# The Role of Computerized Tomography Angiography in the Management of Cases with Erectile Dysfunction with Penile Revascularization

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## Abstract

# Background

In this study, the place and efficiency of computerized tomography angiography(CTA) in the postoperative management of patients with penile revascularization were evaluated.

# Methods

Between 2014–2018, penile revascularization surgery was performed to 78 patients who applied with the complaint of erectile dysfunction(ED). The mean age of the patients was 47.17 ± 13.26(23–69). Patients with a regular sexual partner and relationship, who didn't benefit from medical treatment and who had erectile dysfunction for at least three months were included in this study. The cases were divided into three groups (20–40, 41–60, > 61) according to their age. All cases were evaluated preoperatively by International Index Of Erectile Dsysfunction(IIEF)5–15, Cavernosometry, Corpus Cavernosum Electromyography (CC-EMG), Penil Color Doppler Ultrasonography(PCDU). In the postoperative 3rd month, IIEF 5–15 test was applied and the anostomosis patency was evaluated with CTA.

# Results

In the postoperative 3rd month CTA, 56 patients had an open anostomosis. In 22 cases, the anostomosis area could not be observed. In patients with open anostomosis, the rate of IIEF-5 increasein the postoperative periodwas between 35,0% and 80,8%. In patients without anostomotic patency, the increase rates of IIEF-5 were between 12,5% and 23,3%. Increases in the IIEF 5–15 questionnaire were found to be significantly higher in patients with anostomotic opening in the CTA compared to patients without anostomotic opening.

# Conclusion

CTA results and changes in IIEF rates after penile revascularization show a great correlation. Evaluating the patency of the anostomosis with CTA may guide the timing of more invasive procedures such as penile prosthesis implantation.


## Background

Erectile dysfunction can be defined as inability to achieve and/or maintain erection for satisfactory sexual performance [1]. There is an increase in the global prevalence of ED. According to the Massachusetts Male Aging Study data, ED is seen at varying degrees in more than 52% of men aged 40 to 70 [2]. It has been reported that in more than 70% of cases without endocrine or neurological disorders, ED has an organic origin and is caused by hemodynamic factors and arterial or venous insufficiency. In

cases where an organic etiology is suspected, the penile anatomy, physiology, and hemodynamics should be well evaluated. ED is assessed using methods such as penile color doppler ultrasonography, dynamic pharmacocavernosometry, selective pudendal pharmacovigilance, nocturnal penile tumescence test, and corpus cavernosum electromyography[3, 4]. CTA is a rapid, non-invasive imaging technique used to diagnose vascular diseases, to show the relationship between non-vascular diseases and vascular structures, and to reveal vascular anatomy; thus, this method can be useful in identifying patients who require endovascular treatment. Various publications report that CTA is an effective and reliable method for the diagnosis and treatment of priapism, arterial injury, and erectile dysfunction, as well as detecting venous leakage in venous erectile dysfunction [5–8]. In the current study, CTA with intracavernous contrast material was performed after penile revascularization surgery. This allowed the investigation of not only the correlation between CTA findings and IIEF scoring but also the usability of CTA as a non-invasive method in evaluating the penile anatomy and vascular structures in patients that had undergone penile revascularization surgery.

# Methods

Penile revascularization surgery was performed on 78 patients with ED of organic origin between June 2014 and September 2018. The mean age of the patients was 47.17 ± 13.26 (23–69). The patients were divided into three age groups: Group 1 (20–40), Group 2 (41–60), and Group 3 (> 60). The personal information and medical history obtained from the patients revealed diabetes in 15 cases, smoking in 18 cases, hyperlipidemia in 11 cases, and cardiovascular disease in 9 cases. In addition, the body mass index of 9 cases was greater than 26. The inclusion criteria were having had ED for a minimum of 3 months, having a regular sexual partner, not benefitting from medical treatment, and having ED of a non-psychogenic origin. After obtaining the detailed anamnesis of the patients, their complete blood count, fasting blood glucose, lipid profile, luteinizing hormone, testosterone and prolactin levels were determined and the blood pressure values were measured. In preoperative PCDU, cases with peak systolic velocity (PSV) value less than 25 cm/s and/or end diastolic velocity (EDV) value higher than 5 cm/s were evaluated together with cavernosometry and CC-EMG tests, and then arterial and/or venous insufficiency distinction was made. In addition, the diameters and flow velocities of the inferior epigastric arter (IEA) were evaluated to determine the appropriate side for anastomosis. All the cases were also assessed using the IIEF-5, IIEF-15 and IIEF-erectile function domain scores preoperatively and at the postoperative 3rd month. In addition, at the postoperative 3rd month, CTA with intravenous contrast material was performed 10 minutes after the intracavernous injection of 60 mg papaverine and the blood level in the anastomotic region, deep dorsal vein, and cavernosal vascular structures were examined (Fig. 1). The study protocol was approved by the Local Ethics Committee, and all patients signed an informed-consent agreement. Moreover, the patients were asked to give consent for their photographs to be taken during surgery.

