Asian Journal of Urology (2021) 8, 197–203

Available online at www.sciencedirect.com

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Original Article

Impact of surgical volume and resident involvement on patency rates after vasectomy reversal—A 14-year experience in an open access system

Alexandria M. Hertz [a,*], Andrew W. Stamm [b], Mark I. Anderson [a], Karen C. Baker [c]

[a] Department of Urology, Madigan Army Medical Center, Tacoma, WA, USA
[b] Division of Urology and Transplantation, Virginia Mason Medical Center, Seattle, WA, USA
[c] Division of Urology, Duke University Hospital, Durham, NC, USA

Received 22 April 2019; received in revised form 7 August 2019; accepted 13 January 2020
Available online 23 April 2020

KEYWORDS
Vasectomy reversal;
Vasoepididymostomy;
Obstructive azoospermia;
Outcomes research;
Learning curve

Abstract *Objective:* Evaluate the influence of fellowship training, resident participation, reconstruction type, and patient factors on outcomes after vasectomy reversals in a high volume, open access system.
Methods: Retrospective review of all vasectomy reversals performed at a single institution from January 1, 2002 to December 31, 2016 was conducted. Patient and spouse demographics, patient tobacco use and comorbidities, surgeon training and case volume, resident participation, reconstruction type, and postoperative patency were collected and analyzed.
Results: Five hundred and twenty-six vasectomy reversals were performed during the study period. Follow-up was available in 80.6% of the cohort and overall patency, regardless of reconstruction type was 88.7%. The mean time to reversal was 7.87 years (range of 0–34 years). The majority of cases included resident participation. Case volume was high with faculty and residents logging a mean of 37.0 and 38.7 (median 18 and 37) cases respectively. Bilateral vasovasostomy was the most common reconstruction type (83%) and demonstrated a significantly better patency rate (89%) than all other reconstructions ($p=0.0008$). Overall patency and patency by reconstruction type were not statistically different among faculty surgeons and were not impacted by fertility fellowship training, resident participation or postgraduate year. Multivariate analysis demonstrated that increased time to reversal and repeat reconstructions had a negative impact on patency ($p=0.0023$ and $p=0.043$, respectively).
Conclusions: Surgeons with a high volume of vasectomy reversals have outcomes consistent with contemporary series regardless of fellowship training in fertility. Patency was better

* Corresponding author.
E-mail address: alexandria.m.hertz.mil@mail.mil (A.M. Hertz).
Peer review under responsibility of Second Military Medical University.

https://doi.org/10.1016/j.ajur.2020.04.001

for bilateral vasovasostomies. Patency was not negatively impacted by tobacco use, comorbidities, resident participation, or post-graduate year.

1. Introduction

The National Survey of Family Growth indicates that 175 000—354 000 men have vasectomy in the United States (US) each year [1]. It is estimated that 6% of those men will choose to undergo vasectomy reversal [2].

Microsurgical vasectomy reversals are associated with better postoperative outcomes than other methods [3—6]. Microsurgery is a unique skill set and like many technically demanding skills, it is logical to postulate that the experience level of the surgeon will impact surgical outcomes. The majority of publications examining vasectomy reversal outcomes are published by dedicated fertility practices and/or fellowship trained fertility specialists—surgeons whose volumes indicate a high level of expertise. Yet a recent study indicates that the majority of vasectomy reversals are performed by general urologists, likely because fellowship trained fertility specialists represent a minority of board certified urologists [7,8]. Two recent publications found that as few as one in 10 urologists reported completing a vasectomy reversal during a 6 months period and the median number of reversals performed by certifying urologists was one [7,8].

Ideally, residency provides trainees the opportunity to complete the surgical learning curve before performing interventions without expert oversight. Yet surgical faculty are constantly pressured to balance operating room utilization against graduate medical education and are under increasing scrutiny for their own surgical outcomes. To our knowledge, no publication has addressed the impact of resident involvement on vasectomy reversal outcomes or compared the patency rates between urologist with and without fertility fellowship training. Our objective was to define the impact of fellowship training, resident involvement, and patient factors, such as tobacco use and medical comorbidities, on patency after vasectomy reversal in an open access health care system.

