

Treatment of Palpable Varicocele in Infertile Men: A Meta-analysis to Define the Best Technique

Review

SELAHITTIN ÇAYAN,* SHAVKAT SHAVAKHABOV,† AND ATEŞ KADIOĞLU†

From the *Department of Urology, University of Mersin School of Medicine, Mersin, Turkey; and the †Section of Andrology, Department of Urology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey.

ABSTRACT: To date, there have been no randomized, controlled, prospective clinical studies that compare various techniques to describe the best method for the treatment of varicocele in infertile men. This meta-analysis aims to address the best treatment modality for palpable varicocele in infertile men. A MEDLINE search was performed for articles published between January 1980 and April 2008, and we analyzed 36 studies reporting postoperative spontaneous pregnancy rates and/or complication rates after varicocele repair using various techniques in infertile men with palpable unilateral or bilateral varicocele. Spontaneous pregnancy rates and postoperative complications such as hydrocele formation, recurrence, or persistence were compared among the techniques. In addition, interventional failure with radiologic embolization and reported complications with the laparoscopic approach were reviewed. Overall spontaneous pregnancy rates were 37.69% in the Palomo technique series, 41.97% in the microsurgical varicocelelectomy techniques, 30.07% in the laparoscopic varicocelelectomy techniques, 33.2% in the radiologic embolization, and 36% in the macroscopic inguinal (Ivanissevich) varicocelelectomy series, revealing significant differences among the techniques ($P = .001$). Overall recurrence rates were 14.97% in the Palomo technique series,

1.05% in the microsurgical varicocelelectomy techniques, 4.3% in the laparoscopic varicocelelectomy techniques, 12.7% in the radiologic embolization, and 2.63% in the macroscopic inguinal (Ivanissevich) or subinguinal varicocelelectomy series, revealing significant difference among the techniques ($P = .001$). Overall hydrocele formation rates were 8.24% in the Palomo technique series, 0.44% in the microsurgical varicocelelectomy techniques, 2.84% in the laparoscopic varicocelelectomy, and 7.3% in the macroscopic inguinal (Ivanissevich) or subinguinal varicocelelectomy series, revealing significant difference among the techniques ($P = .001$). We conclude that the microsurgical varicocelelectomy technique has higher spontaneous pregnancy rates and lower postoperative recurrence and hydrocele formation than conventional varicocelelectomy techniques in infertile men. However, prospective, randomized, and comparative studies with large number of patients are needed to compare the efficacy of microsurgical varicocelelectomy with that of other treatment modalities in infertile men with varicocele.

Key words: Varicocele repair, varicocelelectomy, pregnancy, recurrence, hydrocele.

J Androl 2009;30:33–40

Varicocele is the most commonly seen and correctable cause of male factor infertility (Dubin and Amelar, 1971; Schlesinger et al, 1994). Although the incidence of varicocele in the general male population is approximately 15%, it is implicated as a factor in about one-third of infertile males (Nagler et al, 1997).

Although many individual studies report improvement after varicocele repair, there are still conflicting opinions as to whether a varicocele repair improves fertility. The Cochrane database suggested no benefit of varicocele treatment on a couple's chances of conception compared with control subjects (Evers and Collins, 2004). However, this meta-analysis included men with subclinical varicoceles or normal semen analyses.

Physical examination is the reference standard to diagnose varicoceles in subfertile men. Additional radiologic imaging is not necessary to diagnose subclinical varicocele, because only a varicocele detected by physical examination should be considered potentially significant (Jarow et al, 2002; Sharlip et al, 2002; Dohle et al, 2005). When clinical palpable varicocele coexists with impaired semen quality, surgical repair may potentially restore spermatogenesis and fertility. Recent meta-analyses have suggested that varicocele repair has a beneficial effect on fertility status in infertile men with palpable varicocele (Ficarra et al, 2006; Marmar et al, 2007). Ficarra et al (2006) reviewed randomized clinical trials for varicocele repair and found a significant increase in pregnancy rate in patients who underwent varicocele treatment (36.4%) compared with patients having no treatment (20%). Marmar et al (2007) reported a 33% pregnancy rate in patients who underwent surgical varicocelelectomy and a 15.5% pregnancy in the controls receiving no varicocelelectomy.

Correspondence to: Dr Selahittin Çayan, Associate Professor of Urology, University of Mersin School of Medicine, Department of Urology, 33079-Mersin, Turkey (e-mail: selcayan@mersin.edu.tr).

Received for publication June 13, 2008; accepted for publication September 4, 2008.

DOI: 10.2164/jandrol.108.005967

Treatment options for varicocele in infertile men include open surgical, radiologic, and laparoscopic approaches (Palomo, 1949; Ivanissevich, 1960; Nagler et al, 1997; Çayan et al, 1999, 2000, 2001, 2002; Tefekli et al, 2001). Agarwal et al (2007) analyzed 17 studies reporting outcomes of microsurgical varicocelectomy and high ligation series for varicocele treatment in infertile men, and they demonstrated that surgical varicocelectomy significantly improves semen parameters in infertile men with palpable varicocele and abnormal semen analysis. To date, there have been no randomized, controlled, prospective clinical studies that compare various techniques to describe the best method for the treatment of varicocele in infertile men. The best treatment modality for varicocele can be chosen only after comparing the spontaneous pregnancy outcomes and complication rates of these approaches. This meta-analysis aims to address the best treatment modality of palpable varicocele in infertile men.

