

ROBOTIC MICROSURGICAL VASOVASOSTOMY AND VASOEPIDIDYMOSTOMY: A PROSPECTIVE RANDOMIZED STUDY IN A RAT MODEL

JONATHAN SCHIFF, PHILIP S. LI AND MARC GOLDSTEIN*

From the Department of Urology and Center for Male Reproductive Medicine and Microsurgery, Cornell Institute for Reproductive Medicine, New York Presbyterian Hospital-Weill Medical College of Cornell University and Center for Biomedical Research, The Population Council, New York, New York

ABSTRACT

Purpose: Microsurgical vasovasostomy and vasoepididymostomy remain technically challenging procedures. Refinements in technique have continually improved patency and pregnancy rates for the 2 procedures in experienced hands. Advances in surgical robotics produced the Da Vinci robot (Intuitive Surgical, Inc., Sunnyvale, California) with motion reduction and no tremor, features that may improve outcomes in microsurgery. We report a randomized prospective study of vasoepididymostomy and vasovasostomy using the Da Vinci robot in rats.

Materials and Methods: A total of 24 adult male Wistar rats underwent vasectomy through a midline abdominal incision. Two weeks later the animals were randomized to microsurgical multilayer vasovasostomy, longitudinal vasoepididymostomy or robotic vasovasostomy and vasoepididymostomy groups. Outcomes measured included surgical time, complications, patency and sperm granuloma formation at 9 weeks.

Results: Animals were sacrificed 9 weeks after microsurgery. There were no significant differences in complications among the groups. Robotic vasovasostomy was significantly faster than the conventional microsurgical technique (68.5 vs 102.5 minutes, $p = 0.002$). The robotic and microsurgical vasoepididymostomy groups did not differ significantly in time. Patency rates were 100% for the robotic vasovasostomy and vasoepididymostomy groups, and 90% in the microsurgical vasovasostomy and vasoepididymostomy groups. These differences were not significant. Sperm granulomas were found in 70% of microsurgical vasovasostomy anastomoses and 27% of robotic vasovasostomy anastomoses ($p = 0.001$). No significant difference in the sperm granuloma rate was found between the robotic or microsurgical vasoepididymostomy groups (42% and 50%, respectively, $p = 0.37$).

Conclusions: To our knowledge we report the first randomized prospective study using the Da Vinci robot for microsurgery. We believe that the improved stability and motion reduction during microsurgical suturing with the robot helped achieve excellent patency rates for vasovasostomy and vasoepididymostomy. The robot may also allow experienced microsurgeons to perform microsurgical procedures in patients at remote locations where no experienced microsurgeons are available.

KEY WORDS: testis; rats, Wistar; robotics; vasovasostomy; microsurgery

More than 500,000 men undergo vasectomy in the United States to effect permanent contraception yearly.¹ Of vasectomized men 3% to 8% ultimately request reversal, usually as a result of divorce and remarriage.^{2,3} Microsurgical vasovasostomy, initially described by Owen and Silber and subsequently modified, remains the most successful procedure to restore patency to the vas deferens with return of sperm to the ejaculate.^{4–6}

The Vasovasostomy Study Group reported the largest series of outcomes with this technique.⁷ Patency and pregnancy rates varied directly with the obstructive interval. While the overall patency rate was 86% and the pregnancy rate was 51.6%, results in men with obstruction for fewer than 3 years were 97% patency with a 76% pregnancy rate. Others reported similarly good results with a microsurgical approach

to vasectomy reversal⁸ and patency rates of 99.5% have been reported for microsurgical vasovasostomy in humans.⁹

Approximately 10% of male infertility is due to nonvasectomy related obstructive azoospermia. The majority of these obstructions are epididymal. Microsurgical vasoepididymostomy is required to restore sperm to the ejaculate in cases of epididymal obstruction.^{6,10–13} Currently patency rates of 52% to 85% can be expected with a pregnancy rate of 11% to 56%.^{10,11,14–16} Despite these excellent results the technical demands and lengthy operative times preclude all except the most experienced microsurgeons from routinely performing this operation.