2. Patients and methods

Institutional review board approval was obtained and a retrospective chart review was performed of all men who underwent vasectomy reversal at a single institution in the military health system from January 1, 2002 to December 31, 2016. The military health system represents an open access with no limitations on access to care based on coverage and vasectomy reversal is a covered benefit. Relevant demographic, surgical, and postoperative information were recorded to include age at reversal, time since vasectomy, spouse age at reversal, history of previous attempt at vasectomy reversal, active tobacco use at the time of reversal, type of reconstruction, characterization of effluence, presence of sperm in postoperative semen analysis, and postoperative pregnancy.

Surgeon information record included the faculty surgeon, resident participation, and resident post-graduate year (PGY). Patency was defined as motile sperm reported in the postoperative semen analysis with a concentration of 1 mol/mL or greater, or pregnancy of the partner without the use of assisted reproductive techniques. We deemed this sufficient as it is consistent with other contemporary studies [9], and recent meta-analyses and systematic reviews have used less restrictive definitions of patency with "any sperm" presence being considered patent [10,11].

All reversals in this cohort were done using a microsurgical approach. Vasovasostomies were done using the modified two-layer technique with 9-0 Nylon suture and vasoepididymostomy were done using the end-to-side intussuscepted technique with 10-0 Nylon suture. The presence of a learning curve was investigated by analyzing the outcomes of faculty directly out of residency training and who logged 20 or more cases during the study period. Resident participation is a graduating role with all residents having involvement starting their first case. This progression is usually through starting with interstitial stitches and then advancing to luminal stitches, to completing a full anastomosis commensurate to the resident's demonstrated skill and under direct supervision of the faculty surgeon. Attending surgeon was scrubbed during every case.

Descriptive statistics were then performed when appropriate. To evaluate differences in patency rates based on other demographic and technical factors student *t*-tests, Wilcoxon rank sum, logistic regression (for multivariate comparison) and analysis of variance (ANOVA) were performed using R:A language and environment for statistical computing (v 3.4.1, 2017, Vienna, Austria).

3. Results

3.1. Demographics and descriptive statistics

Five hundred and twenty-six vasectomy reversals were performed during the study period and the characteristics of the surgical cohort are listed in Table 1. Restoration of fertility was the indication for 517 subjects of which 34 (6.6%) were re-do reconstructions. One subject was deemed unreconstructable bilaterally and was not included in the analysis of outcomes. Nine subjects (1.7% of the cohort) underwent reconstruction because of pain and these men were kept in the dataset because they completed at least one postoperative semen analyses. The

Table 1 Characteristics of the surgical cohort broken down by fellowship status.

Characteristics	Patients for all surgeons ($n=526$)	Patients for fellowship trained surgeons ($n=120$)	Patients for non-fellowship trained surgeons ($n=406$)
Age at reconstruction, mean (range), year	36.56 (23–76)	36.94 (23–76)	36.44 (23–64)
Spouse age at reconstruction, mean (range), year	31.01 (19–46)	31.17 (19–42)	30.95 (19–46)
Time since reversal, mean (range), year	7.87 (0–34)	7.73 (0–34)	7.92 (0–30)
Post-graduate year of resident involved, mean (range), year	3.65 (1–6)	3.51 (1–6)	3.70 (1–6)
Active tobacco use at time of reconstruction, *n* (%)	151 (28.7)	76 (57.1)**	75 (19.1)
Re-do reversal performed, *n* (%)	34 (6.5)	3 (2.5)	31 (7.6)*
Comorbidities (one or more), *n* (%)	193 (36.7)	76 (57.1)**	117 (29.7)
Pain as an indication, *n* (%)	9 (1.7)	3 (2.5)	6 (1.5)
Postoperative semen analysis or report of pregnancy, *n* (%)	423 (80.4)	100 (83.3)	323 (79.6)