Materials and Methods

A MEDLINE search was performed for articles published between January 1980 and April 2008, using the key words *varicocele repair*, *infertile men*, *varicocelectomy*, *techniques*, *pregnancy*, *recurrence*, and *hydrocele*. We pooled 107 studies reporting outcomes of varicocele treatment in infertile men. We included only studies of varicocele repair done for palpable unilateral or bilateral varicocele in infertile men with abnormal semen parameters. Studies including azoospermic men who underwent varicocele repair were excluded from the review. Studies consisting of subclinical varicocele were not included in this review, because only clinical varicocele should be considered potentially significant according to European Association of Urology, American Urological Association, and American Society for Reproductive Medicine recommendations (Jarow et al, 2002; Sharlip et al, 2002; Dohle et al, 2005). Studies in which either the technique of varicocele repair or the number of patients undergoing varicocele repair with various techniques was not reported exactly were excluded from the analyses. In addition, varicocelectomy techniques done with loupe magnification of originally macroscopically described techniques were excluded from the analyses.

Of the 107 studies reporting outcomes of varicocele treatment in infertile men, 36 studies met the inclusion criteria. We analyzed these 36 studies that reported postoperative spontaneous pregnancy rates and/or complication rates after varicocele repair using various techniques in infertile men with palpable varicocele. Pregnancies achieved with assisted reproductive technologies after varicocele repair were not included in the analyses. We did not include the data on postoperative improvement in semen parameters between the techniques, because some studies have reported improvement as a percentage, and some studies reported an increase or decrease in semen parameters from the mean value. Therefore,

comparison of the seminal improvement after varicocele repair would not be unique among the techniques used for varicocele repair.

Postoperative comparison among the techniques used for varicocele repair included pregnancy rates and complications such as hydrocele formation or recurrence or persistence of varicocele. In addition, interventional failure with the radiologic approach and major complications with the laparoscopic approach were reviewed. To compare spontaneous pregnancy rates among the techniques used for varicocele repair, the approaches in this review included retroperitoneal high ligation (Palomo technique) with 10 studies (Cockett et al, 1984; Baker et al, 1985; Menchini-Fabris et al, 1985; Rageth et al, 1992; Hirokawa et al, 1993; Nieschlag et al, 1993; Madgar et al, 1995; Shlansky-Goldberg et al, 1997; Çayan et al, 2000; Watanabe et al, 2005), microsurgical subinguinal or inguinal technique with 12 studies (subinguinal, 7; inguinal, 5; 1 study to compare both approaches; Goldstein et al, 1992; Ito et al, 1993; Marmar and Kim, 1994; Çayan et al, 2000, 2002; Jungwirth et al, 2001; Kamal et al, 2001; Perimenis et al, 2001; Kumar and Gupta, 2003; Orhan et al, 2005; Watanabe et al, 2005), laparoscopic varicocelectomy with 5 studies (Mehan et al, 1992; Jarow et al, 1993; Enquist et al, 1994; Milad et al, 1996; Watanabe et al, 2005), radiologic embolization with 6 studies (Vermeulen et al, 1986; Yavetz et al, 1992; Nieschlag et al, 1993; Ferguson et al, 1995; Shlansky-Goldberg et al, 1997; Nabi et al, 2004), and macroscopic inguinal (Ivanissevich) with 3 studies (Newton et al, 1980; Marks et al, 1986; Yavetz et al, 1992). To compare postoperative recurrence and hydrocele formation rates among the techniques used for varicocele repair, the analysis included retroperitoneal high ligation with 4 studies (Yavetz et al, 1992; Çayan et al, 2000; Ghanem et al, 2004; Watanabe et al, 2005), microsurgical technique with 10 studies (subinguinal, 6; inguinal, 4; 1 study to compare both approaches; Goldstein et al, 1992; Ito et al, 1993; Marmar and Kim, 1994; Çayan et al, 2000; Jungwirth et al, 2001; Kamal et al, 2001; Ghanem et al, 2004; Orhan et al, 2005; Watanabe et al, 2005), laparoscopic varicocelectomy with 5 studies (Mehan et al, 1992; Jarow et al, 1993; Enquist et al, 1994; Milad et al, 1996; Watanabe et al, 2005), radiologic embolization with 3 studies (Yavetz et al, 1992; Nabi et al, 2004; Tanahatoc et al, 2004), and macroscopic inguinal (Ivanissevich) or subinguinal varicocelectomy with 2 studies (Yavetz et al, 1992; Ross and Ruppman, 1993). The comparison of hydrocele formation for radiologic embolization approaches was not included in the present review, because those studies did not include the postprocedure hydrocele formation rate. In addition, major complications in the laparoscopic approach with 5 studies (Mehan et al, 1992; Jarow et al, 1993; Enquist et al, 1994; Milad et al, 1996; Watanabe et al, 2005), and unsuccessful intervention in the radiologic embolization approach with 6 studies (Gonzalez et al, 1981; Yavetz et al, 1992; Feneley et al, 1997; Nabi et al, 2004; Tanahatoc et al, 2004) were reviewed.

Statistical analyses were performed using Pearson's χ^2 test to compare pregnancy rates, complications such as hydrocele formation or recurrence or persistence of varicocele, and interventional success among the techniques. *P* values of $<.05$ were considered statistically significant.