Recent advances in surgical robotics produced the Da Vinci surgical robotic system. Rapidly this device was applied to the fields of general, vascular, cardiac, pediatric, gynecologic and urologic surgery.¹⁷ The advantages of the surgical robot include improved visibility with a 3-dimensional view, a comfortable and ergonomically superior position during surgery, and increased degrees of freedom of motion of instruments, which are especially important for laparoscopic surgery. Another important ad-

Accepted for publication October 3, 2003.

Study received institutional animal care and use committee approval.

* Correspondence: Box 580, 525 East 68th St., New York, New York 10021-4873 (telephone: 212-746-5470; FAX: 212-746-8153; e-mail: mgoldst@med.cornell.edu, www.maleinfertility.org).

vantage of the robot is improved stability during suturing as a result of the motion reduction feature in the robot.¹⁸ Specific to urology, the Da Vinci robot has been applied to laparoscopic pyeloplasty and laparoscopic radical prostatectomy with great success.^{19,20} These reports demonstrate the feasibility of the Da Vinci robot in aiding the performance of complex reconstructive maneuvers during laparoscopy.

Prior to this study the only published data exploring the Da Vinci robot for urological microsurgery were the encouraging results of a small pilot study of suture placement for vasovasostomy.²¹ To our knowledge there have been no prior reports of robotic vasoevididymostomy. In our study we used the Da Vinci to perform microsurgical vasovasostomy and vasoevididymostomy. We hypothesized that the advantages of motion reduction and the improved stability of suturing would lead to results at least as good as or better than those currently obtained using standard microsurgical techniques. Furthermore, the robot may allow microsurgical reconstruction to be performed by an experienced microsurgeon at a location remote from the patient.

MATERIALS AND METHODS

Animal selection. A total of 24 adult male Wistar rats were housed in groups of 2 animals per cage. Weight ranged from 250 to 275 gm at the start of the study.

Creation of obstructive azoospermia animal model. Animals were anesthetized with a ketamine/xylazine mixture (0.22 ml/100 gm animal weight). To achieve an obstructive azoospermia animal model each animal underwent bilateral vas occlusion through a lower midline incision with a small hemostatic clip (Auto Suture Premium Surgiclip S-9.0', Ethicon Corp., Greenwich, Connecticut) placed on the vas 1.5 cm from the vasal-epididymal junction.²¹ After the procedure the testes were carefully placed back into the scrotum and the abdomen was closed with 3-zero absorbable sutures (Ethicon chromic gut U213, Ethicon Corp.).

Standard microsurgical techniques. After 2 weeks of vas occlusion the animals were randomized to undergo a microsurgical or a robotic procedure. In the microsurgical group animals were further randomized to undergo multilayer vasovasostomy or longitudinal vasoevididymostomy. In the robotic group animals were further randomized to undergo robotic vasovasostomy or robotic vasoevididymostomy. All microsurgical and robotic procedures were performed by one of us (JS) using techniques previously described.²² The animals were anesthetized with a ketamine/xylazine mixture. A midline abdominal incision was made through the old incision. The testes and vasa were delivered into the wound and any adhesions were bluntly dissected. Standard microsurgical procedures were done with an OPMI1 Zeiss operating microscope (Carl Zeiss, Oberkochen, Germany) providing 4 to 25× magnification.

Robotic microsurgical techniques. Our initial experience with the robot involved familiarizing the operating surgeon with the robot design and setup. The ergonomic design facilitates the fine hand-to-eye coordination required for precision suture placement. The intuitive design allowed for rapid acquisition of basic microsurgical skills with robotic hands. Hand and foot pedal controls integrate seamlessly to allow simultaneous camera and robotic hand control, similar to an operating microscope for standard microsurgical vasovasostomy and vasoevididymostomy (fig. 1). Initial exercises involved placing sutures on a practice card with the robotic hands. We then simulated suture placement in the vas lumen and epididymal tubule with thin polyvinyl chloride tubing. We also incised the tubing to simulate opening the tubule.

