Symposium

Techniques for microsurgical reconstruction of obstructive azoospermia

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ABSTRACT

About 10%–15% of infertile men present with azoospermia, and ductal obstruction is the cause in 40% of them. For about 25–30 years, microsurgical reconstruction was the only way to manage obstructive azoospermia, and several innovative techniques have been developed and implemented. Presently, assisted reproductive technologies (ART) are available for these men as an alternative to surgery. Clinicians who treat these men must be familiar with all of these options, and many of the ART techniques have been covered in other sections of this symposium. However, the present article focuses on vasovasostomies and vasoepididymostomies. The intent of this review is to critique these microsurgical procedures, and present some surgical "pearls" related to them.

Key words: Obstructive azoospermia, vasovasostomy, vasoepididymostomy

INTRODUCTION

The EUA Guidelines on Male Infertility defined obstructive azoospermia as absence of both spermatozoa and spermatogenic cells in semen and postejaculate urine due to bilateral obstruction of the seminal ducts.[1] The Male Infertility Best Practice Policy Committee of the American Urologic Association reported that 10%–15% of infertile men present with azoospermia, and that ductal obstruction is the cause in about 40% of these men.[2] Prior to 1985, surgery was the only treatment for the obstruction, and several innovative microsurgical procedures were developed to correct these problems. The intent of this review is to critique these microsurgical procedures, and present some surgical "pearls" related to them.

However, before embarking on a discussion of the microsurgical procedures, it is important to recognize that assisted reproductive technologies (ART) offer other treatment options for these men. Sperm may be obtained by percutaneous testis biopsies and epididymal aspirations with local anesthesia[3] and used for in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI). In cases of obstruction, the sperm may be acquired either in the IVF center or other locations and transported in protective fluids.[4] In some cases, the sperm may be cryopreserved for use at a later date.[5] Therefore, the clinicians who manage these men must be familiar with these procedures. Some of these procedures have been described in other sections of this symposium, but the readers are encouraged to review.[4–6]

In some of these cases, the men with obstructive azoospermia may be diagnosed with bilateral congenital absence of the vas deferens or ejaculatory duct obstruction (EDO), but this article focuses on microsurgical aspects of vasovasostomies (VVs) and vasoepididymostomies (VEs).

VASOVASOSTOMY

At the beginning of the 20th century, the first VVs were performed with stents for men who were seeking vasectomy reversals and several stented procedures were described using wire, suture, silicone, and dissolvable material.[6] These stents were relatively large, and they presented a risk of leakage at the points of entry and exit in the vas wall. Nevertheless, some results reported a patency rate of 72%–82% and a pregnancy rate of 40%–45%, but these results were not confirmed in surveys completed by other urologists.[7-8]

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The enthusiasm for these stented procedures shifted after magnifying loupes were introduced to provide better visualization.[9] With magnification, the closures were completed by 3–6 small full-thickness sutures (7-0) through the mucosa and muscular vas wall. Several additional muscularis sutures were used for support. The patency rates increased to 80%–90%,[10] but some clinicians claimed similar results simply by careful suture placement without magnification.[11] Schmidt,[12] an early advocate of optical aids, presented the case for simplicity. He stated, "A simple end-to-end, mucosa-to-mucosa anastomosis performed with nonabsorbable monofilament sutures is, in the author's opinion, the best procedure." Most clinicians continued to use full-thickness closures, but the field changed dramatically when Silber[13] and Owen[14] introduced an operating microscope and a 2-layer closure for VVs.

The vas mucosa was reapproximated with 6–8, 10-0 sutures and the muscularis was closed with 9-12 and 9-0 sutures. These methods provided a water tight seal, and the reported patency rates were 92% with pregnancy rates of 58%, but some investigators continued to perform a modified full-thickness closure with the operating microscope and achieved similar results with the 2-layer procedures.[15] Nevertheless, Belker[16] and Silber and Grotjan[17] agreed that experience with a 2-layer closure could help clinicians develop the necessary skills needed to perform the more demanding VEs, and manage closures of luminal openings with different diameters. However, it was still unclear when to perform a VV or a VE.

