Y, et al. Pelvic venoablation with ethanol for the treatment of erectile dysfunction due to veno-occlusive dysfunction. Urology 2001;58:76–9.

39. Peskircioglu L, Tekin I, Boyvat F, et al. Embolization of the deep dorsal vein for the treatment of erectile impotence due to veno-occlusive dysfunction. J Urol 2000;163:472–5.

40. Malossini G, Ficarra V, Cavalleri S, et al. Long-term results of the veno-occlusive percutaneous treatment of erectile disorders of venous origin. Arch Ital Androl 1998;70:203–9.

41. Rebonato A, Auci A, Sanguinetti F, et al. Embolization of the periprostatic venous plexus for erectile dysfunction resulting from venous leakage. J Vasc Interv Radiol 2014;25(6):866–72.

42. Hellstrom JG, Montague DK, Moncada I, et al. Implants, mechanical devices, and vascular surgery for erectile dysfunction. J Sex Med 2010;7(1 Pt 2):501–23.

43. Andersson C. Vasan RS. Epidemiology of cardiovascular disease in young individuals. Nat Rev Cardiol 2018;15(4):230–40.

44. Osundu CU, Vo B, Oni ET, et al. The relationship of erectile dysfunction and subclinical cardiovascular disease: a systematic review and meta-analysis. Vasc Med 2018;23(1):9–20.

45. Mishra K, Bukavina L, Mahran A, et al. Variability in prices for erectile dysfunction medications-are all pharmacies the same? J Sex Med 2018;15(12):1785–91.

46. Rezaee ME, Ward CE, Brandes ER, et al. A review of economic evaluations of erectile dysfunction therapies. Sex Med Rev 2020;8(3):497–503.