Percutaneous Varicocele Embolization versus Surgical Ligation for the Treatment of Infertility: Changes in Seminal Parameters and Pregnancy Outcomes[1]

Richard D. Shlansky-Goldberg, MD
Keith N. VanArsdalen, MD
Carolyn M. Rutter, PhD
Michael C. Soulen, MD
Ziv J. Haskal, MD
Richard A. Baum, MD
Douglas C.B. Redd, MD
Constantin Cope, MD
Michael J. Pentecost, MD[2]

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PURPOSE: To compare the success of percutaneous varicocele embolization to surgical ligation with regard to changes in semen characteristics and pregnancy outcome.

MATERIALS AND METHODS: Infertility records from 346 men who underwent correction of their varicocele for infertility (surgical ligation 149; embolization 197) were reviewed retrospectively. Preprocedural and postprocedural semen analyses and pregnancy outcomes were obtained with use of chart and telephone follow-up.

RESULTS: In men who successfully impregnated their partners, there were significant improvements in sperm density, percent total improvement, motility, and progression. Postprocedural (embolization vs surgery) percentage increases in seminal parameters were density, 156.8% versus 138.5%; total, 168.8% versus 157.9%; and motility, 2.7% versus 3.2%. The percent of individuals who had a change in sperm progression was 31% versus 41%. There was no statistical difference between the techniques based on t tests. The pregnancy rates were similar for the two groups, 39% and 34% for embolization and surgery, respectively.

CONCLUSION: There is no significant statistical difference in seminal values or pregnancy outcome between the two techniques.

IN the late 1800s, Barwell, and then Bennett, demonstrated a relationship between fertility and varicocele, the abnormal dilatation of the pampiniform plexus due to reflux of blood down the gonadal veins (1,2). In 1929, Macomber and Sanders described the significance of sperm count relative to fertility, reporting an increase in total sperm count and pregnancy in a patient after varicocele repair (3). However, it was not until 1952 when Tulloch reported restored spermatogenesis in a previously azoospermic male that resulted in pregnancy that the association was given greater attention (4). Since then, multiple studies on varicocele, its diagnosis, and correction have been published.

Charny, in 1962, was one of the first in the United States to advocate the surgical correction of varicocele to improve fertility (5). In the late 1970s, Iaccarino and later Lima et al, using sclerosing agents, followed by Thelen et al, using metal coils, described the percutaneous technique to embolize the gonadal vein to treat infertility (6–8). The

[1] From the Department of Radiology (R.D.S.G., M.C.S., Z.J.H., R.A.B., C.C.) and Urology (K.N.V.A.), Hospital of the University of Pennsylvania, 3400 Spruce St, Philadelphia, PA 19104, and Center for Health Studies (C.M.R.), Group Health Cooperative of Puget Sound, Seattle, Washington. Presented at the 1996 SCVIR annual meeting. Received December 3, 1996; revision requested January 10, 1997; revision received May 9; accepted May 10. **Address correspondence to** R.D.S.G.
[2] Current address: Department of Radiology, Georgetown University Medical Center, 3800 Reservoir Rd, NW, Washington, DC.

aim of both procedures is to interrupt the reflux of blood into the varicocele to improve semen quality. The association of varicocele with diminished semen quality was quantified by MacLeod in 1965; he demonstrated a lower sperm density with less motile and more abnormal forms in patients with varicocele, which improved after surgical correction (9). Although the effect of varicocele on fertility remains controversial, overwhelming evidence supports varicocele as a cause of infertility (10–13). The etiology of sperm dysfunction is unknown but is believed to be due to thermal effects of the varicocele, or due to refluxing adrenal metabolites or prostaglandins (14–17).

Presently, spermatic vein embolization is performed with multiple agents and devices by means of both the femoral and jugular approaches (18–34). In addition, there are three primary surgical procedures performed that vary by the level at which the spermatic vein is ligated: retroperitoneal, inguinal, or subinguinal; also known as the modified Palomo, Ivanissevich, or Marmar procedures, respectively (35–39). Percutaneous embolization has been reported to be better tolerated because of its shorter postprocedural recovery time (40). The purpose of this study was to determine whether there are differences in improving seminal parameters and success in achieving pregnancy between surgical correction and percutaneous embolization. Also reviewed were the success rates in performing the procedure, as well as related complications.