DETERMINING THE NEED FOR A "VASOEPIDIDYMOSTOMY"

The Vasovasostomy Study Group evaluated the intraoperative vas fluid in all of their patients, and they classified the fluid into 5 groups.[18] In groups 1–4, the fluid was mostly clear and contained sperm or sperm parts. In group 5, the fluid was creamy and had no sperm. Among those with clear fluid and motile intravasal sperm, the patency rate after a VV was 94%, compared with 60% for men with no intravasal sperm, and these evaluations helped the surgeon decide between a VV or a VE. However, Sharlip[19] performed a study on patients with bilateral intravasal azoospermia, and suggested that a VV could be successful in men even with a creamy fluid so long as the obstructive interval was <12 years. The Practice Committee of the American Society for Reproductive Medicine[20] had more specific recommendations. They stated that a VE should be considered when the fluid is like toothpaste or when there was no luminal fluid, but they recommended that the surgeon carefully examine the epididymis for tubular dilatation and consider the interval of obstruction before committing to a VE. Although these recommendations were more specific, there is still some debate on the matter.

Bolduc *et al*.[21] presented a retrospective experience with 747 VVs. In all of these cases, the vas fluid findings were recorded, but regardless of the findings, only single-layer VVs were performed. The overall patency rate was 88% and the pregnancy rate was 53%. No VEs were offered even in cases with an intraoperative finding of thick creamy vas fluid and no sperm. In a separate report, Chawla *et al*.[22] challenged that approach and reported that 48% of men may have an epididymal obstruction on one or both sides at the time of an initial VV. They acknowledged that it was not unusual in their community for surgeons to initially perform a VV for vasal obstruction, and if the procedure failed, then the patients were referred to a center with more experience. They concluded that a VE at the time of the first procedure could avoid a second operation and reduce the time needed to obtain the return of sperm to the ejaculate, especially for women older than 30 years. They recommended that all surgeons performing vasectomy reversals should be able to offer a VE. Some of the history and current details of VE surgery are reviewed in the next section.

VASOEPIDIDYMOSTOMY (END-TO-END AND END-TO-SIDE)

Surprisingly, VEs were performed before VVs[23] and the first successful VEs were "fistula techniques."[24] The surgeons intentionally cut an epididymal tubule and then covered it with a portion of the vas deferens that had a linear cut through the muscularis and lumen. These "fistula" procedures were done first in dogs and then on men with a patency rate of 64% and a pregnancy rate of 27%.

These techniques had limited success in clinical practice until Silber[25] reported a specific tubule anastomosis. The epididymis was transected at a right angle, and the end tubule was identified because it continued to leak sperm-containing fluid. This tubule and the vas lumen were anastomosed, "end-to-end" with 10-0 nylon sutures, and the vas muscularis and epididymal tunic were closed with 9-0 sutures. In these early series, the patency rates reached 86%, but the return of sperm to the ejaculate could take up to 2 years.

Despite these results, the techniques were often bloody and cumbersome because the transected epididymis was vascular, and the structures had unequal diameters. Marmar modified an end-to-end VE by the "Sling and Blanket" technique, which utilized the differences in diameter for a mechanical advantage.[26] The epididymis was transected below the obstruction in the caudal portion, and the tunic was preserved. The tubules were progressively cut toward the caput until the leaking end tubule was identified. The vas lumen was anastomosed to the end tubule, and the structures were supported posteriorly by the preserved tunic acting as a sling. The remainder of the redundant tunic was wrapped around the structures as a blanket to complete the

closure. Although the end-to-end procedure is seldom used in clinical practice today, there are occasional situations that require extra length to bridge a large gap between the epididymis and vas, and the end-to-end procedure may be used to complete the anastomosis without tension in selective cases.

END-TO-SIDE VASOEPIDIDYMOSTOMIES

Thomas[27] seemed to overcome some of the technical problems associated with an end-to-end VE when he introduced an end-to-side procedure. He modified an older, single tubule operation[28] and utilized fine sutures and magnification for an "end-to-side" VE. After opening a small window in the epididymal tunic, a single tubule was exposed and opened with a linear cut. The muscular back wall of the vas was secured to the epididymal tunic, and the opened tubule was anastomosed directly to the lumen of the vas with 10-0 nylon sutures. In the original series of 50 men, the patency rate was 66% and the pregnancy rate was 49%. This approach has been used widely in clinical practice, and there have been modifications.

The double armed 10-0 suture was developed with "fish-hooked" needles which enabled the surgeon to place the needles "inside-out" even in very small openings,[29] and Marmar[30] advocated that 4 of these sutures be placed into the opened epididymal tubule before attaching the vas wall to the tunic of the epididymis. In this way, the surgeon was able to complete the delicate epididymal suture placement without crowding. The anastomosis was completed with less difficulty with these preplaced sutures after the vas wall was attached to the epididymal tunic.

