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Robot-assisted vasovasostomy and vasoepididymostomy: Current status and review of the literature

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ABSTRACT

Objective: Microscope-assisted vasovasostomy (MAVV) is a standard procedure used to reverse vasectomies. Robotic surgery has been established primarily for technically demanding urological procedures and has also been recently implemented in male reproductive surgery. We aimed to review the current evidence of robot-assisted vasovasostomy (RAVV) and robot-assisted vasoepididymostomy (RAVE).

Material and methods: We performed a systematic literature review using PubMed to identify relevant original articles. We identified 2017 records through database search, and after removing duplicates, 782 records remained for further analysis.

Results: In total, 12 human and three animal studies were selected. Reported vasal patency rate ranges were 88%–100% for RAVVs and 55%–61% for RAVEs. The sperm count and postoperative pregnancy rates of RAVV ranged between 8.4×10^6–120×10^6 sperm/mL and 65%, respectively. Finally, procedure times in the human studies, recorded for extracorporeal RAVVs and RAVEs ranged from 97 to 238 minutes.

Conclusion: Robot-assisted vasal reversal is feasible with similar patency rates as for the microsurgical approach and showing comparable outcomes. Additional benefits of this technique include improved vision and movement precision.

Keywords: Robotic surgery; vasoepididymostomy; vasovasostomy.

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Introduction

An estimated 40–60 million men worldwide rely on vasectomy as a method of contraception because of its simplicity, effectiveness, and low morbidity rate. About 2% of these men undergo a reversal operation within the first 10 years because of their desire for fertility.[1] Conventionally performed vasal reversal was initially described in 1919, achieving only 60% patency rates until the introduction of the microscope in the 1970s.[2] The first microsurgical approach was described in 1975.[3] The use of the operating microscope has significantly improved the outcomes. However, microscope-assisted vasovasostomy (MAVV) is a technically challenging procedure and requires a long training and learning curve, with a good assistant. This predicament results from the difficulty in placing microsutures precisely under magnification due to a physiological tremor that becomes more apparent under magnification and with the surgeon's growing age.

Using a robot simplifies suture placement.[4] Potential advantages of robotic surgery include the elimination of physiological tremor in placing fine sutures, improved stability, optimal ergonomy, scalability of motion, multi-input visual interphases with up to three simultaneous visual views, enhanced magnification, and the ability to manipulate four surgical instruments and cameras simultaneously. The view is stereoscopic (3D) with high definition.[5] Moreover, the training period or learning curve for robot-assisted vasovasostomy (RAVV) appears to be shorter than for traditional microscopic techniques and may require 10–20 cases.[4] Nevertheless, the lack of tactile sensation can

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cause adverse haptic events to constitute a significant predicament of this new technology.[6]

Material and methods

Surgical technique

The surgeon uses the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California), with two 5-mm micro forceps and an 8-mm optic for the anastomosis. Patients are usually placed in a lithotomy position. After sterilizing and draping the patient, a 16F urethral Foley catheter is inserted into the urinary bladder. The preparation of the operating field and vasa deferentia is identical to that of the microsurgical technique. A longitudinal scrotal incision is made in the median raphe, and the testis is delivered from the scrotum. The site of vasectomy is identified, and the proximal and distal ends (away from the testicle) of the vas deferens are isolated. The distal end is dissected to allow a tension-free anastomosis to the proximal vas. The proximal vas is carefully transected. The microvasculature supply to the vas deferens should be preserved; hence, care should be taken not to strip the vas deferens of the perivasal adventitia. The deferential artery should be preserved. Efflux from the lumen is expressed and collected on a glass slide, and the end is flushed with saline. The two ends of the vasa deferentia are placed over on a 5 × 5 cm corkboard for fixation and better visualization. The da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California) robot is then docked into the surgical field from the left side as in kidney surgery or between the legs as in a prostatectomy (Figure 1). Three robotic arms with two 5-mm micro forceps and an 8-mm 30 or 0 degree optic are used for the anastomosis. Both ends are approximated loosely using an 8/0 Prolene (or PDS) suture in the perivasal sheath to create a tension-free anastomosis. The surgeon places two or three full-thickness 7/0 or 8/0 Prolene (or PDS) sutures through the mucosa and muscular layer posteriorly and then three anterior sutures in the same way (Figure 2). The same step is then repeated on the contralateral side. After performing the microsurgical part of the anastomosis on both sides, the robot is pulled away from the field. The anastomosis is covered with perivasal connective tissue, and the vasa deferentia with the testis are placed back into the scrotal cavity. The dartos layer is closed using a running 4/0 Vicryl suture, and the skin is closed using 3/0 Vicryl-rapid interrupted sutures.

