Advances in Male Reproductive Surgery: Robotic-Assisted Vasovasostomy

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Abstract
It is estimated that 3–6\% of all vasectomised men request vasectomy reversal for different reasons. Microsurgical vasovasostomy is the gold standard technique of vasectomy reversal. However, the microsurgical technique is time-consuming and challenging to most urological surgeons. Therefore, alternative methods of vasal anastomosis have been studied including robotic-assisted vasovasostomy. This review discusses the feasibility and practice of robotic-assisted vasovasostomy. Based on the available studies robotic-assisted vasovasostomy is feasible. The reported rate of vasal patency associated with this new technique is similar to that of microsurgical vasovasostomy. There is no clear difference between the 2 approaches in terms of operating time. Robotic-assisted vasovasostomy does not appear to afford significant advantages in the era of vasectomy reversal.

Introduction
Vasectomy is considered to be the most effective permanent method of male contraception [1], with some 175,000–345,000 men in the United States [2], and some 28,000 in central Europe [3] undergoing the procedure each year.

The popularity of vasectomy as an effective method of contraception combined with an increasing frequency of divorces and separation of relationships has inevitably resulted in a growing number of men requesting vasectomy reversal [4, 5]. Other reasons for vasectomy reversal include death of children, a wish for further children within the same relationship, and altered financial circumstances [6]. The estimated incidence of vasectomy reversal is 3–6\% of all vasectomised men [3].

Since its introduction, microsurgical vasovasostomy is considered the gold standard approach of vasectomy reversal [7], and better results in terms of vasal patency and pregnancy rate are reported in the hands of well trained surgeons [8]. However, the procedure is time-consuming and challenging to most urological surgeons.

Robotic-assisted surgery (RAS) is a rapidly expanding discipline with practical use in many fields. RAS has been used successfully in minimally invasive procedures...
including cardiac bypass [9] and gynecological tubal re-anastomosis [10]. The main advantages of the RAS are complete elimination of tremors, clear visualization of microscopic details with a three-dimensional view and suture placement facilitated by freedom in movement and motion downscaling software. Also, the robotic arms completely handle the 10-0 suture.

This review discusses the feasibility of robotic-assisted vasovasostomy as an alternative method to conventional vasal anastomosis and whether it could simplify the procedure, improve outcome results in terms of vasal patency and reduce operative time.

A PubMed and EBSCOhost search was performed for articles published in English querying the key words robotic surgery, vasectomy reversal and vasovasostomy. We collected 8 articles from 3 different countries that reports on robotic-assisted vasovasostomy published between 2003 and 2010. Of the 8 articles, 5 were experimental studies and 3 were clinical studies including one case report.

### Robotic-Assisted Vasovasostomy

The feasibility of robotic-assisted vasovasostomy in an ex vivo animal model using fresh vas specimens from rats was first studied by Schoor et al. [11]. The study comprised 8 experiments undertaken by one experienced surgeon (4 vas, each). The technique of anastomoses was one-layer using a 10-0 Nylon suture. Both surgeons performed the anastomoses with accuracy and enhanced comfort. Unfortunately, vasal patency was not assessed in this study. In an ex vivo human model using fresh vas from cystecomised patients Kuang et al. [12] performed 10 experiments (5 robotic-assisted and 5 microsurgical vasovasostomies). The procedures were performed by the same surgeon using a one-layer technique and 9-0 Nylon suture. Both surgeons performed the anastomoses with accuracy and enhanced comfort. Unfortunately, vasal patency was not assessed in this study. In an ex vivo animal model, Kuang et al. [14] performed the experiments in 8 New Zealand male rabbits (4 robotic-assisted and 4 microsurgical vasovasostomies). The procedures were performed by a single surgeon using two-layer anastomosis and 10-0 Nylon suture. Vasal patency was evaluated by passing a 2-0 Prolene suture through the anastomosis. Patency of vasal fluid was assessed by noting the presence or absence of sperm in the ejaculate. Robotic-assisted vasovasostomies were associated with a higher rate of vasal fluid patency compared to microsurgical vasovasostomies (75 vs. 42 minutes, p = 0.03, respectively). No tremors and adverse haptic events were observed in either group.

De Naeyer et al. [15] published a case report of a 34-year-old man who underwent robotic-assisted vasovasostomy to re-establish his fertility using a one-layer approach and 8-0 Prolene suture. The operation time was 120 minutes with no reported adverse haptic events or post operative complications. Vasal patency was confirmed by the presence of sperm in the ejaculate 3 months later. Parekattil et al. [16] published the largest study yet comparing the outcome results of 20 patients who underwent robotic-assisted vasovasostomies (group 1) and 7 men who underwent microsurgical vasovasostomies (group 2). The operations were performed by the same surgeon using a 3-layer technique with 10-0 and 9-0 Nylon sutures. The reported rate of vasal patency was 100% in both groups. The length of operating time did not differ significantly between groups (109 vs. 128 minutes, p > 0.05) (table 1).

In summary, the reported rate of vasal patency associated with robotic-assisted vasovasostomy is similar to that of microsurgical vasovasostomy. There was no clear
difference between the 2 approaches in terms of operating time.