A "VE" BY INVAGINATION (TRIANGULATION, TIVE AND LIVE)

A breakthrough occurred for VE surgery when Berger[31] introduced the "triangulation end-to-side vasoepididymostomy." He placed 3 double-armed sutures of 10-0 nylon into the unopened epididymal tubule and made a linear cut between them. After the needles were passed through the mucosa of the vas lumen and tied, Burger successfully completed a tubular intusseption intussusception, which reduced the operating time and produced a patency rate of 92%. Marmar[32] modified the procedure by using only 2 sutures in the epididymal tubule. Two needles from 2 separate sutures were placed into the same needle holder at the same time. Both needles were passed simultaneously and transversely through the unopened epididymal tubule, and a small transverse tubulotomy was placed between with a 1.5-mm microblade (transverse incision VE [TIVE]). The opening was observed after methylene blue was applied over the tubule, and the functional drainage of the tubulotomy was estimated by the amount of the pink epididymal fluid expelled in the midst of the blue dye. The needles from the epididymal sutures were passed through the abdominal vas lumen to catch mucosa and a bit of muscularis. These 2 epididymal sutures were easier to access and tie from the sides, even after the anterior wall of the vas had been tipped forward and secured with a single stitch to minimize tension on the tubule. These knots were completed and tied by the same suture and produced the intussecception,intussusception The postoperative patency rate was 77.7%.

In a series of laboratory experiments, Chan *et al.*[33] evaluated the 2-suture TIVE in a rat model and proposed a modification. They placed the needles of the epididymal sutures in a linear direction along the epididymal tubule prior to creating a linear opening between them. These needles were part of a double-armed suture, and the needles were passed inside-out, through the abdominal vas lumen to catch the mucosa and a bit of muscularis. To complete the knot, the ends of the separate sutures were tied to each other to create an intusseption intussusception. These investigators compared the patency of the longitudinal intusseption intussusception vasoepididymostomy (LIVE) procedure to the TIVE, based on histology of the postmortem rat models. They reported more sperm in the vas beyond the point of the connection with LIVE, but there was no evaluation of ejaculated sperm. In addition, the patency was evaluated by retrograde injection of methylene blue into the testicular vas lumen, and with this approach, the dye passed backward into the epididymal tubules, and the patency appeared similar for the LIVE and TIVE techniques.

In clinical practice, both LIVE and TIVE procedures have been used successfully in humans, but Kumar[34] pointed out that the length of the tubulotomy should not exceed the length of the suture bite. In addition, he cautioned that the ties with the LIVE involved 2 separate sutures, which may take more time and make knot tying difficult to accomplish without slippage. In search of a more reliable suture strategy, the original TIVE procedure was modified (see the next section). After a window was created in the epididymal tunic, a tubule was selected that was perpendicular to the surgeon. The needles were passed simultaneously in a linear direction through the tubule, and a linear opening was cut between them. With this orientation, the ties were knotted and completed with the same suture on each side.

In the following section, more specific surgical methods are presented, and these represent the "surgical pearls" related to VVs and VEs.

SPECIFIC SURGICAL TECHNIQUES AND OPERATIVE "PEARLS"

"Microscoops" and full-thickness VVs: Some surgeons prefer to use a full-thickness closure for VVs, and a "microscoop"

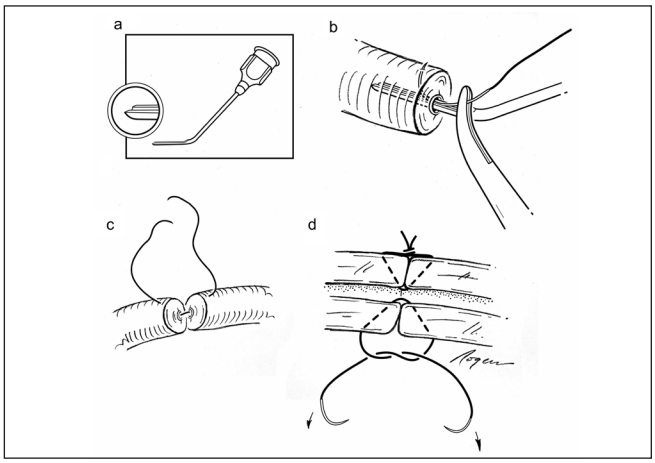

Figure 1: (a) The tip and anterior wall of a 25-G needle are filed. (b) The blunt tip is inserted into the vas lumen as a needle guide or "microscoop". (c) A full-thickness suture of 9-0 or 10-0 is passed through the mucosa and muscularis without catching the back wall. (d) The suture is passed and tied in a triangular configuration. There is only a small bite of mucosa and a larger bite of muscularis to maintain maximum patency of the lumen.