PCDU (B-K Medical, Herlev, Denmark) was performed with an 8 MHz linear probe to diagnose arterial or veno-occlusive pathology. Before the test, papaverine hydrochloride (60 mg) was injected into one of the

cavernosal bodies. After 20 min, systolic arterial flow of < 25 cm/s or enddiastolic flow of > 5 cm/s was interpreted as arterial insufficiency or veno-occlusive dysfunction, respectively.

For preoperative CC-EMG evaluation, the cavernosal electrical activity (CEA) of the penis was measured with a high-speed electromyography module (Medical Measurement Systems, Enschede, the Netherlands) connected to a computer. The sampling frequencies were 200 Hz and band-pass filters with threshold frequencies of 0.1–20 Hz were used. CEA recordings were obtained using coaxial needle electrodes during the flaccid state of the penis, and a ground electrode was placed on the patient's foot to prevent electrical noise. CEA recordings were carried out for 10 min and cavernosal electrical potentials were recorded. The amplitudes of the potentials were marked peak to peak. After 10 min, 60 mg papaverine hydrochloride was injected into one of the cavernosal bodies to exclude the possible presence of a discoordination pattern (the presence of an increase or no change in CEA after papaverine injection) in CC-EMG recordings, which is suggestive of neurogenic ED. Patients with a discoordination pattern were not included in the study.

After 10-min CC-EMG evaluations, cavernosometry was performed with the same device. Caverno-occlusive dysfunction was suspected based on two criteria:

1. An erection maintenance flow rate of > 5 mL/min at an intracavernosal pressure of 150 mmHg; 2. A decrease in intracavernosal pressure from 150 mmHg of more than 45 mmHg 30 s after stopping infusion.

Before surgery, all the men signed an informed consent form in which detailed information about the revascularization operation was given. In operations, using the Furlow–Fisher modification of the Virag–V procedure [9, 10]. Unlike with the Furlow– Fisher procedure, the circumflex collaterals were preserved and the deep dorsal venous valves were not disrupted by a stripper. Four to six emissary veins were identified and preserved. The whole dissection was performed under optical magnification (×2.5) to prevent arterial or nervous injuries.

The inferior epigastric artery was brought to the penile root through a subcutaneous tunnel. And end-to-side anastomosis was made between the IEA and the proximal part of the deep dorsal vein. Interrupted sutures of 7 – 0 polypropylene were used according to a standard microsurgical technique. After the anastomosis, the deep dorsal vein was ligated proximal to the arteriovenous anastomosis. The patients received postoperative intravenous heparin (5000 IU/day) for 72 h, after which they were put on daily dipyridamole 75 mg and acetylsalicylic acid 300 mg for 3 months, and coitus was allowed 2 months after surgery.

# Analysis of outcomes and statistics

All the patients completed a 15-item IIEF questionnaire preoperatively and during the postoperative follow-up. In addition, the results of the IIEF-5 and EF domain scores were recorded preoperatively and postoperatively. All the statistical analyses were performed using SPSS software for Windows (version

21.0, SPSS Inc, Chicago, Illinois, USA). A p value of ≤ 0.05 was considered to be statistically significant. Continuous data was expressed as mean ± standard deviation (SD). A student's t-test was used for the comparison of the averages and a chi-square Fischer test was undertaken to compare the categorical variables. The categorical data was expressed as values and percentages. P < 0.05 was considered as statistically significant.