Main Points:

- Robot-assisted vasovasostomy (RAVV) is a feasible option with similar patency rates as the microsurgical approach.
- The main advantages of RAVV are improved vision and movement precision and tremor filtration.
- The learning curve for RAVV appears to be shorter than for the microsurgical approach.
- Despite all the advantages of RAVV, this robotic surgery could be linked to higher treatment costs.

Review of the current literature

We performed a systematic literature review up to February 2020 using PubMed to identify relevant original articles (Figure 3). Three reviewers performed the search (AG, TT, and ET) and selected keywords after a consensus, and the suggestions of the senior author. Different keywords included “vasovasostomy,” “vasectomy reversal,” “vasal reconstruction,” and “urological microsurgery.” We identified 2017 records through database search. We included human and animal studies presenting outcomes regarding robotic vasovasostomy or vasoepididymostomy. After removing duplicates, 782 records remained. Of these, 763 were excluded as they did not study robotic vasovasostomy or vasoepididymostomy procedures. We also removed seven commentaries or editorial papers. Finally, we assessed cited references from the selected articles

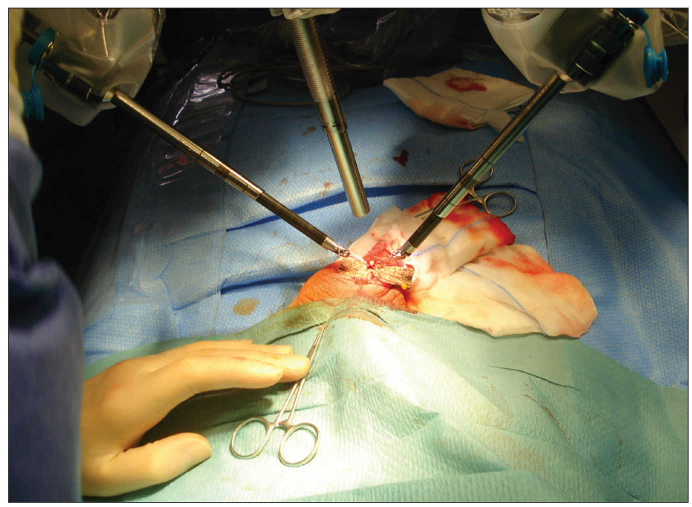

Figure 1. The da Vinci Surgical robot is docked into the surgical field between the legs like in a prostatectomy

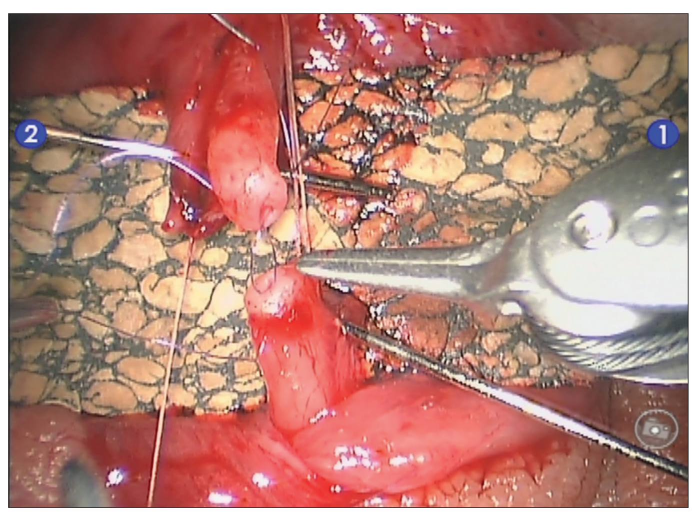

Figure 2. Performing the two-layer robotic anastomosis (robot-assisted vasovasostomy)

retrieved in the search for essential papers. We graded the quality of the studies according to the Grading of Recommendations, Assessment, Development, and Evaluation system.[7]