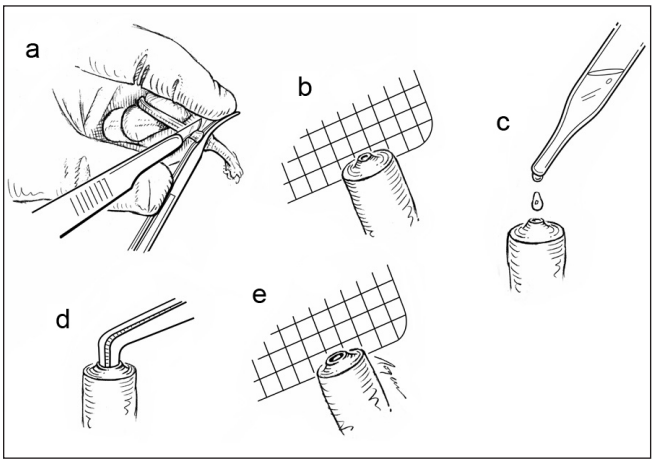

Figure 2: (a) The abdominal vas is secured in a hemostat beyond the vas scar and placed on stretch. (b) After the abdominal vas is cut at a right angle, extra mucosa will protrude from the lumen. (c) 1–3 mL of papaverine (30 mg/mL) is dripped onto the cut end of the vas. (d) The lumen (mucosa and muscularis) is dilated with a jeweler's forceps. (e) The luminal opening will double in size and accept more sutures.

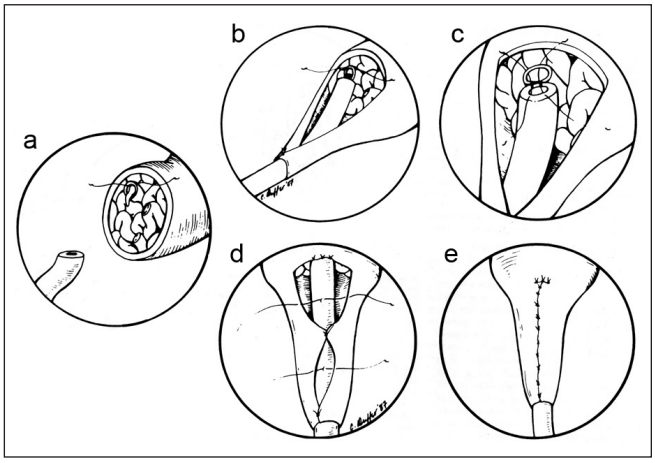

Figure 3: (a) During a standard end-to-end VE, the epididymis is cut at a right angle and the end tubule is identified. The size differential between vas and epididymis are apparent. (b) During the "Sling and Blanket" VE, the excess epididymal tunic is preserved and acts as a "sling" to support the vas. (c) The end tubule is anastomosed to the vas lumen. (d) The remaining tunic is secured to the anterior wall of the vas. (e) The tunic is closed like a blanket over the vas

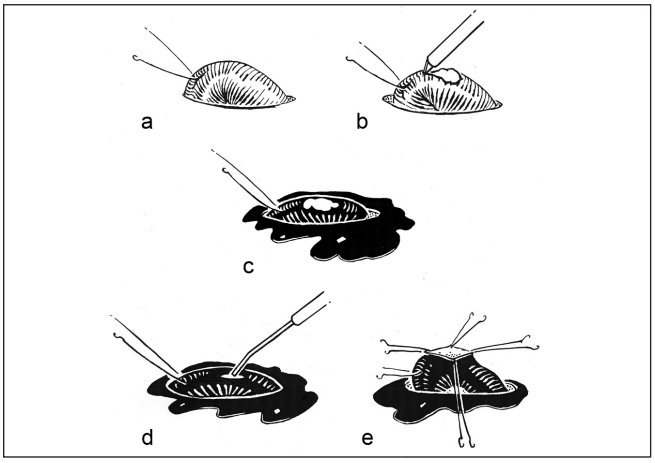

Figure 4: (a-d) (a) After the epididymal tunic is opened, a single tubule is identified and marked with a #11-0 suture; (b) The tubule is opened with a 1.5mm microblade; (c) Methylene blue is dripped over the tubulotomy to evaluate flow; (d) Epididymal fluid may be suctioned for cryo-preservation.