Standard Microsurgical Vasovasostomy: The testicular and vasal ends were cut with microscissors and any sperm granuloma found was dissected free and discarded. After the



FIG. 1. Initial experience with robot involved familiarizing operating surgeon with robot design and setup in laboratory (A) and some robotic exercises involved placing sutures (B) on practice card with robotic hand and foot coordination (C and D).

vasal ends were prepared they were placed in a Goldstein microspike vas approximating clamp (ASSI, Long Island City, New York). Under 16 to 25× magnifications conventional sutured vasovasostomy with 4, 10-zero nylon mucosal double armed sutures (Surgical Specialties, Reading, Pennsylvania) was performed. Eight to 12, 10-zero nylon muscular sutures were then placed to support the anastomosis.

Standard Microsurgical Longitudinal Intussusception Vasoevididymostomy: The epididymis was examined under high power to select a dilated epididymal tubule. After the vasal end was prepared a single 9-zero suture was placed through the vasal adventitia and the epididymal tunic to fix the vasal end near the epididymal tubule selected. Under 16 to 25× magnification the control group underwent longitudinal intussusception pull-through vasoevididymostomy.²³ Two 10-zero nylon double armed sutures were placed parallel and longitudinal into the epididymal tubule with the needles left in. An opening was then made in the epididymal tubule. The needles were pulled through and then placed inside out into the vasal end. This maneuver intussuscepted the epididymal tubule into the vas after the sutures were tied. Eight to 10, 10-zero nylon sutures were placed to approximate the epididymal tunic to the vasal muscle and adventitia (fig. 2, A and B).

Robotic Microsurgical Vasovasostomy: Robotic vasovasostomy was performed in a manner identical to that of the control group. Briefly, the vasa were prepared under an OPMI1 Zeiss operating microscope and the 2 cut vasal ends were placed in a vas approximating clamp. After the anastomosis was set up under the operating microscope the animal was transferred to the Da Vinci surgical robot field for microsurgical anastomosis (fig. 3). The anastomosis was performed using 4, 10-zero double armed fishhook needles for the mucosa, which were placed with the Da Vinci surgical robot (fig. 4). All suture placement and tying were performed with the Da Vinci robot. After all 4 sutures were tied 8 to 12, 10-zero muscular sutures were placed to support the anastomosis, again using the Da Vinci surgical robot. The sutures were cut by an assistant wearing surgical loupes. After the anastomosis was completed on 1 side the testicle was returned to the scrotum on that side and the contralateral side was prepared under the Zeiss operating microscope. Identical robotic anastomosis was performed.

Robotic Microsurgical Longitudinal Intussusception Vasoevididymostomy: As in the control group, an epididymal tubule was selected under the Zeiss operating microscope and the vasal end was secured to the epididymal tunic with a

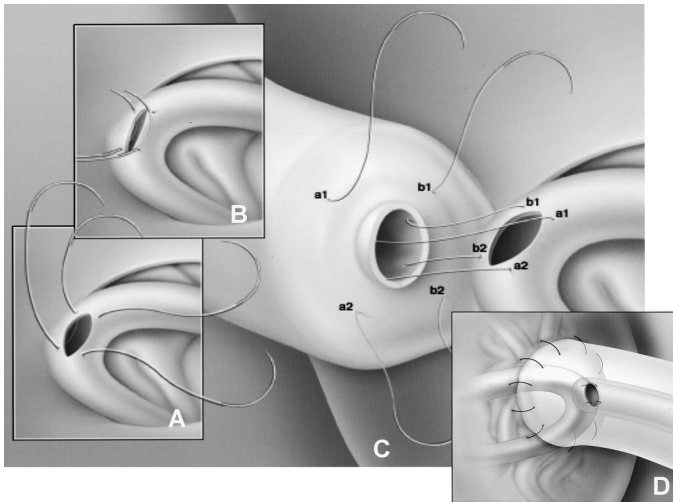


FIG. 2. Standard microsurgical longitudinal intussusception vaso-epididymostomy. Two 10-zero nylon double armed sutures were placed parallel and longitudinal into epididymal tubule (A and B) with needles left in. Opening was made in epididymal tubule. Needles were pulled through and placed inside out into vasal end (C), which intussuscepted epididymal tubule into vas after sutures were tied. Eight to ten, 10-zero nylon sutures were made to approximate epididymal tunic to vasal muscle and adventitia (D).