MATERIALS AND METHODS

A retrospective review of the charts from the infertility clinic revealed 346 patients who had varicocele correction performed from February 1980 through December 1994. One hundred forty-nine men underwent surgical ligation (43%), while 197 men underwent percutaneous therapy (57%). The average age of the embolization and surgical patients was 34 years (range, 20–56 years) and 33 years (range, 21–49), respectively. Patients underwent semen analyses prior to and after therapy. Patients who underwent semen analyses generally had two repeated measures, although some had up to five. Patients with multiple samples had their sperm measures averaged together.

The World Health Organization has attempted to standardize laboratory techniques and has established normal criteria (41). Currently, the World Health Organization's normal values of semen analysis include a volume of 2 mL or more, a density of at least 20×10^6 sperm per milliliter and a total of 40×10^6 sperm per ejaculate. Motility and progression measures are determined by averaging two observations of 100 successive sperm, recording the number of motile and immotile sperm in addition to their direction. Semen samples with normal motility and progression are defined as having either (*a*) at least 50% of sperm with a combination of rapid, slow or sluggish progressive motility, or (*b*) at least 25% of sperm with rapid progressive motility. Morphology is also graded as the percentge of normal forms, with normal representing at least 30% without head, midbody, tail deformities or immature forms (41).

The quantitative semen analyses of the study patients were reviewed for volume of ejaculate (mL), density of sperm (sperm/mL), total counts (millions of sperm), and motility (% motile). In addition, qualitative analyses were performed evaluating for forward progression rated on a 0–4 scale. Each nonzero rating allows ± coding, so that ratings were effectively made on a 0–12 scale. Morphology measurements were not statistically analyzed because these measurements were not usually performed for specimens with less than 10 million sperm, resulting in a large amount of missing data.

Patients were determined to have varicoceles by physical examination. Clinically suspected small varicoceles were confirmed with ultrasound. Telephone follow-up was attempted in all of the patients to obtain pregnancy, recurrence, and complication data. If telephone contact could not be made, the last fertility clinic visit chart entry was used for follow-up information. Pregnancy was defined as having a successful conception confirmed by the usual diagnostic tests. To calculate the time from the treatment to conception, the date of conception was estimated. The conception date was estimated by subtracting 9 months from the birth date of a successful pregnancy and 3 months from the date of spontaneous abortion because most would be in the first trimester.

• Varicocele Correction

Surgical varicocele correction was performed as outpatient surgery with general anesthesia and with use of the standard Ivanissevich procedure or lower retroperitoneal approach, which was carried out through an inguinal incision. A 3-cm skin incision was made two finger breadths above and lateral to the pubic tubercle. The incision was extended deep through the external oblique fascia to expose the cord. The internal spermatic vein and its tributaries were ligated at the level of the internal ring, sparing the artery (39,42,43).

Percutaneous embolization was performed as an outpatient procedure with conscious sedation consisting of midazolam hydrochloride and fentanyl citrate. In addition, 10 mg of nifedipine was given sublingually to reduce potential venous spasm in the gonadal vein.

Prior to 1992, embolization was generally performed by means of the right common femoral vein approach with use of a 5-F, straight catheter (Cook, Bloomington, IN) with a tip-deflecting wire (Cook) to access the left gonadal vein and a 5.5-F Simmons 3 catheter (Cook) for the right gonadal vein. After 1992, the right jugular vein was generally used, accessed with a 501 microvascular set (Cook) with use of a 21-gauge needle to puncture the internal jugular vein as previously described (30,44). A long, 25-cm, 6-F sheath (Medi-tech/Boston Scientific, Watertown, MA) was introduced, through which a 5.5-F H1H (Cook) or 5-F Berenstein (Medi-tech/Boston Scientific) catheter was used to catheterize the renal veins, usually with the aid of an angled Glidewire (Terumo, Tokyo, Japan).