**Technique**

*Preparation of the Vas*

Similar to the microsurgical technique, a paramedian scrotal incision is used and the testis is delivered from the scrotum. The site of the previous vasectomy is identified and both ends of the vas are mobilised for a tension free anastomosis. The ends of the vas are then transected and dilated, and fluid from the testicular end of the vas is assessed both macroscopically and microscopically. Then, the two ends are approximated without tension using a vasovasostomy clamp and a traction suture in the perivascular sheath.

*Robotic Positioning*

When the vas is prepared, the robot is brought into the operating field. The assistant remains in position, while the operating surgeon moves to the robot console and the robot is placed adequately. The trocars are loaded only to allow the instruments to function and to stabilize their movements outside the patient’s body. The camera lens (zero-degree for left-sided surgery, and the 30-degree down lens for the right side to optimize the visual field during procedures) is loaded onto the robot camera arm. Two microforceps (used as needles drivers) are loaded onto the left and right robotic arms. A micro Potts scissors (to cut the sutures) is loaded onto the fourth robotic arm which is placed lateral to the left robotic arm to minimize instrument clashes. This preparation requires about 30 minutes [16, 17].

<table>
<thead>
<tr>
<th>Variables</th>
<th>Microsurgical vasovasostomy (n = 7)</th>
<th>Robotic-assisted vasovasostomy (n = 20)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>34</td>
<td>43</td>
<td>na</td>
</tr>
<tr>
<td>Obstructive time (years)</td>
<td>7.0</td>
<td>9.0</td>
<td>0.09</td>
</tr>
<tr>
<td>Operating time (minutes)</td>
<td>128</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Vasal patency (%)*</td>
<td>100</td>
<td>100</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Sperm count (millions)*</td>
<td>11</td>
<td>54</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Data from the study by Parekatti et al. [16]. Procedures were performed by one experienced microsurgeon. na = Not available; * Data obtained 2-month postoperatively.

*Anastomosis*

Once the robot is positioned, the assistant passes field sutures (9-0 or 10-0 Nylon) on cards from the suture packages into the operating field. The operating surgeon takes the needle directly from the foam card using the microforceps and the anastomosis is performed in the same manner as in the microsurgical technique.

In summary, microsurgical and robotic-assisted vasovasostomy are similar in regard to preparation of the vas and the technique of anastomosis. For robotic-assisted vasovasostomy the presence of an assistant is necessary and 30 minutes extra time for preparation of the robot is required. Also, mechanical failure of the robotic arms should be taken into account.

*Learning Curve*

The learning curve is a graphic representation of the relationship between the surgeons mastery of a specifically assigned task and the chronological number of cases performed. For microsurgery, Hui et al. [18] used a simple protocol based on the rat femoral venous anastomosis to provide a quantitative representation of the progress of the surgical skills. There was an insignificant difference when comparing the results of anastomoses performed by a group of experienced surgeons (surgeons with considerable prior laboratory and/or clinical microsurgical experience) to those performed by a group of beginner surgeons (surgeons with no prior microsurgical experience) after 25 anastomoses. In a similar study, Lascar et al. [19] found an insignificant difference when comparing the results of anastomoses performed by a
group of experienced residents (residents in their last year of training in plastic surgery with special interest in microsurgery and with considerable experimental and clinical microsurgical experience) to those performed by a group of beginner surgical residents (residents in their first year of residency in plastic surgery with no prior microsurgical experience) after 52 anastomoses, or with the beginner surgical residents (residents in their first year of residency in plastic surgery, but with a basic non animal microsurgical training) after 32 anastomoses, or with the midlevel surgical residents (residents in their fourth year of residency with basic experimental and clinical microsurgical experience and with a short [3 day] basic microsurgical training course) after 16 anastomoses.

Regarding robotic surgery, most experts agreed that after a learning curve phase of 15 to 30 cases, the beginner surgeons may achieve a higher level of competence and obtain the necessary credentialing [20–22]. To demonstrate whether prior experience with microsurgery is required in learning robot-assisted microsurgery using a simple protocol based on microsurgical anastomoses of coronary arteries harvested from explanted pig models, Karamanoukian et al. [23] compared the outcome results (anastomosis time and integrity of anastomoses) between three fully trained vascular surgeons and five midlevel surgical residents. Each surgeon performed 5 freehand and 5 robotic-assisted anastomoses. Compared with microanastomosis, the fully trained surgeons and residents demonstrated an ability to master the robotically assisted procedure with similar length of operating time and integrity of anastomoses.

In summary, the learning curve for robotic surgery seems to be shorter than that of microsurgery, and the curve is not affected by having previous experience in microsurgery. This factor seems to play an important role in the learning curve of conventional microsurgery.

**Conclusions**

Robotic-assisted vasovasostomy is feasible in humans. The reported rate of vasal patency associated with robotic technique is similar to that of the microsurgical approach. There is no clear difference between the 2 approaches in terms of operating time. However, the current instruments and magnifications are not yet to the same standards as microsurgery. Also, one should take into account some extra time to prepare the robot. Nevertheless, robotic technique is economically unacceptable in most countries. Thus, it is hard to imagine that robotic-assisted microsurgery will be widely adopted in urological microsurgery.

**References**