Results

Review outcomes

A total of 12 human and three animal studies were selected (Table 1). Of them, one was an *ex vivo* rat model study,[8] one an *ex vivo* human study,[6] another two were *in vivo* animal studies,[9,10] and 11 were *in vivo* human studies.[4,5,11-19] In human studies, surgeons performed vasectomy reversals 1–23 years after vasectomy. In total, the study groups recorded 408 extracorporeal RAVVs and 167 extracorporeal robot-assisted vasoepididymostomies (RAVEs). Only three intracorporeal RAVVs have been reported.[15,17] Five studies had a control group presenting 66 MAVVs and 22 microscopic vasoepididymostomies.[6,10,12,13,18] Regarding the surgical technique, surgeons preferred a one-layer anastomosis of the vas deferens in six studies,[6,8,11,14,18,19] a two-layer anastomosis in nine studies[4,5,9,10,13-17], and a three-layer anastomosis in one study.[12] Most groups mainly used nylon 9-0 and 10-0, and only one group used nylon 8-0 sutures.[11] Vasal patency rates ranged from 88% to 100% for RAVVs and 55% to 61% for RAVEs.[4,5,9,12-14,16,18,19] On the contrary, microsurgical vasovasostomy (MVV) patency rates ranged from 80% to 100%,[9,12,13] the difference being statistically significant in one paper in favor of RAVV.[13] The sperm count reported ranged from 8.4×10^6 to 120×10^6 sperm/mL for RAVV,[11,12,14,15,17,18] and 11×10^6 to 28×10^6 sperm/mL for MVV,[12,18] the difference being statistically significant in one study [12]. One work documented postoperative pregnancy rates reaching 65% for RAVV and 55% for MVV.[13] Finally, in human studies, surgeons performed extracorporeal RAVVs and RAVEs in 97–238 minutes,[11-14,16,18,19] and intracorporeal RAVVs in 278 minutes [17]. On the contrary, procedure times for MVV ranged from 120 to 141 minutes,[12,13,18] with the difference being statistically significant in favor of RAVV in only one study.[13]

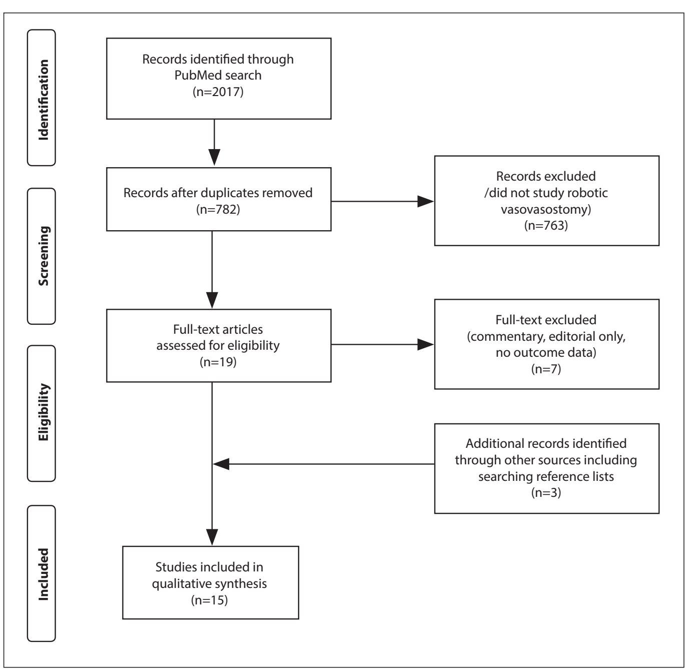

Figure 3. Study flow chart

We have operated six cases (five cases of RAVV and one case of RAVE) successfully during the last 5 years in our institution. The anastomosis was performed in two layers (Musculo-mucosa, Adventia) using 7/0 polydioxanone sutures. The median total operating time was 109 minutes, of which the console time was 75 minutes. There were no intra or postoperative complications. The postoperative pregnancy rate was 67%, and this was in line with that in the published literature.