Independent of which venous access approach was used, the patient was placed in the reverse Trendelenburg position and the left renal vein was catheterized. Gonadal vein opacification was then performed to visualize the incompetent spermatic vein and filling of systemic and portal collaterals. The catheter was then advanced with the use of the Glidewire to the region of the inguinal ligament. If spasm was encountered, 1-mL aliquots of nitroglycerin (100 μg/mL) were administered. In all but three cases, Gianturco coils (Cook), ranging in size from 3 mm to 12 mm, were used to embolize the gonadal vein depending on its size. In one additional case, ethanol was combined with coils because of the small size of the venous collaterals. In two additional cases, embolization balloons were used. After embolization of the left gonadal, an attempt was made to selectively catheterize and embolize the right gonadal vein.

• Analysis

Results include a description of laterality of the procedure, sperm counts prior to therapy, recurrence rate, and comparisons of change in seminal parameters for each procedure. The analyses use data from the first known varicocele procedure. All preprocedure semen analyses were averaged together, as were postprocedure analyses, and changes in these average seminal parameters were compared by pregnancy outcome and by type of procedure for density, percent increase in total count, motility, and progression. Changes in approximately continuous measures were assessed using *t* tests. Between-group comparisons were made using *t* tests with degrees of freedom based on the Satterthwait approximation. Change in progression, an ordinal measure, was dichotomized based on average increases of 1 point or more. This represents an observable increase on the 12-point measurement scale. The associations between a 1-point or greater increase in average progression and pregnancy and procedure were assessed with use of a χ^2 test. Significance, as measured by P value, was not adjusted for multiple comparisons. Data from the two procedure groups were pooled to describe the overall effect of varicocele correction when there were similar observed changes and there were no statistical differences in changes between the surgical and embolization groups.

All patients were included in the analyses, whether the procedure was successful or not. Because patients who underwent unsuccessful procedures rarely underwent seminal analysis after the procedure, comparison of seminal parameters is effectively a comparison among patients who were successfully treated. Analysis of pregnancy outcomes includes patients with failed procedures.

Survival analysis was used to compare pregnancy outcomes for the two procedures to adjust for censoring in time to pregnancy. Censoring occurs when the event being modeled (in this case pregnancy) does not occur within the follow-up period. Patients who do not achieve pregnancy during the follow-up period are censored at the time that pregnancy status was last known, either the time of last chart entry or the time of phone contact. Patients who underwent a second procedure were censored at the time of their second procedure because the hypothetical outcome from the first procedure cannot be observed beyond this point. A secondary analysis also censors patients who achieved pregnancy when the women were also receiving fertility treatment. The product-limit method was used to model the time-to-pregnancy, and the log-rank statistic was used to test for group differences.

RESULTS

• Varicocele Correction

The distribution of the anatomic side of varicocele corrections by procedure is shown in **Table 1. Table 2** shows that the preprocedure total sperm counts were similar between the surgical and embolization groups. First degree infertility, defined as never having a successful conception, was seen in 70% of the embolization patients and 76% of the surgical patients. Surgery had a failure rate of 1%, whereas the percutaneous failure rate was 12%. Among all percutaneously treated patients with suspected bilateral varicocele, 15% only underwent embolization only one side. The recurrence rate (as determined by telephone follow-up or the last fertility clinic chart entry, depending on which was later) was 16% for surgery and 4% for emboli-

Table 1
Distribution of the Anatomic Side of Varicocele Corrections

Procedure	Left	Right	Bilateral	Total
Embolization	95 (55%)	15 (9%)	63 (36%)	173
Surgical ligation	105 (71%)	1 (1%)	42 (28%)	148

Note.—Patients either had only the left, only the right, or both gonadal veins treated.