FIG. 3. Animal was transferred to surgical robot field for microsurgical anastomosis.

single 9-zero nylon suture. After preparation of the animal under the Zeiss operating microscope longitudinal intussusception pull-through vasoepididymostomy was done with 2, 10-zero nylon double armed sutures placed parallel and longitudinal into the epididymal tubule. They were then placed inside out into the vasal end using the Da Vinci robot. Eight to ten, 10-zero nylon serial sutures were placed to reinforce the anastomosis from epididymal tunic to vasal muscle and adventitia, again placed with the robot. All anastomosis suture placement and tying were performed with the robot. Sutures were cut by the assistant with the aid of operating loupes. After the anastomosis was completed on 1 side the testicle was returned to the scrotum on 1 side and the contralateral side was prepared under the Zeiss operating microscope. Identical robotic anastomosis was performed (fig. 5).

Wound closure. A single side was completed prior to the performance of the second anastomosis. After bilateral vasovasostomies the testicles were returned to the scrotum. The abdominal musculature was reapproximated with 4-zero

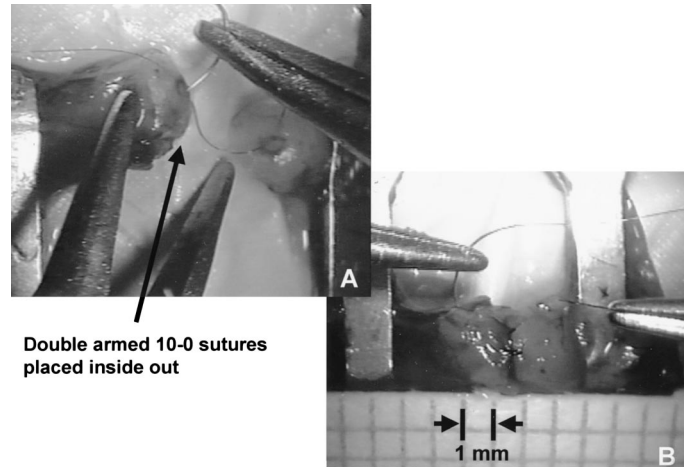


FIG. 4. Robotic microsurgical vasovasostomy. All suture placement and tying were performed with microsurgical robotic instruments. After all 4 sutures were tied 8 to 10, 10-zero muscular sutures were placed to support anastomosis using surgical robot. Ten-zero double armed needle was placed into vas lumen (A) and muscularis layer was completed with 6 to 8, 10-zero sutures (B).

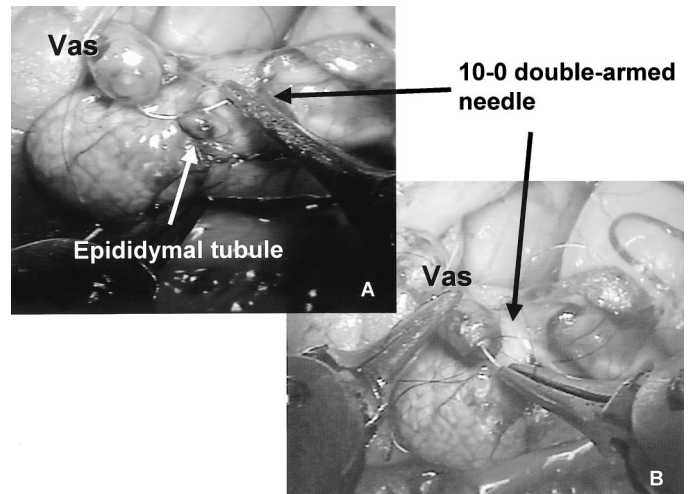


FIG. 5. Robotic microsurgical longitudinal intussusception vaso-epididymostomy. Pull-through vasoepididymostomy was done with 2, 10-zero nylon double armed sutures placed parallel and longitudinal into epididymal tubule (A), and then placed inside out into vasal end using robot (B).

chromic catgut (Ethicon Corp.) and the skin was closed with clips (Baxter International, Deerfield, Illinois).