Discussion

Vasectomy is considered as the most effective method of permanent male contraception, with 175,000–345,000 and 28,000 men in the United States and central Europe, respectively, undergoing the procedure each year.[20] Vasal reversal is the most cost-effective option to assist fertility following a vasectomy that also allows couples to conceive naturally. Vasovasostomy is performed more commonly than vasoepididymostomy, demonstrating better overall success rates.[21] Vasal reversal is technically challenging but has significantly evolved into a microsurgical procedure to improve success rates and decrease technical difficulty. This shift during the 1980s improved success rates from vasal patencies of 80% and pregnancies of 20%–30% after conventional procedures to patencies of 90% and pregnancies of 50%–60% after microsurgical techniques.[22]

Urologists have implemented the da Vinci robotic platform (Intuitive surgical Inc., Sunnyvale, CA) in a broad spectrum of urological procedures. Technology in microsurgical infertility procedures followed the evolution of the da Vinci robotic platform introduction.[5] Schoor et al.[8] reported the first RAVV using *ex vivo* animal models. Kuang et al.[6] published one of the initial robotic microsurgery studies that compared RAVV with pure MVV on an *ex vivo* vasovasostomy model, using human vas segments from cystectomised patients. Schiff et al.[9] performed the first randomized prospective animal model study comparing RAVV with MVV) using vasectomized rats. Fleming reported the first human RAVV procedures in two patients.[4] Three more extensive cohort studies came from the same group.[5,13,16] Finally, two groups reported a few cases of intracorporeal vaso-vasostomies.[15,17]

Robotic surgery may be the adjunct acquired to overcome microsurgical challenges such as tremor, limited dexterity, miniaturized

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Table 1. Robot-assisted vaso-vasostomy (RAVV) series in the literature

Sr. No. Study	Type of study	Duration from vasectomy (years)	MAVV/ MAVE Nr	RAVV/ RAVE Nr	Nr of layers	Sutures	Vasal patency (%)	Sperm count post op (sperm/ mL)/pregnancy rates (%) post op	Procedure times (min)
Schoor et al.[8]	*Ex vivo*, rat	-	No	8/0	1	Nylon 10-0	NA	-	NA
Kuang et al.[6]	*Ex vivo*, human	-	5/0	5/0	1	Nylon 9-0	Similar	NA	84 vs. 38 p=0.01
Schiff et al.[9]	*In vivo*, rat,	-	NA	NA	2	Nylon 10-0	100 vs. 90	NA	68.5 vs. 102.5 p=0.002
Fleming et al.[4]	*In vivo*, human	NA	No	2	2	Nylon 9-0	100	NA	NA
Kuang et al.[10]	*In vivo*, rabbit	-	4/0	4/0	2	Nylon 10-0	Similar	NA	75 vs. 42 p=0.03
De Naeyer et al.[11]	*In vivo*, human	NA	No	1/0	1	Nylon 8-0	Yes	120 x10^6	120
Parekattil et al.[12]	*In vivo*, human	Mean 9 (1-19)	7/0	2 x 20/0	3	Nylon 10-0 Nylon 9-0 Prolene 6-0 for adventitia	100 vs 100	54 x10^6 vs 11 x10^6 p=0.04	109 vs 128 p=0.09
Santomauro et al.[14]	*In vivo*, human	Mean 5.5 (3-10)	No	20/0	1 2	Nylon 9-0 Nylon 10-0 Nylon 9-0	92	14 x10^6	182 238
Parekattil et al.[13]	*In vivo*, human	Median 7 (1-21)	28/17	66/44	2	Nylon 10-0 Nylon 9-0	96 vs 80 p=0.02	NA/65% vs. 55%	97 vs 120 p=0.0003
Parekattil and Gudeloglu [5]	*In vivo*, human	Median 7.5/11	No	71/46	2	Nylon 10-0 Nylon 9-0	97/61	NA	120/150
Gudeloglu et al.[16]	*In vivo*, human	Median 7 (1-23)	No	106/74	2	Nylon 10-0 Nylon 9-0	97/55	NA	120/150
Barazani et al.[15]	*In vivo*, human	10	No	1 intracor-poreal	2	Nylon 10-0 Nylon 9-0	NA	30 x10^6	NA
Trost et al.[17]	*In vivo*, human	-	No	2 intracor-poreal	2	Nylon 10-0 Nylon 9-0	NA	8.4 x 10^6	278
Kavoussi[18]	*In vivo*, human	0 - >15	22/5	23/2	1	Nylon 9-0/10-0	92 vs 89	26 x 10^6 vs 28 x 10^6	150 vs 141
Marshall et al.[19]	*In vivo*, human	Median 5.6 (1.9-5.8)	No	60/0	1	Nylon 9-0	88	NA	191.5
Heilbronn series	*In vivo*, human	Median 9 (2-13)	No	5/1	2	PDS 7/0	84	67%	109