Table 2
Distribution of Patient's Preprocedural Total Sperm Counts

Procedure	Missing Patients	< 10 million	10–<20 million	20–<40 million	40+ million	Total
Embolization	14	60 (33%)	35 (19%)	40 (22%)	48 (26%)	183
Surgical ligation	6	46 (32%)	30 (21%)	32 (22%)	35 (25%)	143

zation. Minor complications for the surgical group included transient wound infections or hematomas, whereas for the percutaneous group these included extravasation of contrast material, minor contrast material reactions, severe venous spasm, hematomas, or nontarget embolizations. The minor complication rates for surgery and embolization were 7% and 11%, respectively. There was one major complication within the embolization group, which was an arrhythmia that was believed to be related to the sedation and which necessitated hospitalization. There were two major complications within the surgical group. One complication, which represented the only technical surgical failure, resulted in the loss of the patient's testicle. The other major complication was an incisional hernia, which required surgical repair.

Thirty-nine patients underwent two procedures: 18 surgical patients had a second percutaneous embolization; 19 embolization patients had a second surgical ligation; and two additional embolization patients had repeated embolization. As previously stated, patients with multiple procedures were censored at the time of their second procedure so that the analyses are restricted to pregnancies due to the first procedure. Because these patients were more likely to have a failed first procedure, they tended to have earlier censoring times. Follow-up information was available for 98% of the surgical patients with a median time of 15 months (range, 1 week to 191 months). Information was available from 87% of the embolization group with a median time of 51 months (range, 1 month to 158 months). Many more surgical ligations were performed in the early 1980s, whereas a larger number of percutaneous procedures were performed in the 1990s, as is shown in **Figure 1.** Surgical patients had more chart visit follow-up because these patients generally had their procedures longer ago and, therefore, were more difficult to contact.

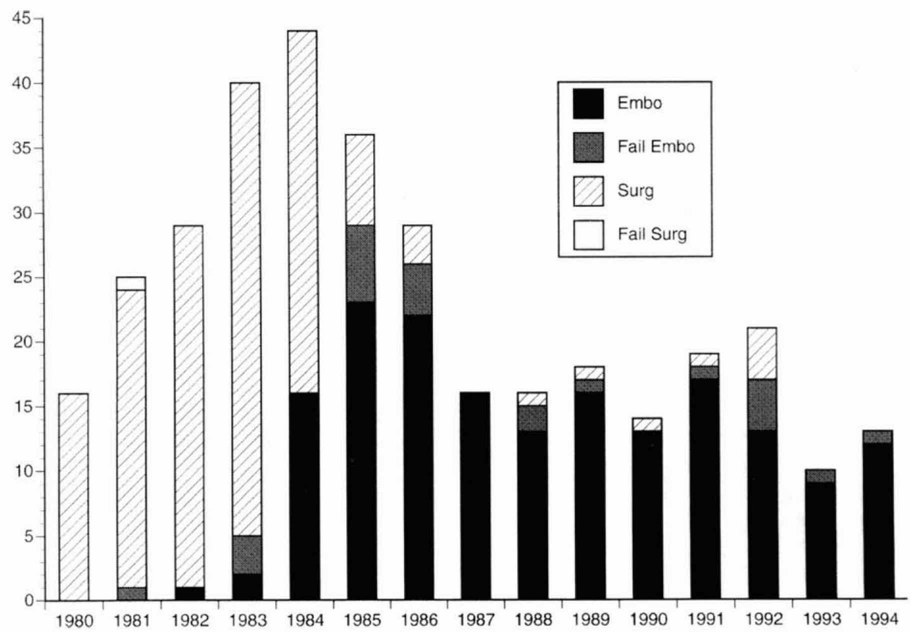

Figure 1. Frequency and distribution of successful procedures and failures during the study dates.