Assessment of anastomoses. The animals were sacrificed 9 weeks after surgery. The anastomotic sites were inspected for the presence of adhesions, scarring and sperm granulomas (fig. 6). The presence and size in ml of the longest dimension of sperm granulomas were recorded.

Patency evaluations. Anastomotic patency was assessed functionally and mechanically.²³ The distal vas was transected and the presence or absence of vasal fluid was noted. Fluid was then examined microscopically to assess for the presence or absence of motile sperm. Mechanical patency was then assessed by isolating the whole vas proximal and distal to the anastomosis (fig. 7). Methylene blue diluted with saline was gently injected into the distal vas and the flow of fluid was examined under the microscope. If methylene blue was observed intraluminally distal to the anastomosis under the microscope, the anastomosis was deemed patent.

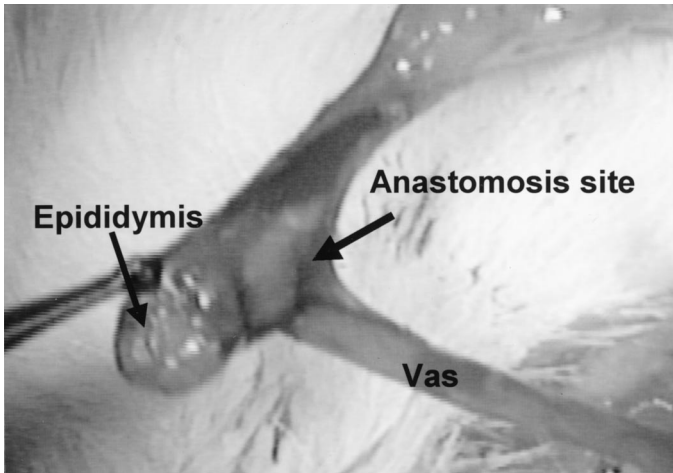


FIG. 6. At 9 weeks anastomotic sites were inspected for adhesions, scarring and sperm granulomas.

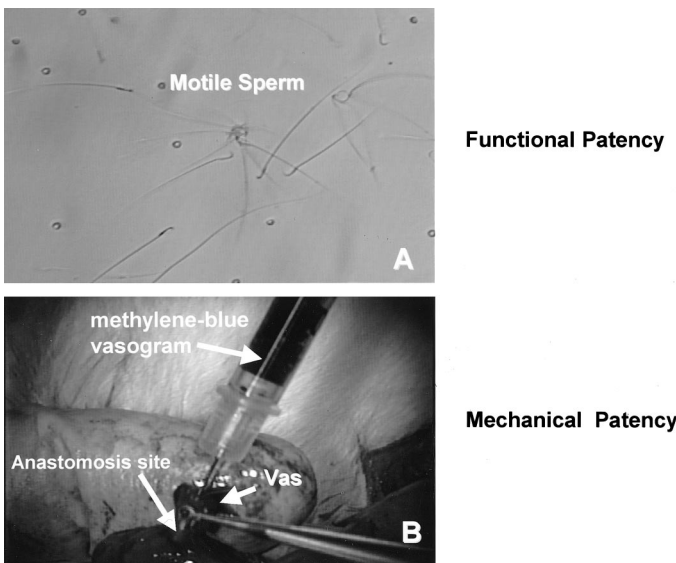


FIG. 7. Anastomotic patency was assessed functionally and mechanically. Distal vas was transected and presence or absence of vasal fluid was noted. Functional test was examined microscopically to assess presence or absence of motile sperm in distal end of vasal fluid (A). Retrograde methylene blue vasogram demonstrates mechanical patency of anastomosis (B). Dye flowed freely through anastomosis and filled epididymal tubules in retrograde fashion.