*$p<0.05$, **$p<0.001$. All other comparisons were not statistically significant.

mean time to reversal was 7.87 years (range 0–34 years). Tobacco use was common (28.7% of subjects) and 36.7% of subjects had at least one comorbidity. The five most common comorbid conditions were hypertension, hyperlipidemia, depression/anxiety/post-traumatic stress disorder, gastroesophageal reflux disease, and asthma. Fourteen faculty surgeons performed at least one reconstruction during the study period. Two of these surgeons had fellowship training in fertility (referred to as fellowship trained) and they performed 22.8% of the reconstructions. Tobacco users and subjects with comorbidities were more likely to have surgery by a fellowship trained surgeon ($p<0.0001$) and re-do reversal were more likely to have reconstruction by a surgeon who did not have fertility fellowship training (referred to as non-fellowship trained). Otherwise there were no differences in the cohort between fellowship and non-fellowship trained surgeons.

3.2. Postoperative outcomes

The surgical outcomes by reconstruction type and fellowship status are listed in Table 2. Follow-up was available in 80.4% (423/526) subjects of whom 326 completed at least one semen analysis and 107 reported a postoperative pregnancy. The number of subjects lost to follow-up did not differ between fellowship and non-fellowship trained surgeons. The overall patency rate for all reconstructions was 87.0%. The overall patency rate for bilateral vasovasostomy was 88.7% and this rate was statistically better than all other reconstruction types ($p=0.0008$). There was no statistically significant difference in patency between fellowship and non-fellowship trained faculty for all reconstructions or among reconstruction subtypes.

3.3. Surgeon volume, outcomes, and learning curve

All faculty were from military-based residency programs. Faculty surgeons were in the data set for a mean of 4.12 years and median of 4 years (range 1–13 years). The mean number of vasectomy reversals performed by faculty surgeons was 37 (median 18, range 1–198). Overall patency and patency of bilateral vasovasostomy were not statistically different among individual surgeons. Both fellowship trained faculty, but only four of the non-fellowship trained faculty, performed vasoepididymostomies (alone or in combination with vasovasostomy). The number of vasoepididymostomies was too small for meaningful comparison among individual surgeons. Non-fellowship trained surgeons performed 31 of the 34 "re-do" reversals, and there was no statistically significant difference in patency of "re-do" procedures between fellowship and non-fellowship trained faculty ($p=0.66$).

Three faculty met criteria for analysis for a learning curve (Table 3). There was no statistically significant difference in patency rates between the first ten and the last ten reconstructions ($p>0.1$) for these faculty individually or as a group.

3.4. Patient variables and resident involvement

Fig. 1 demonstrates patency rate for all reconstructions categorized by the time since vasectomy. There was a statistically significant decrease in patency for reconstructions done 11–15 years after vasectomy ($p=0.04$). This outcome was unchanged when evaluating by reversal subtype.

Analysis of the covariates is summarized in Table 4. Increased time to reversal, as a continuous variable, was associated with a significantly worse overall patency rate ($p=0.0023$), however this impact was lost after controlling for type of reconstruction. Notably active tobacco use had no apparent impact on overall postoperative patency and this finding was confirmed after controlling for type of reconstruction. Similarly, the presence of medical comorbidities did not impact the overall patency rate or patency by type of reconstruction. Age of the spouse at the time of reconstruction did not impact the postoperative pregnancy

Table 2 The surgical outcomes by reconstruction type and fellowship status.

Reconstruction type	Patency, % (number patent/total number)			*p*-Value
	All surgeons	Fellowship trained surgeons	Non-fellowship trained surgeons	
All reconstructions	87.0 (368/423)	90 (100/111)	85.9 (268/312)	0.32
Reconstructions by subtype				
Bilateral vasovasostomy	88.7 (315/355)	90.7 (78/86)	88.1 (237/269)	0.56
Bilateral vasoepididymostomy	54.6 (6/11)	50 (3/6)	60 (3/5)	1.0
Unilateral vasovasostomy	76.7 (23/30)	100 (7/7)	69.5 (16/23)	0.15
Unilateral vasoepididymostomy	60.0 (3/5)	100 (2/2)	33.3 (1/3)	0.4
Vasovasostomy/Vasoepididymostomy	95.5 (21/22)	100 (10/10)	91.67 (11/12)	1.0

Table 3 Patency of first 10 and last 10 reconstructions.