• Results of Semen Analyses by Procedure

Comparison of the postprocedural increases for the various seminal parameters are shown in **Table 3.** The semen volume changed very little for both groups, 0.005 mL ± 1.59 (mean ± standard deviation) and −0.292 mL ± 2.40 for embolization and surgery, respectively (P = .27). The improvement in seminal parameters between the embolization and the surgical groups demonstrates no statistical difference between procedures for sperm density, percent increase in total sperm count, motility, and progression. The embolization and surgical patients had average improvements in their total sperm counts of 26.4 ± 160.1 and 29.4 ± 129.7 million sperm, respectively, after varicocele correction. The differences in percent morphology improvement were 1.96% ± 19.9% and 9.45% ± 19.4%; however, more than 70% of the data were missing because patients with low sperm counts are more likely to lack this measure. The percent improvements in density were not significantly different between the two procedures, 156.8% and 138.5% after emboliza-

Table 3
Improvement in Seminal Parameters for Embolization versus Surgery

Seminal Improvement	Embolization	Surgery	*P* Value
Density (sperm $\times 10^6$/mL)	10.59 ± 29.94 (111)	13.30 ± 24.32 (121)	.44
% increase in total count	168.8 ± 356.1 (109)	157.9 ± 440.9 (121)	.84
Motility (% movement)	2.70 ± 16.45 (109)	3.21 ± 13.71 (117)	.80
Progression (% forward)	31 (104)	41 (117)	.11

Note.—Values are before and after differences per procedure ± standard deviation. The values in parentheses indicate the number of patients.

Table 4
Pooled Data from the Two Procedures Demonstrating Mean Changes in the Various Seminal Parameters after Varicocele Correction

Pooled Data	No. of Patients	Pre-treatment	Post-treatment	Change	*P* Value
Density (sperm $\times 10^6$/mL)	232	27.9	39.9	12.0	<.0001
Sperm total (10^6 sperm)	230	91.0	119.0	28.0	<.002
Motility (% movement)	226	38.8	41.7	3.0	<.002

tion and surgical ligation, respectively ($P = .68$).

• Combined Results of Semen Analyses

Because the type of procedure was not associated with change in seminal parameters and similar changes were observed for both groups, the seminal changes are described for the sample as a whole. There was significant improvement in the sperm measures of density, total count, and motility after varicocele correction **(Table 4).** With regards to progression, 36.2% of the patients had a 1 point or greater improvement in their rating after varicocele correction, whereas 47.5% of the patients had no change and 16.3% had decreased improvement ($n = 221$). After varicocele correction, fewer patients had decreases in progression and more had no change than would be expected if these three outcomes were equally likely ($P < .0001$; χ^2), indicating that the treatment had no significant effect on increasing progression.

• Results of Semen Analyses by Pregnancy

Data from the semen analyses were also pooled to compare sperm changes in patients whose wives became pregnant versus those who did not. **Table 5** demonstrates the relationship between preprocedure total sperm count and pregnancy. Of those patients who achieved pregnancy, 38% had sperm counts below 10 million. The results of the differences in seminal measures after varicocele correction for volume, density, and percentage change in sperm count in the patients who were able to achieve pregnancy versus those who were not are seen in **Table 6.** Changes in sperm density were significant for the pregnancy group compared to the nonpregnancy group, 16.99×10^6 sperm/mL versus 9.01×10^6 sperm/mL, respectively ($P = .03$). There was also a significant difference in percent improvement in total sperm count between the two groups. Patients who were unable to achieve pregnancy had an average percent increase in total sperm count of 104.5%, whereas those patients who were able to achieve pregnancy had an improvement of 263%, a 2.6-fold increase ($P = .02$). There was a small, but significant, improvement in the percent motile forms after varicocele correction for those patients who were able to achieve pregnancy versus those who were unable, 6.12% versus 1.03%, respectively ($P = .02$). There was a significant association between pregnancy and improved progression, with only 30% of the patients who were unable to achieve pregnancy improving in progression, and 46% of the patients who were able to achieve pregnancy improving in progression ($P = .02$).

• Pregnancy Failure Analysis

Patients who underwent both successful and unsuccessful procedures were included in the analysis. Thirty-nine percent of the embolization patients and 34% of the surgery patients achieved pregnancy after varicocele correction. Life-table analysis of pregnancy rates demonstrated a median time to pregnancy for both the surgical and embolization groups of 42 months. The survival analysis did not find a difference in pregnancy rates for either groups, as seen in **Figure 2.** An attempt was made to segregate patients who had only varicocele correction for treatment of infertility without known female intervention; however, very few pregnancies satisfied this criteria. Again, survival did not reveal a difference between the surgical and embolization groups ($P = .42$).