may be helpful. The "scoop" is developed by filing the tip of a #25-G needle, and when this needle is attached to a 1-cc syringe as a handle, it may be place in the vas lumen as a needle guide.[35] When the full-thickness suture is placed, it should conform to a "triangular pattern" to insure maximal luminal patency and minimize bunching [Figure 1].[10]

Management of luminal openings with different diameters:The placement of 6 mucosal sutures is usually sufficient to create a watertight closure for a VV. However, when the diameter of the testicular lumen is >1.50 mm, more sutures may be needed. We noted that a "dog eared deformity" occurred with the potential for leakage whenever the distance between mucosal sutures exceeded 0.75 mm on the testicular side. Accordingly, we constructed a chart to display the luminal diameters, the circumferences and the number of sutures needed to maintain a distance between mucosal sutures of <0.75 mm [Table 1].

Table 1: Management of vas luminal openings with different diameters no. of sutures

Luminal diameter (mm)	Circumference (mm)	No. of sutures
1	3.14	4–5
1.25	3.93	5–6
1.5	4.71	6–7
1.75	5.47	7–8
2	6.28	8–9

To accommodate for these differences in diameter, we utilized 2 methods to create more room on the abdominal side. First, the abdominal vas was placed on stretch and cut.

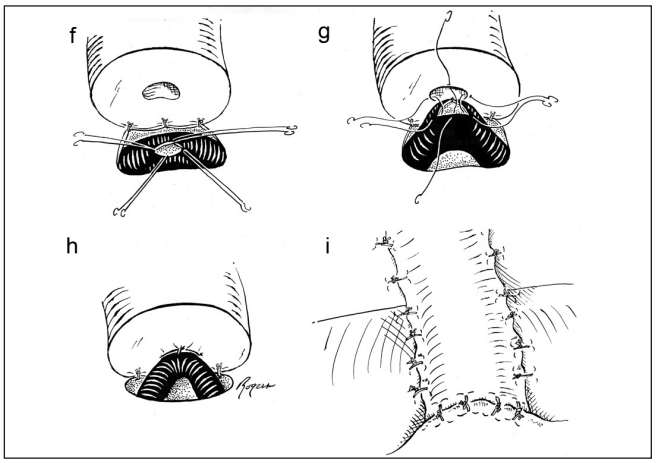

Figure 4: (e-i) (e) 4 double armed, 10-0 nylon sutures with 75 micron bi-curved needles are placed into the tubule before attaching the vas wall to the tunic; (f) The vas wall is attached to the epididymal tunic, and the epididymal sutures are temporarily rotated out of the way; (g) The needle of the posterior epididymal suture is passed through the vas lumen and tied. The lateral sutures were positioned next. The anterior suture was placed last into the vas lumen; (h) After the epididymal sutures were tied, the anastamosis was complete; (i) The anterior wall and side walls of the vas were secured to the tunic.

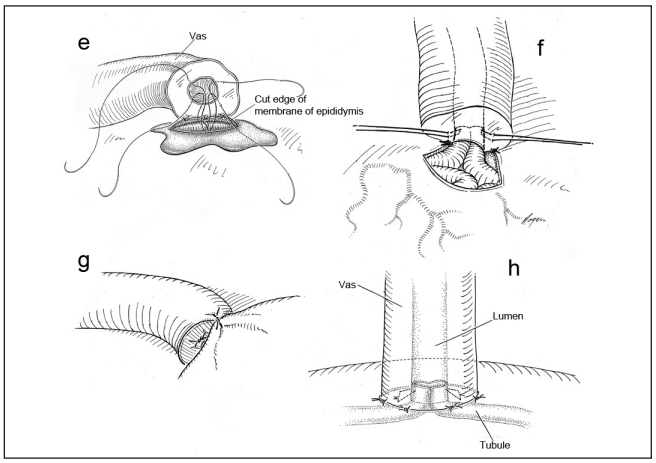

Figure 5: (e-h) (e) The needles of the double-armed sutures are passed into the vas lumen and out through the muscularis, on each side. (f) When the sutures are retracted laterally, this maneuver will simulate the intussecception; (g) The anterior vas wall is tipped forward and tied to reduce stress on the tubule; (h) After the lateral sutures are tied, the epididymal tubule will be intusseccepted into the vas lumen

This action produced extra mucosa for the abdominal vas lumen. Second, 1–3 mL of papaverine hydrochloride (30 mg/mL) were dripped onto the cut surface.[36] The extra mucosa and muscularis relaxed and the lumen was easily dilated to accommodate additional sutures [Figure 2].