# Results

Penile revascularization surgery was performed on 31 patients in Group 1, 28 in Group 2, and 19 in Group 3. These cases were evaluated using PCDU, CC-EMG, and cavernosometry tests and classified according to the etiology of ED. There were 42 cases of arterial insufficiency, 17 cases of venous insufficiency, and 19 cases of both arterial and venous insufficiency. In preoperative PCDU, the mean PSV values was found for the right and left cavernosal arteries, respectively, 13,41/14,16 cm/s in patients with arteriel insufficiency, 38,42/41,20 cm/s in patients with venous insufficiency, 16,33/15,84 cm/s in patients with mixed insufficiency. In preoperative PCDU, the mean EDV values was found for the right and left cavernosal arteries, respectively, 3,41/2,16 cm/s in patients with arteriel insufficiency, 8,50/9,35 cm/s in patients with venous insufficiency, 7,65/8,33 cm/s in patients with mixed insufficiency. Veno-occlusive dysfunction was detected in 17 cases in cavernosomotry performed after complete compression of cavernosal smooth muscles after intracavernosal papaverine injection in CC-EMG. Based on the preoperative IIEF-5 scores, 2 patient had mild ED, 6 had mild to moderate ED, 22 had moderate ED, and 48 had severe ED (Table 1).

Table 1
Classification of the degree of ED according to the patients' preoperative IIEF-5 scores.

| IIEF-5 | 20–39 year | 40–59 year | > 60 year |
|---|---|---|---|
| No ED (22–25) | 0 | 0 | 0 |
| Mild ED (17–21) | 0 | 2 (%2,56) | 0 |
| Mild&Moderate ED (12–16) | 2 (%2,56) | 4 (%5,12) | 0 |
| Moderate ED (8–11) | 7 (%8,97) | 10 (%12,8) | 5 (%6,41) |
| Severe ED (5–7) | 11 (%14,1) | 20 (%25,6) | 17 (%21,79) |

In the patients for whom the anastomotic region and the deep dorsal vein were visualized in the CTA, the IIEF-5 / IIEF-15 scores were calculated as 8.66 / 19.77 in Group 1, 9.46 / 21.15 in Group 2, and 4.0 / 12.66 in Group 3 in the preoperative period and as 15.66 / 38.33, 17.23 / 39.46, and 5.40 / 17.33 in Groups 1, 2, and 3, respectively in the postoperative period. The rate of increase in the IIEF-5 score was 80.8% in Group 1, 82.1% in Group 2, and 35.0% in Group 3. Concerning the IIEF-15 scores, there was an increase of 93.8% for Group 1, 86.5% for Group 2, and 36.8% for Group 3.

In the patients with no CTA visualization of the anastomotic region and the deep dorsal vein, the IIEF-5 / IIEF-15 scores were 6.0 / 21.0 in Group 1, 9.50 / 22.25 in Group 2, and 4.80 / 11,60 in Group 3 preoperatively, and 7.40 / 26.0 in Group 1, 12.0 / 27.75 in Group 2, and 5.40 / 12.80 in Group 3 postoperatively. The rate of increase in the IIEF-5 score was 23.3% in Group 1, 26.3% in Group 2, and 12.5% in Group 3. The IIEF-15 score increased by 23.8% for Group 1, 24.7% for Group 2, and 10.3% for Group 3 (Table 2). The preoperative total IIEF-EF domain scores were calculated as 6.4, 4.8, and 5.9 in Groups 1, 2, and 3, respectively. For the patients with and without the visualization of the anastomotic opening in the postoperative final follow-up CTA, the total IIEF-EF domain scores were 18.16 in Group 1, 21.13 in Group 2, and 8.65 in Group 3 and 9.35 in Group 1, 13.6 in Group 2, and 6.62 in Group 3, respectively. Although anastomosis line was followed in a total of 8 cases, sufficient IIEF increase was not observed. However in these cases were not rushed for penile prosthesis implantation. In 4 of these cases, IIEF values gradually increased between 6–12 months postoperatively. In four cases, there was no expected benefit.