Patency	Attending surgeon A		Attending surgeon B		Attending surgeon C	
	First 10 cases	Final 10 cases	First 10 cases	Final 10 cases	First 10 cases	Final 10 cases
Patent/not patent	Patent	Patent	Patent	Patent	Patent	Patent
	Patent	Patent	Patent	Patent	Not patent	Patent
	Patent	Patent	Patent	Patent	Not patent	Patent
	Patent	Patent	Patent	Patent	Patent	Patent
	Patent	Patent	Patent	Patent	Patent	Not patent
	Not patent	Patent	Not patent	Patent	Patent	Not patent
	Patent	Patent	Patent	Patent	Not patent	Patent
	Patent	Patent	Patent	Patent	Patent	Patent
	Patent	Patent	Patent	Patent	Patent	Not patent
	Patent	Patent	Patent	Patent	Patent	Patent
Patency rate (%)	90	100	90	100	70	70

rate ($p=0.473$), however all pregnancy outcomes should be interpreted cautiously as this information was retrievable in a limited number of subjects.

Multivariate analysis demonstrated bilateral vasovasostomies had a significantly better patency rate than all other types of reconstruction ($p=0.037$) even after controlling for other covariates. Repeat reversals were less likely to be successful ($p=0.043$) with an overall patency rate of 70%. There was no difference in pregnancy rate of the "re-do" cohort ($p=0.16$). The vasa fluid was characterized in the operative report of 402 subjects, however there was no standard convention for how this information was categorized. We found no difference in patency rates by fluid quality or presence of sperm, however the validity of this finding is difficult to justify based on the lack of standardization and inconsistent documentation of the vas effluence among the panel of surgeons.

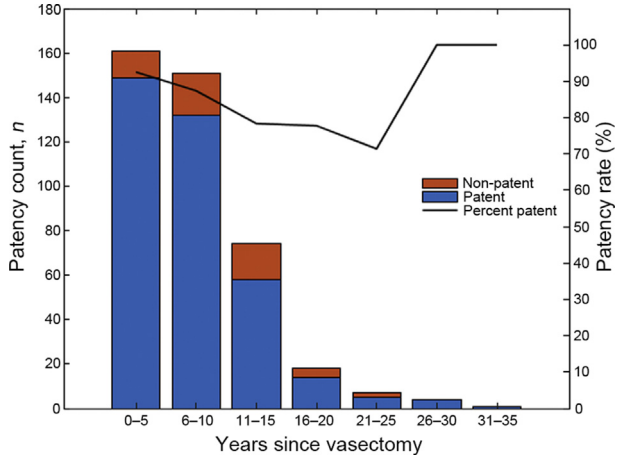

Figure 1 Number of reconstruction (all types) and postoperative patency rate categorized by years since vasectomy.

The vast majority of reconstructions included resident participation (489/526; 93%) and the remaining cases (37/526; 7%) were single faculty procedures. The mean PGY was 3.65 (range 1–6) and resident PGY had no influence on patency ($p=0.19$). There were 34 different resident surgeons during the study period, including rotating residents and interns. Graduating residents logged a mean of 38.7 vasectomy reversals (median = 37; range = 16–55).

4. Discussion

This study addresses several important gaps in the literature regarding fellowship training, resident involvement, and case volume on outcomes after vasectomy reversal. First, this analysis of our single institution series demonstrated no difference in patency between surgeons with and without fertility fellowship training. Eighty-seven percents of subjects were patent after vasectomy reversal, regardless of reconstruction subtype. Patency

Table 4 Factors affecting patency.