RESULTS

All animals survived surgery. In 1 animal in the robotic vasovasostomy group the epididymis was completely replaced by sperm granuloma after vasectomy. No epididymal tubule could be isolated to perform vasoepididymostomy. One animal in each of the vasovasostomy and vasoepididymos-

tomy standard groups died postoperatively. Autopsy examination 3 and 4 days after the procedure revealed intact anastomoses with the likely cause of death unrelated to the anastomosis. Patency results in these animals were excluded from analysis. Therefore, the standard groups had 10, the robot vasovasostomy group had 11, and the robotic vasoepididymostomy group had 12 anastomoses available for analysis.

At microsurgical reconstruction the average weight of animals was 446 gm in the standard vasovasostomy group vs 414 gm in the robotic group ($p = 0.12$) and 392 gm in the standard vasoepididymostomy group vs 435 gm in the robotic group ($p = 0.15$). Eight sides in the standard vasovasostomy group had sperm granulomas vs only 1 in the robotic group ($p = 0.03$, see table). Four sides in the standard vs 3 in the robotic vasoepididymostomy groups had sperm granulomas upon reversal ($p = 0.4$).

Da Vinci robot vasovasostomy was significantly more rapid than the standard microsurgical technique. Mean surgical time was 102.5 minutes in the standard vasovasostomy group and 68.5 minutes in the robotic vasovasostomy group ($p = 0.002$, see table). After correcting for the animal in which only 1 was performed the mean time was 74 minutes in the robotic group ($p = 0.003$ vs standard vasovasostomy). The time difference between standard microsurgical and robotic vasoepididymostomy was not significant, although the robotic group was more rapid. The mean time for standard vs robotic vasoepididymostomy was 107.3 vs 90.3 minutes ($p = 0.29$). The number of sutures placed was the same for microsurgical and robotic vasovasostomy, and for microsurgical and robotic vasoepididymostomy.

The animals were sacrificed 9 weeks after microsurgical reconstruction. The table lists results. Vasovasostomy was successful in 90% of standard vasovasostomy animals and in 100% of Da Vinci robot vasovasostomy animals, which was not statistically significantly different ($p = 0.23$). Similar results were observed in the vasoepididymostomy groups with 90% of standard longitudinal vasoepididymostomy animals having patent anastomoses and 100% of Da Vinci robot vasoepididymostomy animals having patent anastomoses. This difference was also not statistically significantly different ($p = 0.16$).

Sperm granulomas were found in 70% of standard vs 27% of Da Vinci robot completed vasovasostomy anastomoses ($p = 0.001$). There was no statistically significant difference between sperm granulomas for standard vs Da Vinci robot vasoepididymostomy (50% vs 42%, $p = 0.37$).

DISCUSSION

To our knowledge our results represent the first randomized trial comparing standard microsurgical vasovasostomy and vasoepididymostomy to Da Vinci robot assisted procedures. We performed identical vasovasostomy or vasoepididymostomy whether using the standard microsurgical or robotic technique. Pre-anastomosis preparation of the vas was the same and anastomoses were constructed in the same fashion.

The lack of difference in results is not surprising. Previous reports have documented a greater than 90% patency rate for

Outcome of standard vs robotic vasovasostomy and standard vs robotic vasoepididymostomy by overall patency, surgical time and sperm granuloma

| Surgical Technique | No. Anastomoses | Operative Time (mins) | Percent Patency | Percent Sperm Granuloma |
|-------------------------------------|-----------------|-----------------------|-----------------|-------------------------|
| Vasovasostomy: | | | | |
| Standard | 10 | 102.5 | 90 | 70 |
| Robotic | 11 | 68.5 | 100 | 27 |
| p Value (chi-square for comparison) | | 0.002 | 0.23 | 0.001 |
| Vasoepididymostomy: | | | | |
| Standard | 10 | 107.3 | 90 | 50 |
| Robotic | 12 | 90.3 | 100 | 42 |
| p Value (chi-square for comparison) | | 0.29 | 0.16 | 0.37 |

vasovasostomy in laboratory and clinical studies. Prior studies from our laboratory and others also showed greater than 90% patency rates for vasoepididymostomy.^{16,24} Therefore, the 90% patency rates in our control microsurgical groups were expected.