Table 1. Postoperative spontaneous pregnancy rates among the techniques

Technique	Authors	n ^a	Pregnancies, No. ^b (%)
Palomo	Çayan et al, 2000	232	444/1178 (37.69)
	Menchini-Fabris et al, 1985	324	47/140 (33.57)
	Madgar et al, 1995	25	11/25 (44)
	Watanabe et al, 2005	50	18/50 (35.8)
	Shlansky-Goldberg et al, 1997	149	50/149 (34)
	Nieschlag et al, 1993	38	11/38 (29)
	Hirokawa et al, 1993	58	32/58 (55.2)
	Rageth et al, 1992	55	23/55 (42)
	Cockett et al, 1984	56	14/56 (25)
	Baker et al, 1985	283	127/283 (45)
Microscopic Subinguinal	Watanabe et al, 2005	66	981/2337 (41.97)
	Jungwirth et al, 2001	272	34/66 (50.9)
	Orhan et al, 2005	65	130/272 (48)
	Kumar and Gupta, 2003	100	22/65 (33)
	Kamal et al, 2001	159	17/50 (34)
	Marmar and Kim, 1994	159	76/159 (48)
	Perimenis et al, 2001	466	186/466 (35.6)
	Orhan et al, 2005	146	67/146 (46.6)
	Ito et al, 1993	147	60/147 (41)
	Ito et al, 1993	31	17/31 (56)
Inguinal	Goldstein et al, 1992	357	152/357 (43)
	Çayan et al, 2000	236	57/133 (42.85)
	Çayan et al, 2002	540	163/445 (36.6)
	Watanabe et al, 2005	33	40/133 (30.07)
	Mehan et al, 1992	51	12/30 (40.4)
Laparoscopic	Enquist et al, 1994	14	16/38 (42)
	Jarow et al, 1993	19	2/14 (14.3)
	Milad et al, 1996	32	5/19 (26)
	Yavetz et al, 1992	51	5/32 (16)
	Nabi et al, 2004	71	167/503 (33.2)
Radiologic embolization	Shlansky-Goldberg et al, 1997	197	10/51 (20.6)
	Ferguson et al, 1995	87	18/45 (40)
	Nieschlag et al, 1993	33	77/197 (39)
	Vermeulen et al, 1986	90	29/87 (33)
	Newton et al, 1980	149	11/33 (33)
	Yavetz et al, 1992	43	22/90 (24)
Macroscopic inguinal	Marks et al, 1986	130	116/322 (36)
	Newton et al, 1980	149	50/149 (34)
	Marks et al, 1986	130	50/130 (39)
	Yavetz et al, 1992	43	16/43 (38.2)

^a Reported number of patients in the series.

^b Reported number of patients who were assessed for spontaneous pregnancy.

Results

Of the 4473 men, 1748 (39.07%) initiated spontaneous pregnancy with their partners after treatment of varicocele with various techniques. Postoperative spontaneous pregnancy rates according to the techniques are listed in Table 1. The highest spontaneous pregnancy rate was seen with the microsurgical techniques. Overall spontaneous pregnancy rates were 37.69% in the Palomo technique series, 41.97% in the microsurgical varicocelectomy techniques, 30.07% in the laparoscopic varicocelectomy techniques, 33.2% in the radiologic embolization approach, and 36% in the macroscopic

inguinal (Ivanissevich) varicocelectomy series, revealing significant difference among the techniques ($P = .001$).

Postoperative recurrence and hydrocele formation rates according to the techniques are listed in Table 2. Overall recurrence rates were 14.97% in the Palomo technique series, 1.05% in the microsurgical varicocelectomy techniques, 4.3% in the laparoscopic varicocelectomy techniques, 12.7% in the radiologic embolization, and 2.63% in the macroscopic inguinal (Ivanissevich) or subinguinal varicocelectomy series, revealing significant difference among the techniques ($P = .001$).

Overall hydrocele formation rates were 8.24% in the Palomo technique series, 0.44% in the microsurgical

Table 2. Postoperative recurrence and hydrocele formation rates among the techniques

Technique	Authors	n ^a	Recurrence, No. ^b (%)	Hydrocele, No. ^c (%)
Palomo			65/434 (14.97)	19/241 (8.24)
	Çayan et al, 2000	232	36/232 (15.51)	12/132 (9.09)
	Watanabe et al, 2005	50	6/50 (12)	5/50 (10)
	Ghanem et al, 2004	109	8/109 (7)	7/109 (6.4)
Microscopic	Yavetz et al, 1992	43	15/43 (35)	NA
			23/2184 (1.05)	9/2001 (0.44)
	Subinguinal			
	Watanabe et al, 2005	66	0	0
	Ghanem et al, 2004	304	0	5/304 (1.6)
	Jungwirth et al, 2001	272	4/272 (1.4)	1/272 (0.3)
	Orhan et al, 2005	65	2/65 (3)	0
	Kumar and Gupta, 2003	100	1/50 (2)	0
	Marmar and Kim, 1994	466	4/606 (0.82)	1/466 (0.2)
	Inguinal			
Orhan et al, 2005	147	1/147 (0.68)	0	
Ito et al, 1993	56	2/56 (3.57)	0	
Goldstein et al, 1992	382	4/382 (0.6)	0	
Çayan et al, 2000	236	5/236 (2.11)	1/143 (0.69)	
Laparoscopic			4/93 (4.3)	5/176 (2.84)
	Watanabe et al, 2005	33	2/33 (6.1)	1/33 (3.3)
	Mehan et al, 1992	51	NA	1/51 (2)
	Enquist et al, 1994	14	1/14 (7.14)	0
	Jarow et al, 1993	46	1/46 (2.17)	0
	Milad et al, 1996	32	NA	3/32 (9.4)
Radiologic embolization			13/102 (12.7)	NA
	Yavetz et al, 1992	51	12/51 (24)	NA
	Nabi et al, 2004	71	1/51 (2)	NA
Macroscopic inguinal or subinguinal			16/608 (2.63)	41/565 (7.3)
	Ross and Ruppman, 1993	565	0	41/565 (7.3)
	Yavetz et al, 1992	43	16/43 (37)	NA