The "Sling and Blanket" for end-to-end VE: This procedure is a modification of an end-to-end VE. Extraepididymal tunic was preserved during the initial dissection, and this tissue was used to support the vas. This maneuver enabled the surgeon to develop a mechanical advantage from these structures with different diameters [Figure 3].

Suture placement into the epididymal tubule as part

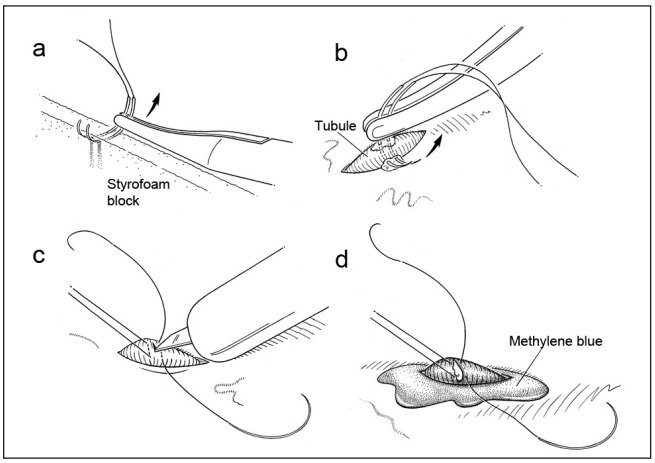

Figure 5: (a-d) (a) Two 75 micron needles from separate double armed sutures are placed into a styrofome card. These needles are about 0.5 mm apart when they are both grasped as a unit by a single needle holder; (b) The needles are passed together through a dilated epididymal tubule; (c) A tubulotomy is cut transversely into the tubule, and between the sutures; (d) The opening is evaluated after methylene blue is applied

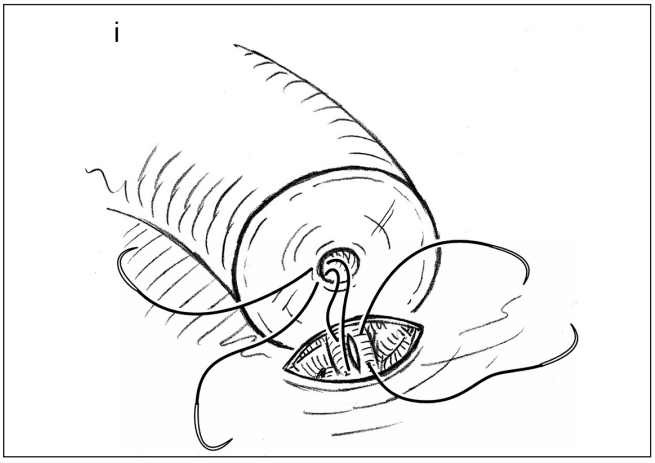

Figure 5: (i) If an epididymal tubule is selected with an orientation that is perpendicular to the surgeon, The sutures and tubulotomy will be linear, and the ties will be completed by knots from only one suture. This approach produces a Linear Intussecption Vaso Epididymostomy (LIVE).

of a standard VE: A linear tubulotomy is cut into the dilated epididymal tubule. The opening was evaluated by the application of methylene blue over the tubule. The epididymal fluid flow is observed by the amount of pink liquid accumulated in the midst of the blue. The 4 double-armed sutures are placed into the lumen of the epididymal tubule before attachment of the vas to the tunic of the epididymis [Figure 4].

The TIVE procedure with a modification: The standard TIVE procedure is shown below, and a modification is added. The position of the selected tubule was reoriented. When the selected tubule was perpendicular to the surgeon, then the sutures may be placed in a parallel manner along the length of the epididymal tubule, and a linear cut was made between them. With this orientation, both needles

from the same suture were placed through the vas lumen and muscularis. When the suture is tied on each side, the knot was completed by only one suture, it was secure and it avoided slippage [Figure 5].

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