While there was no significant difference between the control and Da Vinci robot groups, our study was not powered to detect this degree of difference. Since the patency rates of microsurgical vasovasostomy and vasoepididymostomy were high, we would have needed to include at least 10 additional anastomoses per group to power the study adequately to detect significant differences of this magnitude. Nevertheless, the robotic groups had 100% patency compared to 90% for the microsurgical groups.

The benefits of the surgical robot for microsurgery are the enhanced control of suturing and the elimination of tremor. While the magnification of the robotic camera (10 to 15 \times) is not as high as that of the Zeiss operating microscope (up to 25 \times), enhanced control with motion reduction compensated for this difference.

While patency was not statistically different between the groups and sperm granuloma rates were not different in the vasoepididymostomy groups, robotic vasovasostomy had a significantly lower sperm granuloma rate than the standard microsurgical group. This result was likely due to the improved precision of suture placement with the robotic instruments, resulting in a more watertight anastomosis. Minimal handling of the tissue with the robotic graspers is advised because of the lack of tactile feedback. It decreases tissue trauma and we believe that it may improve patency. We believe that the improved precision of the robot allows more rapid suture placement and tying than with a microsurgical approach. With the robot there is little difference between placing sutures with the left or right hand, which also facilitates suturing.

The benefits achieved with the surgical robot were acquired with a short learning curve. Prior to this study robotic training was performed during a 6-hour period, consisting of suture placement and tying on a practice card and through plastic tubing. After this brief inanimate exposure and after performing the microsurgical procedures robotic vasectomy reversals were performed. We believe that the experience gained by doing the standard microsurgical techniques first accounts for some of the difference in time observed for microsurgical vs robotic vasovasostomy. In the operating room with human patients the robotic setup may add time to the procedure. However, since this operation is open, we believe that setup would be shorter than for a laparoscopic procedure.

A major difficulty that we noted when performing robotic surgery was the suboptimal instrumentation available for the surgical robot. These instruments are not ideally suited for delicate microsurgery. The needle driver currently available is designed for the smallest vascular sutures commonly used in cardiac surgery, that is a 7-zero suture. In our study we used 10-zero sutures for anastomoses. A true microneedle holder for 10-zero suture would have made the robotic procedure easier and possibly more effective. The lack of tactile feedback was also a drawback to using the robot. During the initial learning phase with the robot several sutures were broken after placement and tying on the practice card. After we discovered that visual cues were crucial to the outcome of suturing and we adapted to this situation we did not break any sutures in the robotic group during the vasovasostomy and vasoepididymostomy procedures. With practice adapting to the robot was not difficult.

CONCLUSIONS

To our knowledge we report the first prospective, randomized trial exploring the Da Vinci robot for microsurgical

surgery. We believe that the improved stability and motion reduction during microsurgical suturing with the Da Vinci robot helped us to achieve excellent patency rates for vasovasostomy and vasoepididymostomy. The robot will also allow experienced microsurgeons to perform the procedure in patients at remote locations where no experienced microsurgeons are available. The future for robotic vasovasostomy and vasoepididymostomy may include telerobotic surgery, which will allow experienced microsurgeons to perform challenging anastomoses on patients in remote locations. Furthermore, proctoring will be much easier because an experienced surgeon can observe and aid remotely in the performance of a procedure by a less experienced microsurgeon.