Abbreviation: NA, not applicable.

^a Reported number of patients in the series.

^b Reported number of patients who were examined for postoperative recurrence.

^c Reported number of patients who were examined for postoperative hydrocele.

varicocelectomy techniques, 2.84% in the laparoscopic varicocelectomy, and 7.3% in the macroscopic inguinal (Ivanisovich) or subinguinal varicocelectomy series, revealing significant difference among the techniques ($P = .001$).

As shown in Table 3, of the 314 patients who underwent radiologic embolization, 13.05% had an unsuccessful intervention. As shown in Table 4, laparoscopic varicocelectomy had complications in 6 (7.59%) of the 79 patients. Reported complications included scrotal subcutaneous emphysema in 2 patients, inferior epigastric artery injury in 1 patient, severe hemorrhage necessitating blood transfusion in 1 patient, epididymitis in 1 patient, and severe scrotal pain in 1 patient.

Table 3. Unsuccessful intervention in radiologic embolization approach

Authors	n	Unsuccessful Intervention, No. (%)
Tanahatoc et al, 2004	61	11 (18)
Nabi et al, 2004	71	3 (4.2)
Feneley et al, 1997	84	16 (19)
Ferguson et al, 1995	87	8 (9)
Gonzalez et al, 1981	11	3 (27.3)
Total	314	41 (13.05)

Discussion

Recent meta-analyses suggested that a surgical varicocelectomy improved the spontaneous pregnancy rates for infertile men with low semen parameters and palpable varicoceles (Ficarra et al, 2006; Marmar et al, 2007). Agarwal et al (2007) analyzed 17 studies reporting outcomes of microsurgical varicocelectomy and high ligation series for varicocele treatment in infertile men, and they demonstrated that surgical varicocelectomy significantly improves semen parameters in infertile men with palpable varicocele and abnormal semen analysis. However, to date, no system-

Table 4. Reported complications with laparoscopic approach

Authors	n	No. and Reported Complications (%)
Watanabe et al, 2005	33	2 scrotal subcutaneous emphysema (6.1)
Enquist et al, 1994	14	1 inferior epigastric artery injury, 1 epididymitis, 1 blood transfusion (21.4)
Milad et al, 1996	32	1 severe scrotal pain (3.1)
Total	79	6 (7.59)

atic review or meta-analysis has determined which technique is the best to treat clinical palpable varicoceles in infertile men. This meta-analysis aims to address the best treatment modality of clinical palpable varicocele in infertile men.

Treatment Options for Varicocele in Infertile Men—Varicocele may be treated with many different modalities, including radiologic, laparoscopic, and open surgical approaches (Palomo, 1949; Ivanissevich, 1960; Nagler et al, 1997; Çayan et al, 1999, 2000, 2001, 2002; Tefekli et al, 2001). The best treatment modality for varicocele in infertile men should include higher seminal improvement and spontaneous pregnancy rates with lower rates of complications such as recurrence or persistence, hydrocele formation, and testicular atrophy. Therefore, the ideal technique should aim for ligation of all internal and external spermatic veins with preservation of spermatic arteries and lymphatics.

Radiologic embolization (balloon or coil) or sclerotherapy of spermatic veins is an alternative treatment, and is promoted as a minimally invasive procedure with less pain in infertile men with varicocele. However, it has interventional failure up to 27%, and requires sufficient skill and experience (Nagler et al, 1997). In the present review, 13% had an unsuccessful intervention with radiologic embolization. Postprocedure complications include contrast extravasation, vascular perforation, coil or balloon migration, thrombosis of the pampiniform plexus, and an allergy to contrast agents. Radiation exposure is another disadvantage of the procedure. The overall complication rate of radiologic approach in the treatment of varicocele is 11% (Pryor and Howards, 1987). Radiologic approach is considered as an alternative treatment in persistent or recurrent varicocele after open surgery (Sharlip et al, 2002). However, current studies suggest that microscopic varicocele repair in persistent or recurrent varicocele after open surgery has resulted in significant improvement in semen parameters, and 23% of the couples achieved spontaneous pregnancy (Grober et al, 2004).