Table 5
Distribution of Preprocedure Sperm Counts versus Pregnancy*

	Missing Patients	< 10 million	10–<20 million	20–<40 million	40+ million	Total
Not Pregnant	10	59 (31%)	37 (19%)	45 (24%)	50 (26%)	191
Pregnant	5	43 (38%)	20 (18%)	23 (21%)	26 (23%)	112

* Pregnancy was not significantly associated with the preprocedure sperm count (P = .61).

Table 6
Improvement in Seminal Parameters between Patients Who Were Able versus Patients Who Were Unable to Achieve Pregnancy

Seminal Improvement	Pregnancy	No Pregnancy	*P* Value
Density (sperm ×10⁶/mL)	16.99 ± 25.98 (87)	9.01 ± 26.61 (145)	.03
% increase in total count	263.0 ± 571.2 (85)	104.5 ± 239.8 (145)	.02
Motility (% movement)	6.12 ± 15.97 (86)	1.03 ± 14.19 (140)	.02
Progression (% forward)	46 (83)	30 (138)	.02

Note.—Values are before and after differences per procedure ± standard deviation.
The values in parentheses indicate the number of patients.

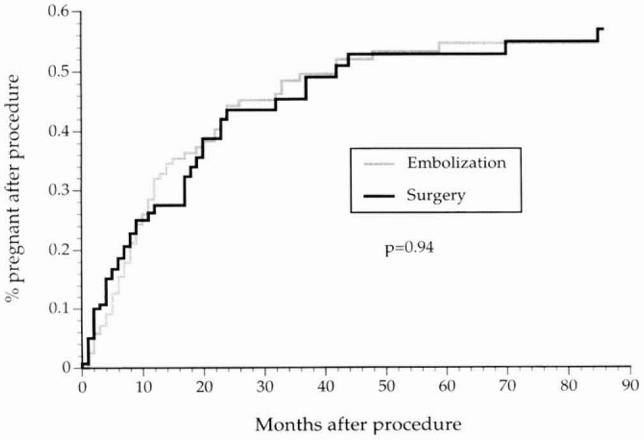

Figure 2. Estimated pregnancy rates among patients undergoing varicocele correction based on survival analysis.

DISCUSSION

In evaluating male patients for infertility, the semen analysis is an essential component of the investigation. Several qualitative and quantitative analyses are performed, including volume of ejaculate, sperm density, total sperm counts, morphology, motility, and progression. It is difficult to establish a clear cut distinction between fertile and infertile seminal parameters, although there is a positive association between semen characteristics and the success of pregnancy (45–47). Approximately 40% of patients with less than 5 × 10^6 motile sperm/mL achieve pregnancy within 12 months (45). In addition, 50% of men with 60%–80% morphologically abnormal sperm, and more than 20% of men with only 20% motile sperm had living children at 20-year follow-up (46). Dunphy et al found that the only significant predictor of pregnancy was concentration of spermatozoa showing progressive motile sperm with normal head movement (48).

One of the earliest investigations into the effect of a varicocele on seminal parameters was by MacLeod who evaluated pre- and postligation semen analyses in 200 patients for the effect of varicocele on counts, motility, and morphology (9). He described the stress pattern of sperm morphology, which was composed of tapering and amorphous cells and the exfoliation of immature cells of the germinal line. Although best known for its association with varicocele, it may also be seen with other conditions, such as congenital adrenal hyperplasia, alcohol abuse, and after a febrile or viral illness. After ligation, he found the stress pattern diminishes and overall sperm morphology improves, with moderate to marked improvement seen in counts with the most striking improvement in motility. Since then, multiple studies have evaluated the effect of varicocele on semen quality.

Although a few studies question the effect of varicocele correction on sperm quality and fertility, the majority of studies support the beneficial effect of varicocele ligation (10–13). Schlesinger et al performed a meta-analysis of the published reports evaluating the effect of varicocele correction on seminal parameters and pregnancy (13).