Table 2
The changes in the preoperative and postoperative IIEF scores revealing significantly higher scores in the patients with the visualization of the anastomotic opening compared to those for whom CTA did not show this structure.

| | **Anostomosis open (n = 56)** | **Anostomosis not open (n = 22)** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Preop. Postop. IIEF 5/15** | **Preop. Postop. IIEF 5/15** | **P Value*** | **IIEF 5/15 IIEF5/15 rate of increase** | **IIEF 5/15 IIEF 5/15 rate of increase** | | |
| Group 1 (20–39 year) | 8,66/19,77 | 15,66/38,33 | %80,8/%93,8 | 6,0/21,0 | 7,4/26,0 | %23,3/%23,8 | < 0.05 |
| Group 2 (40–59 year) | 9,46/21,15 | 17,23/39,46 | %82,1/%86,5 | 9,5/22,25 | 12,0/27,75 | %26,3/%24,7 | < 0.05 |
| Group 3 (> 60 year) | 4,0 / 12,66 | 5,4 / 17,33 | %35,0/%36,8 | 4,8/11,60 | 5,4/12,80 | %12,5/%10,3 | < 0.05 |

# Discussion

In cases where oral pharmacotherapy and intracavernosal injections are not effective in ED treatment, penile revascularization can be performed as a third-line treatment [11]. Surgical modifications can be summarized as modifications of anastomoses between the IEA and the dorsal penile artery or the deep dorsal vein, direct anastomosis to cavernous bodies, or end-to-end (triple-stapled) anastomosis between the IEA, the dorsal artery and the vein [12–14]. Recently, laparoscopic and robot-assisted revascularization techniques have been also applied, but in these studies, the number of patients was low and surgical experience was not sufficient to generalize the outcome to a wider population [15, 16].

The aim of penile revascularization surgery is to raise the amount of blood to the cavernous bodies to increase oxygenation, maintain smooth muscle structure and achieve spontaneous physiological erection. The first study on penile revascularization was published in 1972 by Michal et al. [17]. Later, Goldstein reported 80% success rate with the same method in younger patients with ED secondary to pelvic trauma accompanied by localized obstruction of the internal pudendal or penile arteries [18]. Virag et al. performed an aortic anastomosis between the IEA and the deep dorsal vein and reported normal erection in 49% of the patients and improved erection in 20% [19]. The results of long-term follow-up studies performed over the last three decades using different techniques reported that success rates have varied from 25 to 80% [20–28]. In a study of a large case series with a long follow-up period, Kayigil et al. reported high success rates for penile revascularization in patients with no risk factors [29].

In the current study, an end-to-side anastomosis was performed between the IEA and the deep dorsal vein of the penis. This directed the arterial flow in the deep dorsal vein into the cavernous bodies through emissary veins and aimed to improve erectile function by increasing tissue oxygenation. Penile revascularization surgery does not produce the same result in all patients with ED caused by vascular insufficiency. For successful outcomes, the anastomosis established to increase the blood flow to the cavernous tissue should be maintained in the postoperative period. In a study that used selective pudendal angiography to assess the anastomotic opening in cases that had undergone penile revascularization surgery, no association was reported between anastomotic specificity and the subjective patient satisfaction [30]. However, in that study, arterio-arterial anastomosis was used and the selected imaging technique was highly invasive and had a high complication rate. To evaluate the patients with ED prior to the revascularization procedure magnetic resonance angiography (MRA) and penile angiography were compared and the latter was reported to be superior. However, this method is invasive and expensive, and has the disadvantages of requiring follow-up after surgery. In the same study, proximal iliac and pudendal arteries were reliably shown with MRA but the visualization of the distal pudendal and penile arteries was limited. This was attributed to artifacts due to bowel movements and the limited spectral resolution [31].

In the present study, CTA was performed at the postoperative 3rd month to determine the anastomotic opening. Offering excellent anatomical detail by imaging at all angles, this technique allows for the easy identification of patients that require endovascular treatment. CTA is a fast and non-invasive imaging method for defining vascular diseases and demonstrating the vascular anatomy and the relationship between non-vascular diseases and vascular structures. Contrary to conventional angiography, CTA can be performed with the peripheral intravenous injection of contrast agents (generally into the brachial artery) and has been defined as a first-choice imaging technique for the diagnosis of vascular diseases. This technique can also be used to follow-up previously diagnosed cases in terms of anastomotic opening as described in this paper. The brevity of the imaging period and the patient follow-up after the procedure lasting only minutes are important advantages of CTA over MRA, particularly for patients with claustrophobia. Considering the long duration of MRA and the possibility of artifacts in images due to the patient’s movements, CTA presents as a more favorable method. We consider that the detailed imaging of

vascular and other anatomical structures with CTA can be attributed to the vasodilating effect of papaverine administered before the procedure.