Laparoscopic varicocelectomy can provide higher magnification with low incidence of hydrocele formation. However, external spermatic veins, the second cause of varicocele recurrence, cannot be approached by the laparoscopic technique. In addition, the laparoscopic approach requires skills that take a long time to learn, and is more invasive than an open microsurgical approach, requiring general anesthesia and placement of a urethral catheter. It also has a risk of intestinal and major vascular injuries during needle or trocar insertion that might require laparotomy. In the present review, 7.6% of the patients had major complications with laparoscopic varicocelectomy. Higher cost and the need

to take a day off work are other disadvantages of the laparoscopic approach (Enquist et al, 1994).

Open surgical approaches include high retroperitoneal, modified Palomo, inguinal, and subinguinal approaches done macroscopically or microscopically. The high retroperitoneal or modified Palomo technique exposes the internal spermatic vein within the retroperitoneum after it exits the inguinal channel (Nagler et al, 1997). The advantage of this technique is ligation of a reduced number of veins at this higher level, which might minimize the potential for recurrence of varicocele. However, a disadvantage of this technique is that it does not allow identification and ligation of the external spermatic vein as the second cause of recurrent and persistent varicoceles after varicocelectomy (Coolsaet, 1980; Murray et al, 1986). This technique is advantageous in patients with previous inguinal surgery, because it minimizes incidental injury to the testicular artery and ilioinguinal nerve.

The high retroperitoneal (Palomo), radiologic, and laparoscopic approaches can be performed for internal spermatic vein ligation. The inguinal (Ivanissevich) and subinguinal approaches can be also used to ligate the external spermatic veins that may contribute to the varicocele. Therefore, inguinal or subinguinal approaches have several advantages over the open retroperitoneal, radiologic, and laparoscopic approaches. Although internal and external spermatic veins can be identified via inguinal/subinguinal approaches macroscopically, use of magnification allows identification and preservation of internal spermatic artery and lymphatic vessels, which might prevent testicular atrophy and hydrocele formation, respectively (Raman and Goldstein, 2004; Hopps et al, 2003).

Microsurgical varicocele repair can be performed via an inguinal or subinguinal approach. Although the subinguinal approach to microsurgical varicocelectomy obviates the need to open the aponeurosis of the external oblique, it is associated with a greater number of internal spermatic veins and arteries compared with the inguinal approach. Subinguinal microscopic varicocelectomy has disadvantages, requiring more skill because of a higher number of internal spermatic vein channels and posing higher risk of arterial injury because of a smaller-diameter artery at the level of the external inguinal ring. The primary branch point for the testicular artery occurs most commonly during its course through the inguinal canal. Internal spermatic arteries at the subinguinal level are more than 3 times as likely to be surrounded by a dense network of adherent veins when they are identified than at the inguinal level (Hopps et al, 2003). Inguinal microsurgical varicocelectomy performed at the level of the internal inguinal ring has the advantages of fewer internal spermatic veins and

arteries with larger diameter at the proximal level (Beck et al, 1992; Hopps et al, 2003), which enables the surgeon to encounter fewer veins and artery branches and to shorten the operating time, as well as facilitating the simplification of the operation. However, the main disadvantage of the inguinal approach is the need to open the aponeurosis of the external oblique, which might result in more pain and a longer time before the patient can return to work.

Complications After Varicocele Repair—Postoperative complications vary with surgical techniques. Hydrocele formation is the most commonly seen complication of varicocele repair, with the incidence ranging from 0% to 10% in infertile men. In the present meta-analysis, the lowest hydrocele formation rate seen was an overall rate of 0.44% in the microsurgical series, whereas the rate was 8.24% in the Palomo technique series, 2.84% in the laparoscopic varicoectomy series, and 7.3% in the macroscopic inguinal (Ivanissevich) or subinguinal varicoectomy series.

Recurrences after varicocele repair are reported in the range of 0%–35%, varying with varicoectomy techniques used. Venographic studies demonstrated recurrent varicocele to occur via periarterial, parallel inguinal, midperitoneal, gubernacular, and transscrotal collateral veins (Murray et al, 1986). In the present study, overall recurrence rates were 14.97% in the Palomo technique series, 1.05% in the microsurgical varicoectomy techniques, 4.3% in the laparoscopic varicoectomy techniques, 12.7% in the radiologic embolization approach, and 2.63% in the macroscopic inguinal (Ivanissevich) or subinguinal varicoectomy series, revealing a significant lower recurrence rate with the microsurgical varicoectomy series.

In comparative studies, Ghanem et al (2004) compared complication and recurrence rates between microsurgical subinguinal varicoectomy and retroperitoneal varicoectomy in infertile men, and reported 1.6% and 6.4% hydrocele formation rates, respectively, and 0% and 7% postoperative recurrence rates, respectively. Watanabe et al (2005) reported a recurrence rate of 0% with subinguinal microsurgical varicoectomy, whereas the rate was 6.1% with laparoscopic approach and 12% with the Palomo technique. Çayan et al (2000) compared complication and recurrence rates in infertile men with varicocele, and reported a recurrence rate of 5.51% in the Palomo group and 2.11% in the inguinal microsurgical group, and hydrocele formation rates of 9.09% and 0.69%, respectively. These comparative studies suggest that the lowest complication rates were seen in the microsurgical varicoectomy series supporting the importance of preservation artery and lymphatics and ligation of all internal and external spermatic vein vessels.

Other complications are wound infection, testicular atrophy, and ilioinguinal nerve damage. Several reports have suggested that ligation of the testicular artery during varicoectomy does not cause testicular atrophy in adults and adolescents (Kass and Marcol, 1992; Matsuda et al, 1993; Student et al, 1998). However, preservation of the testicular arteries is recommended for optimal testicular blood flow (Raman and Goldstein, 2004).