Few of the studies were "randomized-controlled," with the majority having significant limitations as described by Schlesinger. With regard to sperm density studies, they reviewed 16 studies in which 12 demonstrated statistically significant improvements in sperm density, with average improvements ranging from 5.2 million/mL to 64 million/mL. Sperm motility was reviewed in 12 studies, with only five demonstrating statistically significant changes ranging from 4.4% to 6.1%. The majority of these studies demonstrated improved motility associated with improved density. The effects of varicocele on morphology was reviewed from 10 studies, with half demonstrating statistically improved morphology after correction ranging from 3.7% to 7%, again associated with improved density. With regard to pregnancy, they reviewed 65 studies involving 6,983 patients. The average pregnancy rate was 32.24% with a weighted rate of 36.95%, similar to our findings. The authors concluded that varicocele correction does have a beneficial effect on sperm density (13). This effect is greater with densities above 10 million/mL, with a ceiling effect at 40 million/mL. Motility and morphology may improve after correction but it is usually associated with a significant rise in density (13).

Our results demonstrated similar success in improving seminal parameters and pregnancy between surgery and percutaneous embolization with findings in keeping with the work of Schlessinger et al. As expected, semen volume did not change much after correction. Significant postprocedural improvements were seen in counts, density, motility, and progression for both procedures, supporting the role of varicocele in infertility. No significant differences in improvements in seminal parameters between surgery and embolization were seen for all analyzed parameters. Changes in morphology could not be adequately evaluated in our study because there was a large amount of missing data due to the fact that morphology was not recorded in the majority of specimens with total counts below 10 million. Because both procedures occlude the gonadal vein at its inferior portion, one would expect similar sperm changes. These findings are consistent with the effect both procedures have on the gonadal vein.

Several studies have also tried to assess differences in outcome between percutaneous and surgical procedures. Two of the investigators performed a retrospective analysis similar to ours with fewer patients. Parsch et al compared the results of 31 left-sided embolizations with a sclerosing agent to 72 cases of retroperitoneal ligations (49). The sperm quality in the surgical and embolization groups significantly improved, although the surgical group initially improved slightly faster. The sclerotherapy and surgical pregnancy rates were 25% and 14%, respectively, but were not significantly different. Another retrospective study was performed by Dewire et al, which compared the clinical outcome and cost considerations of 81 patients demonstrating similar and significant semen improvements between the two procedures with an embolization and surgical pregnancy rate of 38% and 41%, respectively (40). They also demonstrated significant improvement in semen characteristics between patients, with an average increase in sperm density of 19.3 million/mL for those who achieved pregnancy versus 1.2 million/mL for those patients who did not. These findings are similar to ours (16.99 million/mL for patients who achieved pregnancy versus 9.01 million/mL for patient who did not). Although they did not find differences in cost between the two procedures, they recommended embolization because of reduced patient postoperative discomfort and more rapid recovery time (40).

Three attempts at prospective randomized investigations into the differences between the two procedures have been performed. Nieschlag et al performed a prospective randomized trial with 71 patients comparing high retroperitoneal ligation to embolization with tissue adhesive (50). They found only significant changes in density and motility. There was no significant difference in pregnancy rates, 29% and 33% for surgery and embolization, respectively. Yavetz et al randomized 137 men to three procedures, two types of high ligation and coil embolization (51). Although all procedures resulted in significant increases in sperm quality, the Ivanissevich retroperitoneal ligation was associated with greater improvement with a higher pregnancy rate; 38.2% compared to 20.6% for embolization. Even though it was a prospective study, the recurrence rates were extremely high for all of the procedures, 24% for coil embolization and 37% for surgery. They describe placement of one or two 3-mm or 5-mm coils into the gonadal vein. Our patients generally undergo embolization with a greater number of coils of larger size to ensure adequate occlusion. Given the recurrence rate and the small number of coils used for embolization, there is concern about adequate therapy in all of the groups. Finally, a prospective study published by Sayfan et al randomized 119 patients to high retroperitoneal ligation, lower inguinal ligation, and embolization (52). They demonstrated only slight improvement in the seminal variable, with statistical significance only in the surgical groups. Although the pregnancy rates were similar for all groups, they recommended inguinal ligation because of its better success rate compared to the other two procedures. No evidence for recurrence was given for any of the procedures, making complete comparison difficult.