REFERENCES

1. Montie, J. E. and Stewart, B. H.: Vasovasostomy: past, present, and future. *J Urol*, **112**: 111, 1974
2. Cos, L. R., Valvo, J. R., Davis, R. S. and Cockett, A. T.: Vasovasostomy: current state of the art. *Urology*, **22**: 567, 1983
3. Lee, H. Y.: A 20-year experience with vasovasostomy. *J Urol*, **136**: 413, 1986
4. Owen, E. R.: Microsurgical vasovasostomy: a reliable vasectomy reversal. *Aust N Z J Surg*, **47**: 305, 1977
5. Silber, S. J.: Microscopic vasectomy reversal. *Fertil Steril*, **28**: 1191, 1977
6. Silber, S. J.: Microscopic vasoepididymostomy: specific microanastomosis to the epididymal tubule. *Fertil Steril*, **30**: 565, 1978
7. Belker, A. M., Thomas, A. J., Jr., Fuchs, E. F., Konnak, J. W. and Sharlip, I. D.: Results of 1,469 microsurgical vasectomy reversals by the vasovasostomy study group. *J Urol*, **145**: 505, 1991
8. Silber, S. J.: Pregnancy after vasovasostomy for vasectomy reversal: a study of factors affecting long-term return of fertility in 282 patients followed for 10 years. *Hum Reprod*, **4**: 318, 1989
9. Goldstein, M., Li, P. S. and Matthews, G. J.: Microsurgical vasovasostomy: the microdot technique of precision suture placement. *J Urol*, **159**: 188, 1998
10. Fogdestam, I., Fall, M. and Nilson, S.: Microsurgical epididymovasostomy in the treatment of occlusive azoospermia. *Fertil Steril*, **46**: 925, 1986
11. Schlegel, P. N. and Goldstein, M.: Microsurgical vasoepididymostomy: refinements and result. *J Urol*, **150**: 1165, 1993
12. Berger, R. E.: Triangulation end-to-side vasoepididymostomy. *J Urol*, **159**: 1951, 1998
13. Marmar, J. L.: Modified vasoepididymostomy with simultaneous double needle placement, tubulotomy and tubular invagination. *J Urol*, **163**: 483, 2000
14. Matthews, G. J., Schlegel, P. N. and Goldstein, M.: Patency following microsurgical vasoepididymostomy and vasovasostomy: temporal considerations. *J Urol*, **154**: 2070, 1995
15. Thomas, A. J., Jr.: Microsurgical end-to-side vasoepididymostomy: analysis of the outcome of 141 procedures. *J Urol*, suppl., **149**: 436A, abstract 892, 1993
16. McCallum, S., Li, P. S., Sheynkin, Y., Su, L.-M., Chan, P. and Goldstein, M.: Comparison of intussusception pull-through end-to-side and conventional end-to-side microsurgical vasoepididymostomy: prospective randomized controlled study in male Wistar rats. *J Urol*, **167**: 2284, 2002
17. Cadiere, G. B., Himpens, J., Gernay, O., Izizaw, R., Degueudre, M., Vandromme, J. et al: Feasibility of robotic laparoscopic surgery: 146 cases. *World J Surg*, **25**: 1467, 2001
18. Ballantyne, G. H.: Robotic surgery, telerobotic surgery, telepresence, and telementoring. Review of early clinical results. *Surg Endosc*, **16**: 1389, 2002
19. Abbou, C.-C., Hoznek, A., Salomon, L., Olsson, L. E., Lobontiu, A., Saint, F. et al: Laparoscopic radical prostatectomy with a remote controlled robot. *J Urol*, **165**: 1964, 2001
20. Menon, M., Tewari, A., Baize, B., Guillonnet, B. and Vallencien, G.: Prospective comparison of radical retropubic prostatectomy and robot-assisted anatomic prostatectomy: the Vattikuti Urology Institute experience. *Urology*, **60**: 864, 2002
21. Schoor, R. A., Ross, L. and Niederberger, C.: Robotic assisted

- microsurgical vassal reconstruction in a model system. *World J Urol*, **21**: 48, 2003
22. Young, J. P. H., Li, P. S., Gardner, T. A. and Goldstein, M.: Animal models for microsurgical training and research. In: *Surgery of male infertility*. Edited by M. Goldstein. Philadelphia: W. B. Saunders, Co., pp. 297–320, 1995
23. Goldstein, M.: Surgical management of male infertility and other scrotal disorders. In: *Campbell's Urology*, 8th ed. Edited by P. C. Walsh, A. B. Retik, E. D. Vaughan, Jr. and A. J. Wein. Philadelphia: W. B. Saunders Co., pp. 1532–1588, 2002
24. Chan, P. T. K., Li, P. S. and Goldstein, M.: Microsurgical vasoevidymostomy: a prospective randomized study of 3 intussusception techniques in rats. *J Urol*, **169**: 1924, 2003