The most common cause of persistent or recurrent varicocele after surgical repair is through the internal spermatic veins (Murray et al, 1986). Studies support that loupe magnification or no magnification is inadequate for the meticulous dissection required. Conventional varicoectomy performed without optical magnification may miss smaller internal spermatic veins that may dilate in the future and cause recurrence. In addition to varicocele recurrence, conventional varicoectomy may cause ligation of the lymphatics and spermatic artery, which may result in hydrocele formation and testicular atrophy. The use of microscopic magnification allows identification of the testicular artery, lymphatics, and small venous channels. Therefore, this results in a significant decrease in the incidence of hydrocele formation, testicular artery injury, and varicocele recurrence.

Postoperative Results on Fertility—Studies suggest that varicocele repair significantly increases sperm parameters, including sperm concentration, sperm motility, and total motile sperm count, postoperatively. In addition to sperm parameters, varicocele repair probably has positive effects on Leydig cell function, improving serum testosterone level (Su et al, 1995; Çayan et al, 1999). In the present review, we did not include comparison of postoperative improvement in semen parameters between the techniques because of the lack of studies. Some studies have reported improvement as a percentage, and some studies have reported an increase or decrease in semen parameters from the mean value. Therefore, comparison of the seminal improvement after varicocele repair would not be unique among the techniques used for varicocele repair. In addition, spontaneous pregnancy is considered the best indicator to assess fertility status. To investigate whether varicocele repair improves fertility status, meta-analyses included only studies that had spontaneous pregnancy data as an intended outcome.

Spontaneous pregnancy rate after varicocele repair ranges from 16% to 55.2%. Çayan et al (2000) compared postoperative semen parameters and spontaneous pregnancy rates between Palomo and microsurgical inguinal varicoectomy in infertile men with palpable varicocele, and found spontaneous pregnancy rate as 33.57% in the Palomo group and 42.85% in the microsurgical group. Watanabe et al (2005) reported a spontaneous

pregnancy rate of 50.9% with subinguinal microsurgical varicocelectomy, whereas the rate was 40.4% with laparoscopic approach and 35.8% with the Palomo technique. In the present meta-analysis, overall spontaneous pregnancy rates were 37.69% in the Palomo technique series, 41.97% in the microsurgical varicocelectomy techniques, 30.07% in the laparoscopic varicocelectomy techniques, 33.2% in the radiologic embolization, and 36% in the macroscopic inguinal (Ivanissevich) varicocelectomy series. However, spontaneous pregnancy rates after the treatment of varicocele may vary with lack of a uniform posttreatment follow-up interval, and may also depend on female factor parameters including age and reproductive health.

Conclusions

Open microsurgical inguinal or subinguinal varicocelectomy techniques have been shown to result in higher spontaneous pregnancy rates and fewer recurrences and postoperative complications than conventional varicocelectomy techniques in infertile men. Use of higher magnification allows surgeons to preserve the internal spermatic artery and lymphatics and also to visualize and ligate all spermatic veins. However, further prospective randomized studies with large numbers of patients are needed to directly compare efficacy of microsurgical varicocelectomy with other treatment modalities in infertile men with varicocele.