Given the difference in technical success between the two procedures, one might expect the surgical group to perform better. However, the surgical group demonstrated a greater recurrence rate. Because this study included failed procedures in analysis of pregnancy outcomes, our findings suggest that even with the greater failure rate of embolization, the procedures appear to be clinically equivalent for pregnancy outcome; overall pregnancy rates, median time to pregnancy, and estimated survival curves were similar for both groups. When embolization is successful, all collaterals are occluded because they are visualized with contrast material. A percutaneous failure is obvious when there is a failed catheterization of the vein. For surgery, a vein is always ligated so that the technical success rate is high, however, additional parallel veins or small collaterals may remain, resulting in a recurrence. Therefore, the higher technical success rate of surgery appears to be negated by the increased recurrence rate, which may actually represent an unknown technical partial failure.

Our recurrence rates are in keeping with other studies that report rates of 2%–24% for embolization and 0%–37% for surgery (18,23,37,51). Furthermore, embolization has the benefits of requiring only conscious sedation without general anesthesia, and only a venous puncture. These two elements allow quick patient recovery with minimal discomfort compared to surgery. After percutaneous embolization, patients generally return to work in 1–2 days versus several days to weeks for a surgical procedure (40). Another benefit of embolization is that it allows for both left and right varicocele to be treated from the same venous access. Because we evaluate both sides for venous reflux, we are able to diagnose and treat bilateral varicoceles. Surgical ligation relies on the clinical diagnosis of varicocele and requires an additional incision for treatment.

The intent of this study was to compare the outcomes of surgical versus percutaneous varicocele correction in infertile men with use of sperm parameters for a quantitative analysis and for pregnancy outcomes. The primary limitations in this study are its retrospective design and differences in median follow-up time. Unfortunately, the emotional aspect of pregnancy and the desperation of many couples make prospective randomization difficult. Even those studies that have been able to use a prospective randomized method have been flawed (13). At our institution, surgical varicocele correction began in the early 1980s but was quickly supplanted by percutaneous embolization, mostly because of patient preference **(Fig 1).** Because of this change, and the fact that these patients represent a mobile group of individuals, direct telephone follow-up was more difficult in these early surgical patients, resulting in only obtaining clinical chart follow-up. Embolization was performed more often in the later years, enabling more successful telephone contact.

An additional potential limitation of the study caused by the change in distribution of the procedures is improvement in female fertilization techniques, which may have biased the pregnancy results to favor embolization. The survival analysis that censored patients with known female intervention did not demonstrate a statistically significant difference between the two procedures; however, information about female manipulation was very limited. Another potential limitation of the study relates to the use of US to confirm the diagnosis of small varicoceles. Because the resolution of US has improved over the years of the study, smaller varicoceles might have been embolized later in the study, while the earlier ligated patients may have had larger varicoceles. Although this may have skewed the population of patients treated, this seems to represent a negligible effect because the preprocedure sperm counts were nearly identical in the two groups, as seen in **Table 2.**

In conclusion, our retrospective review of the infertility records of 349 patients found no significant difference in the improvement in seminal parameters of those patients who underwent percutaneous embolization versus surgical ligation for the treatment of infertility. The primary parameters that increased were sperm density, total counts, and motility. In addition, the analyses demonstrated a significant difference in the improvement of these seminal parameters in those patients achieving pregnancy versus those who did not, supporting the concept that varicocele impairs seminal production and correction improves semen quality resulting in increased fertility. Given the greater patient comfort, ease of bilateral treatment, and reduced recovery time compared to surgery, varicocele embolization should be considered as the initial treatment of varicocele for the treatment of infertility.

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