Characteristics	*p*-Value[a]	*t* or F-Value	95% confidence interval
Univariate factors			
Time to reversal	**0.0023**	$t=3.173$	0.91—3.99
Patient age	0.093	$t=1.703$	−0.31 to 3.97
Tobacco use	0.16	$t=-1.423$	−0.06 to 0.009
Medical comorbidities	0.59	$t=-0.54$	−0.08 to 0.047
Resident PGY	0.19	$t=1.34$	−0.16 to 0.81
Multivariate factors			
Reversal type-bilateral vasovasostomy	**0.0008**	F=5.469	1.77—2.05
Repeat reversal and category	**0.043**	F=2.587	0.006—0.360
Fellowship training and bilateral VV	0.0686	F=−1.825	2.481—3.198
Fellowship training and unilateral VV	0.406	F=−0.83	1.592—2.688
Fellowship training and unilateral VE	0.604	F=0.519	0.644—3.09
Fellowship training and VV/VE	0.075	F=−1.786	1.303—2.419
Fellowship training and bilateral VE	1.0	F=0.833	0.114—6.11

VV, vasovasostomy; VE, vasoepididymostomy; PGY, post-graduate year.
[a] Significant values were in bold.

for all reconstructions was 90.0% for fellowship trained and 85.9% for non-fellowship trained faculty. Patency for all vasovasostomies was 88.7% which statistically better than other reconstruction subtypes, but again no difference was seen between fellowship and non-fellowship trained surgeons.

Second, our study affirms that urologists with microsurgical experience and high case volumes have postoperative outcomes similar to other published series. Our outcomes are on par with contemporary, high volume series and a recent systematic review which reported a weighted mean vasovasostomy postoperative patency of 89.4% (range 62.9%—97.8%) after review of 31 studies comprising over six thousand patients [10—14]. Likewise, our patient cohort was similar to the patients represented elsewhere in the literature with a mean age of 36.5 years and an obstructive interval of 7.87 years as compared to 38.9 years and 7.2 years respectively in the systematic review [10].

It is noteworthy that our faculty logged a high volume of reversals during our study period with a median of 18 and a mean of 37 cases. Recent studies of case series for board certification indicate this volume exceeds typical practice. Nseyo et al. [8] analyzed the case logs of 5174 urologist applying for certification or recertification from 2008 to 2014 and found that over 90% did not report a vasectomy reversal during their certification/recertification period suggesting that most urologists either do not perform vasectomy reversal or perform them very infrequently. This trend is supported by Bach et al. [7] who reported in 2018 that only 33% of recent certifying urologists performed a male fertility procedure (defined as varicocelectomy, vasectomy reversal, or sperm retrieval). Of urologists that did perform vasectomy reversals, infertility trained urologists performed more, averaging eight vasectomy reversals during a 6-month period as compared to approximately three for non-fellowship trained urologists [8]. Due to the nature of their datasets, neither of these studies could comment on the impact of volume on postoperative outcomes.

Third, this is the first publication to document resident involvement and quantify its impact on vasectomy reversal. Our analysis demonstrates that resident involvement in general and PGY year in particular did not adversely impact patency after vasectomy reversals as evidence by our outcomes. With a median of 37 cases, it is likely that our residents had an above average exposure to microsurgery. As compared to the US population in general, the military health care system has an over representation of insured, reproductive-aged couples and vasectomy reversal is a covered benefit. In addition to our commitment to providing quality comprehensive care to military beneficiaries, we feel the robust microsurgical experience gained during vasectomy reversals has a direct benefit on surgical training. In our experience, there are specific microscopic surgical skills such as limited field of view, focusing and clutching the microscope, constrained entry points and limited degrees of freedom for instrumentation, instrument conflict/collisions, and decreased haptic feedback, which are all directly translated to laparoscopic and robotic surgery [15]. Due to the retrospective nature of our data, there are limitations on precise amount of resident involvement in every case. However, this provides a starting point for future evaluation of resident/trainee involvement and development of training programs.