References

- Agarwal A, Deepinder F, Cocuzza M, Agarwal R, Shart RA, Sabanegh E, Marmar JL. Efficacy of varicocelectomy in improving semen parameters: new meta-analytic approach. *Urology*. 2007;70:532–538.
- Baker HWG, Burger HG, Dekretser DM. Testicular vein ligation and fertility in men with varicoceles. *Br Med J*. 1985;291:1678–1680.
- Beck EM, Schlegel PN, Goldstein M. Intraoperative varicocele anatomy: a macroscopic and microscopic study. *J Urol*. 1992;148:1190–1194.
- Çayan S, Erdemir F, Ozbey İ, Turek PJ, Kadioğlu A, Tellaloğlu S. Can varicocelectomy significantly change the way couples use assisted reproductive technologies? *J Urol*. 2002;167:1749–1752.
- Çayan S, Kadioğlu A, Orhan I, Kandirali, Tefekli A, Tellaloğlu S. The effect of microsurgical varicocelectomy on serum follicle stimulating hormone, testosterone and free testosterone levels in infertile men with varicocele. *BJU Int*. 1999;84:1046–1049.
- Çayan S, Kadioğlu TC, Tefekli A, Kadioğlu A, Tellaloğlu S. Comparison of results and complications of high ligation surgery and microsurgical high inguinal varicocelectomy in the treatment of varicocele. *Urology*. 2000;55:750–754.
- Çayan S, Lee D, Black L, Reijo Pera RA, Turek PJ. Response to varicocelectomy in oligospermic men with and without defined genetic infertility. *Urology*. 2001;57:530–535.
- Cockett AT, Takihara H, Consentino MJ. The varicocele. *Fertil Steril*. 1984;41:5–11.
- Coolsaet BL. The varicocele syndrome: venography determining the optimal level for surgical management. *J Urol*. 1980;124:833–839.
- Dohle GR, Colpi GM, Hargreave TB, Papp GK, Jungwirth A, Weidner W. EAU Working Group on Male Infertility. EAU guidelines on male infertility. *Eur Urol*. 2005;48:703–711.
- Dubin L, Amelar RD. Etiologic factors in 1294 consecutive cases of male infertility. *Fertil Steril*. 1971;22:469–474.
- Enquist E, Stein BS, Sigman M. Laparoscopic versus subinguinal varicocelectomy: a comparative study. *Fertil Steril*. 1994;61:1092–1096.
- Evers JL, Collins JA. Surgery or embolisation for varicocele in subfertile men. *Cochrane Database Syst Rev*. 2004;CD000479.
- Feneley MR, Pal MK, Nockler IB, Hendry WF. Retrograde embolization and causes of failure in the primary treatment of varicocele. *Br J Urol*. 1997;80:642–646.
- Ferguson JM, Gillespie IN, Chalmers N, Elton RA, Hargreave TB. Percutaneous varicocele embolization in the treatment of infertility. *Br J Radiol*. 1995;68:700–703.
- Ficarra V, Cerruto MA, Ligouri G, Mazzano G, Minucci S, Tracia A, Gentile V. Treatment of varicocele in subfertile men: the Cochrane review—a contrary opinion. *Eur Urol*. 2006;49:258–263.
- Ghanem H, Anis T, El-Nashar A, Shamloul R. Subinguinal microvaricocelectomy versus retroperitoneal varicocelectomy: comparative study of complications and surgical outcome. *Urology*. 2004;64:1005–1009.
- Goldstein M, Gilbert BR, Dicker AP, Dwosh J, Gnecco C. Microsurgical inguinal varicocelectomy with delivery of the testis: an artery and lymphatic sparing technique. *J Urol*. 1992;148:1808–1811.
- Gonzalez R, Narayan P, Formanek A, Amplatz K. Transvenous embolization of internal spermatic veins: nonoperative approach to treatment of varicocele. *Urology*. 1981;17:246–248.
- Grober ED, Chan PTK, Zini A, Golstein M. Microsurgical treatment of persistent or recurrent varicocele. *Fertil Steril*. 2004;82:718–722.
- Hirokawa M, Matsushita K, Iwamoto T, Iwasaki A, Asakura S, Masuda M. Assessment of Palomo's operative method for infertile varicocele. *Andrologia*. 1993;25:47–51.
- Hopps CV, Lemer ML, Schlegel PN, Goldstein M. Intraoperative varicocele anatomy: a microscopic study of the inguinal versus subinguinal approach. *J Urol*. 2003;170:2366–2370.
- Ito H, Kotake T, Hamano M, Yanagi S. Results obtained from microsurgical therapy of varicocele. *Urol Int*. 1993;51:225–227.
- Ivanissevich O. Left varicocele due to reflux; experience with 4,470 operative cases in forty-two years. *J Int Coll Surg*. 1960;34:742–755.
- Jarow JP, Assimos DG, Pittaway DE. Effectiveness of laparoscopic varicocelectomy. *Urology*. 1993;42:544–547.
- Jarow JP, Sharlip ID, Belker AM, Lipshultz LI, Sigman M, Thomas AJ, Schlegel PN, Howards SS, Nehra A, Damewood MB, Overstreet JW, Sadowsky R. Best practice policies for male infertility. *J Urol*. 2002;167:2138–2144.
- Jungwirth A, Gögüs C, Hauser W, Gomahr A, Schmeller N, Aulitzky W, Frick J. Clinical outcome of microsurgical subinguinal varicocelectomy in infertile men. *Andrologia*. 2001;33:71–74.
- Kamal KM, Jarvi K, Zini A. Microsurgical varicocelectomy in the era of assisted reproductive technology: influence of initial semen quality on pregnancy rates. *Fertil Steril*. 2001;75:1013–1016.
- Kass EJ, Marcol B. Results of varicocele surgery in adolescents: a comparison of techniques. *J Urol*. 1992;148:694–696.
- Kumar R, Gupta NP. Subinguinal microsurgical varicocelectomy: evaluation of the results. *Urol Int*. 2003;71:368–372.