CTA has been very interesting in the diagnosis of conditions such as developmantal vascular anomalies and atherosclerozis [32–34]. Characteristic findings are of great importance in evaluating the severity of disease and in evaluating the response the treatment [35]. In a study on the use of CTA in patients with ED, the internal pudendal artery, a branch of the internal iliac artery providing penile erection, was assessed in terms of its anatomical variations and effect on the age of developing ED. According to the results, it was found that variations of the internal pudendal artery were seen in about 50% of patients and is considered to play a role as a congenital factor, especially in the early etiology of ED. It was also reported that ED might develop approximately 10 years earlier in patients with bilateral anatomic variations compared to those with a normal bilateral anatomy [36]. Beijer et al suggested that angiography should be considered as the gold standart in detailed imaging of arterial diseases and that CTA can be used as a first-line method in patients with arterial disease [37]. In a study in which 73 patients were evaluated, CTA was stated as a promising and effective method in the diagnosis of erectile dysfunction of vascular origin [6]. In another study, it was emphasized that CTA is a reliable method in the diagnosis of venous erectile dysfunction, showing the exact location of venous leakage in clinical examination, with clearer images, lower contrast agent and radiation dose, and the advantages of faster examination than X-ray penile angiography [8]. In the literature, there is no study reporting CTA being performed to demonstrate vascular structures and anastomotic opening after penile revascularization. We consider that the current study provides a better understanding of the efficacy of penile revascularization surgery in the treatment of ED and contributes to this surgical technique. In the current study, the IEA, deep dorsal vein and anastomotic region were better evaluated in the postoperative CTA with the papaverine injection. The statistical analyses revealed that in patients with the visualization of the deep dorsal vein, the increase in IIEF and patient satisfaction were significantly higher. The patients with an insufficient increase in IIEF but no visualization of the anastomosis opening were recommended for a penile prosthesis implantation. However, in cases with a visible anastomotic opening in CTA despite an insufficient increase in IIEF, prosthetic implantation was not immediately recommended and it was considered more appropriate to continue the treatment with phosphodiesterase 5 inhibitors for a certain period.

As in all other techniques, the most reliable way of performing a CTA evaluation with the correct indications is to understand the positive and negative aspects of the method and its technical capacity, and applying it in cases where it will provide information that will influence the diagnosis and treatment protocol of the patient. Despite providing more information about the anatomical details, CTA has certain disadvantages due to the use of contrast materials and exposure to radiation. However, with the advances in technology, CTA devices now have a higher scanning capacity and require a shorter time for imaging; thus, the duration of exposure to radiation has been minimized.

# Conclusion

In ED cases, penile revascularization surgery can be performed before invasive procedures such as penile prosthesis implantation. The scoring systems used to demonstrate the effectiveness of this surgery in the postoperative period are mostly subjective. Therefore, the similarity of the findings obtained from contrasted CTA with the IIEF scores has shown that CTA is an objective method to identify the success of the surgery and follow-up patients in the postoperative period. It has been observed that CTA can be used as a pre-evaluation before implantation in prosthesis candidates who do not benefit from other treatment options, especially at younger ages. We believe that further studies with a larger case series will shed more light on the effectiveness and advantages of CTA.

# Abbreviations

CTA: Computerized Tomography Angiography, ED:Erectile Dysfunction, IIEF:International Index Of Erectile Dsysfunction, CC-EMG:Corpus Cavernosum Electromyography, PCDU:Penil Color Doppler Ultrasonography, PSV:Peak systolic velocity, EDV:End Diastolic Velocity, IEA; Inferior Epigastric Arter, CEA:Cavernosal Electrical Activity, MRA:Magnetic Resonance Angiography

# Declarations

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# Figures

### Figure 1

A postoperative CTA image of the inferior epigastric artery, the anastomotic line, and the arterialized deep dorsal vein and its branch