MAVV/MAVE: Microscope-assisted vasovasostomy/Microscope-assisted vaso-epidiymostomy; RAVV/RAVE: Robot-assisted vaso-vasostomy/Robot-assisted vaso-epidiymostomy

instrumentation, and placement of excellent sutures. The robot arms nullify the usual physiological tremor and achieve greater ease and precision of suture placement. Moreover, clear visualization of microscopic details such as the vas lumen is easily achieved. The training period or learning curve for RAVV is shorter, allowing more surgeons to provide quality surgical care. Additional costs appear to be minimal.[4,13] A limitation of this technology is the lack of tactile sensation or haptic feedback, which can cause adverse haptic events that do not seem to compromise anastomotic patency. Additionally, improved range of motion and enhanced digital magnification (up to 15–20 times) minimize the deficit in haptic feedback by enhancing visual acuity and instrument handling.

There are several points highlighted in this work. First, the studies identified offer a relative low level of evidence (LE) with only one being a randomized controlled trial (LE 2),[9] seven being cohort studies (LE 3),[5,6,10,12,13,16,18] and seven being small descriptive case series or case reports (LE 4,5).[4,8,11,14,15,17,19] The proof of the superiority of either technique requires further studies and additional randomized trials. Second, it is more than apparent that the intracorporeal RAVV is more tedious and time-consuming, and for the time being used for particular cases like after iatrogenic vasal obstruction,[17] which can happen in 7.2% of pelvic, inguinal or scrotal surgery.[23] An intracorporeal RAVV is also indicated in the setting of insufficient vasal length due to extensive inguinal adhesions or pelvic anatomical limitations.[15,17] Robotic surgery offers several potential advantages in this challenging patient population, including the ability to bypass the inguinal canal in a minimally invasive fashion. In that case, surgeons place the robotic trocars similarly as in robot-assisted prostatectomy. A two-layer anastomosis seems to be preferred by most researchers, which is in line with a survey study that showed that most urologists (61%) perform a two-layer vasovasostomy.[24] The two-layer anastomosis under microscopy offers precise mucosal approximation between the smaller lumen of the distal and the larger lumen of the proximal vas.[25] It requires placement of five to eight interrupted 8-10/0 nylon sutures for an approximation of the inner mucosal edges of the lumen of the vas deferens. The surgeon then places seven to ten interrupted 9/0 nylon sutures in the muscular layer for tension-free reinforcement. Nevertheless, with the two-layer being technically challenging, a modified one-layer vasovasostomy was advocated by some groups.[26] The optimal result is a tension-free anastomosis with mucosa-to-mucosa connection that maintains an adequate blood supply. The anastomosis must be watertight to maximize the likelihood of patency. The fourth important point is that although the outcomes of this review cannot corroborate the RAVV and RAVE superiority over their microscopic counterparts, there are high patency rates and sperm counts recorded even in reversals performed after 20 years of vasectomy.[12,13,16] Finally, there is a general ambiguity regarding procedure times, as authors often do not clearly define if they represent the total operation time, including docking, or only the robotic (vasal anastomosis) time. This information can be significant, as an additional 30 minutes to 1 hour of robot preparation at the beginning of a case can be expected[12], which can be reduced with growing experience.

Our review is not without limitations, the main being the lack of high-quality randomized trials comparing the robotic with the standard microscopically performed techniques. The limitations of using a single database for review are also taken into account.[27] Finally, there are no presented data regarding possible complications such as sperm granuloma formation and their impact on procedure functional outcomes.

In conclusion, robot-assisted vasal reversal is a feasible option with similar patency rates to the microsurgical approach. However, the use of robot can improve vision and movement precision during vas deferens anastomosis, and the learning curve appears to be shorter than for the microsurgical approach. In contrast, robotic surgery could be linked to higher treatment costs.

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