- Madgar I, Weissenberg R, Lunenfeld B, Karasik A, Gold-Wasser B. Controlled trial of high spermatic vein ligation for varicocele in infertile men. *Fertil Steril*. 1995;63:120-124.
- Marks JL, McMahon R, Lipshultz LI. Predictive parameters of successful varicocele repair. *J Urol*. 1986;136:609-612.
- Marmar JL, Agarwal A, Prabakaran S, Agarwal R, Short RA, Benoff S, Thomas AJ Jr. Reassessing the value of varicocelectomy as treatment for male subfertility with a new meta-analysis. *Fertil Steril*. 2007;88:639-648.
- Marmar JL, Kim Y. Subinguinal microsurgical varicocelectomy: a technical critique and statistical analysis of semen and pregnancy data. *J Urol*. 1994;152:1127-1132.
- Matsuda T, Horii Y, Yoshida O. Should the testicular artery be preserved at varicocelectomy? *J Urol*. 1993;149:1357-1360.
- Mehan DJ, Andrus CH, Parra RO. Laparoscopic internal spermatic vein ligation: report of a new technique. *Fertil Steril*. 1992;58:1263-1266.
- Menchini-Fabris GF, Canale D, Basile-Fasolo C, Di Coscio M, Izzo PL, Gianotti P, Marino P, Servadio L, Baldassari S, Fratta M. Varicocele and male subfertility: prognostical criteria in the surgical treatment. *Andrologia*. 1985;17:16-21.
- Milad MF, Zein TA, Hussein EA, Ayyat FM, Schneider MP, Sant GR. Laparoscopic varicocelectomy for infertility. An initial report from Saudi Arabia. *Eur Urol*. 1996;29:462-465.
- Murray RR, Mitchell SE, Kadir S, Kaufman SL, Chang R, Kinnison ML, Smyth JM, White RI Jr. Comparison of recurrent varicocele anatomy following surgery and percutaneous balloon occlusion. *J Urol*. 1986;135:286-289.
- Nabi G, Asterlings S, Greene DR, Marsh RL. Percutaneous embolization of varicoceles: outcomes and correlation of semen improvement with pregnancy. *Urology*. 2004;63:359-363.
- Nagler HM, Luntz RK, Martinis FG. Varicocele. In: Lipshultz LI, Howards SS, eds. *Infertility in the Male*. 3rd ed. St Louis, Missouri: Mosby-Year Book; 1997:336-359.
- Newton R, Schinfeld JS, Schiff I. The effect of varicocelectomy on sperm count, motility, and conception rate. *Fertil Steril*. 1980;34:250-254.
- Nieschlag E, Behre HM, Schlingheider A, Nashan D, Pohl J, Fishedick AR. Surgical ligation vs. angiographic embolization of the vena spermatica: a prospective randomized study for the treatment of varicocele-related infertility. *Andrologia*. 1993;25:233-237.
- Orhan I, Onur R, Semercioz A, Firdolas F, Ardicoglu A, Koksall IT. Comparison of two different microsurgical methods in the treatment of varicocele. *Arch Androl*. 2005;51:213-220.
- Palomo A. Radical cure of varicocele by a new technique: preliminary report. *J Urol*. 1949;61:604.
- Perimenis P, Markou S, Gyftopoulos K, Athanasopoulos A, Barbaliias G. Effect of subinguinal varicocelectomy on sperm parameters and pregnancy rate: a two-group study. *Eur Urol*. 2001;39:322-325.
- Pryor JL, Howards SS. Varicocele. *Urol Clin N Am*. 1987;14:499-513.
- Rageth JC, Unger C, DaRugna D, Steffen R, Stucki R, Barone C, Eijsten A, Rutishauser G, Leibundgut B, Gallo LM. Long-term results of varicocelectomy. *Urol Int*. 1992;48:327-331.
- Raman JD, Goldstein M. Intraoperative characterization of arterial vasculature in spermatic cord. *Urology*. 2004;64:561-564.
- Ross LS, Ruppman N. Varicocele vein ligation in 565 patients under local anesthesia: a long-term review of technique, results and complications in light of proposed management by laparoscopy. *J Urol*. 1993;149:1361-1363.
- Schlesinger MH, Wilets IF, Nagler HM. Treatment outcome after varicocelectomy. A critical analysis. *Urol Clin N Am*. 1994;21:517-529.
- Sharlip ID, Jarow JP, Belker AM, Lipshultz LI, Sigman M, Thomas AJ, Schlegel PN, Howards SS, Nehra A, Damewood MB, Overstreet JW, Sadovsky R. Best practice policies for male infertility. *Fertil Steril*. 2002;77:873-882.
- Shlansky-Goldberg RD, VanArsdalen KN, Rutter CM, Soulen MC, Haskal ZJ, Baum RA, Redd DC, Cope C, Pentecost MJ. Percutaneous varicocele embolization versus surgical ligation for the treatment of infertility: changes in seminal parameters and pregnancy outcomes. *J Vasc Interventional Radiol*. 1997;8:759-767.
- Student V, Zatura F, Scheinar J, Vrtal R, Vrana J. Testicle hemodynamics in patients after laparoscopic varicocelectomy evaluated using color Doppler sonography. *Eur Urol*. 1998;33:91-93.
- Su LM, Goldstein M, Schlegel PN. The effect of varicocelectomy on serum testosterone levels in infertile men with varicoceles. *J Urol*. 1995;154:1752-1755.
- Tanahatoo SJ, Maas WM, Hompes PGA, Lambalk CB. Influence of varicocele embolization on the choice of infertility treatment. *Fertil Steril*. 2004;81:1679-1683.
- Tefekli A, Çayan S, Uluocak N, Poyanlı A, Alp T, Kadioğlu A. Is selective internal spermatic venography necessary in detecting recurrent varicocele after surgical repair? *Eur Urol*. 2001;40:404-408.
- Vermeulen A, Vandeweghe MN, Deslypere JP. Prognosis of subfertility in men with corrected or uncorrected varicocele. *J Androl*. 1986;7:147-155.
- Watanabe M, Nagai A, Kusumi N, Tsuboi H, Nasu Y, Kumon H. Minimal invasiveness and effectivity of subinguinal microscopic varicocelectomy: a comparative study with retroperitoneal high and laparoscopic approaches. *Int J Urol*. 2005;12:892-898.
- Yavetz H, Levy R, Papo J, Yogev L, Paz G, Jaffa AJ, Homonnai ZT. Efficacy of varicocele embolization versus ligation of the left internal spermatic vein for improvement of sperm quality. *Int J Androl*. 1992;15:338-344.