Fourth, we did not detect evidence of a learning curve in our faculty surgeons as evidenced by the absence of change in patency rates overtime for faculty surgeons, however this finding must be interpreted in the context of the high volume of cases for our graduating residents. While the number of cases that are necessary to achieve competency in vasectomy reversals is not known, data regarding the learning curve for robotic surgery (a comparable highly specialized minimally invasive skill set) indicate that 20 or more cases can translate to competency [15]. Our median resident case volume for reversal exceeds this threshold, therefore we presume that the learning curve was achieved during their military residency. In addition, a recent review of American Board of Urology case logs demonstrated that military/government urologists represented only 2% of certifying urologists but completed 43% of all reported reversals—a finding we feel

corroborates that residents with a high case volume of vasectomy reversals feel competent to perform these cases after graduation [8].

Analysis of patient factors demonstrated that active tobacco use at the time of the reversal and the presence of comorbidities did not impact postoperative patency in our series. Our study complements the conclusions of Tosun et al. [17], who demonstrated that smoking by patient and/or partner did not negatively affect patency or postoperative semen parameters after vasectomy reversal in 162 couples. This finding was unexpected given smoking has known broad health effects that include a detrimental impact on wound healing and other anastomoses [16,17]. Our series included 34 patients that underwent repeat vasectomy reversals and analysis indicated that bilateral vasovasostomies had better outcomes than other reconstructions. This finding supports previous publications that demonstrate either no impact or a trend in favor of vasovasostomy for "re-do" reconstructions [18,19]. Active tobacco users and patients with comorbidities were more likely to have surgery by a fellowship trained surgeon, however subjects undergoing repeat reconstruction were more likely to be scheduled with a non-fellowship trained surgeon. We cannot conclude these associations indicate selection bias as it is counterintuitive to select against fellowship trained surgeons when scheduling a "re-do" vasectomy reversal.

Interpretation of our postoperative pregnancy rate is limited by data size. Despite the use of a universal electronic health care record, there were several factors that limited follow-up information about pregnancy: 1) The retrospective nature of the data set; 2) pregnancy information is rarely recorded in the male partner's medical record; 3) partners health records are not linked in military electronic health records, which limits the ability to identify the female partner; 3) due to high demand for obstetric services, many women obtain care outside the military health system; and finally 4) follow-up data are not available after subjects leave military service. In contrast to previous studies, pregnancy was not impacted by spouse age in our series, but again this is difficult to interpret given small number of subjects with pregnancy data [20].

The unique strengths of this study include the availability of both case volume and postoperative patency for a large number of surgeons, the documentation of resident involvement, and high compliance with postoperative follow-up [10—13,20—22]. The lack of financial burden, the wider patient age range, and wider range of time since vasectomy are notable differences in our cohort compared to previous series. It is noteworthy that follow-up was not available in 20% of subjects despite the absence of primary or secondary financial disincentives, the use of a comprehensive electronic health record, and the non-invasive nature of the follow-up testing. We believe this finding highlights the universal challenges inherent in quantifying surgical outcomes.

5. Conclusion

Surgeons with a high volume of vasectomy reversals have outcomes on par with contemporary series regardless of fellowship training in fertility. The analysis of our large, single institution series of 14 faculty surgeons demonstrated no difference in patency after vasectomy reversal between fellowship and non-fellowship trained surgeons. Resident participation and PGY did not negatively impact surgical outcomes. Case volume was high for faculty (mean 37, median 17 cases) and residents (mean 38, median 37 cases) alike. Analysis of new faculty with $\geq$20 cases did not find evidence of a learning curve which we postulate was due to their microsurgical experience during training.

Authors contribution

Study design: Karen C. Baker, Alexandria M. Hertz, Mark I. Anderson.
Data acquisition and analysis: Alexandria M. Hertz, Andrew W. Stamm.
Drafting manuscript: Alexandria M. Hertz, Karen C. Baker, Mark I. Anderson, Andrew W. Stamm.
Critical revision of manuscript: Alexandria M. Hertz, Karen C. Baker, Mark I. Anderson, Andrew W. Stamm.

Conflicts of interest

The authors declare no conflict of interest.

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