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Review Article

Laparoscopic and Robotic-assisted Vesicovaginal Fistula Repair: A Systematic Review of the Literature

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ABSTRACT Two types of laparoscopic or robotic-assisted vesicovaginal fistula (VVF) repairs, the traditional transvesical (O'Conor) and extravesical techniques, dominate the literature. The objectives of this study are to compare success rates between laparoscopic or robotic transvesical and extravesical laparoscopic VVF repair techniques and to evaluate the impact of the number of layers in the closure, interposition flaps, and intraoperative testing of the integrity of the bladder repair. Eligible studies, published between 1994 and March 10, 2014, were retrieved through Medline and bibliography searches. All study designs of laparoscopic/robotic VVF repair were included. Open laparotomy and vaginal approaches were excluded. Only 1 retrospective cohort study was included, with the remaining articles consisting of case reports and case series. Ultimately, only 44 studies were included in a systematic review: 9 articles of robotic-assisted approach, 3 laparoscopic single-site surgeries, and 32 conventional laparoscopic approaches. A literature review revealed a balanced number of reports for both transvesical and extravesical approaches. Statistical meta-analysis was not performed because of high heterogeneity. The overall success rate of laparoscopic VVF repair was 80% to 100% with a follow-up period of 1 to 74 months. The success rate of transvesical and extravesical techniques were 95.89% and 98.04% (relative risk, .98; 95% confidence interval, .94–1.02). There was no statistical difference in success rates of VVF repair with different number of layers in the fistula closure or with use of interposition flaps, but there was a small increase in success in the cases that documented intraoperative bladder filling to test the integrity of the bladder closure. In conclusion, transperitoneal extravesical VVF repair has cure rates similar to the traditional transvesical approach. Laparoscopic extravesical VVF repair is a safe, effective, minimally invasive technique with excellent cure rates similar to those of the conventional transvesical approach in experienced surgeons' hands. Journal of Minimally Invasive Gynecology (2015) 22, 727–736 © 2015 AAGL. All rights reserved.

Keywords: Bladder fistula; Laparoscopic vesicovaginal fistula repair; O'Conor; Omental flap; Robotic vesicovaginal fistula repair; Vesicouterine fistula; Vesicovaginal fistula

The success of vesicovaginal fistula (VVF) repair depends on various factors, including fistula size, location, timing from the antecedent event, severity of symptoms, quality of surrounding tissue, and clinical experience and surgical skill [1,2]. Surgical repairs of VVFs are most commonly performed vaginally, abdominally, or laparoscopically with and without robotic assistance. The approach to VVF repair is often dictated by surgeons' preference and location or complexity of the VVF [2]. Surgeon preference is usually based on training and experience. The success rate of abdominal and transvaginal approaches were 91% and 93%, respectively [3]. Laparoscopic/robotic VVF approaches reveal the most commonly performed techniques are the traditional transvesical technique and the more recent, lesser known extravesical technique. The abdominal transvesical technique was first described in the 19th century by Trendelenburg [4] but was made popular by O'Conor and is therefore most commonly referenced as the O'Conor technique [5]. The O'Conor technique requires

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Fig. 1

O'Conor transvesical approach.

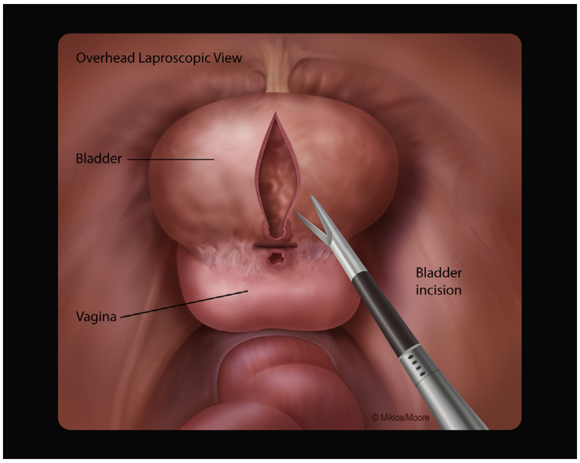
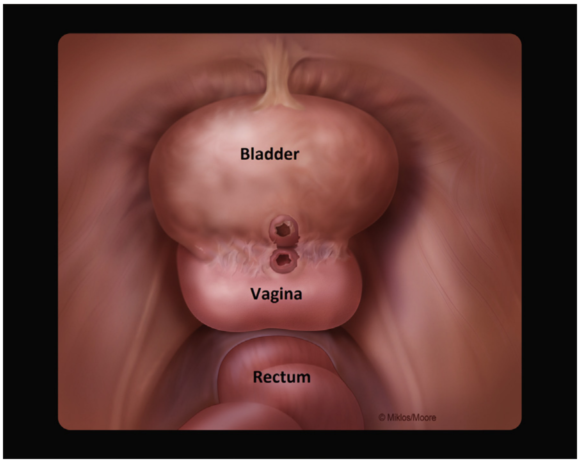


Fig. 2

Extravesical approach.



a bladder bivalving technique or cystotomy to identify and repair the VVF (Fig. 1). The abdominal approach to the extravesical VVF repair was first described in 1803 [6] followed by the first description of the laparoscopic approach in the late 1990s [7,8]. The extravesical technique is performed by focusing on a site-specific dissection (Fig. 2) and repair without cystotomy or bivalving of the bladder.

Although there are distinct differences in the 2 techniques, the literature often does not acknowledge the difference and lumps the 2 techniques together [9–11], claiming all techniques are a variation of the O'Conor technique [12,13] or claiming the laparoscopic extravesical technique is a "novel" technique [14], despite appearing in the literature since the 1990s [7,8,15]. Not only has there been a lack of clarity in the literature distinguishing the 2 techniques, there has also been little to suggest standardization let alone equality or superiority of either technique. In fact, randomized controlled trials are lacking to help determine superiority. Most articles published review outcomes of case reports and case series without standardization to technique, outcomes, or follow-up. This makes the comparison of surgical techniques of VVF difficult. The goals of this systematic review are to review the literature on laparoscopic (including robotic-assisted) surgery in the treatment of VVF, to compare and contrast the extravesical technique to the traditional transvesical O'Conor technique, to review the success of laparoscopic VVF repair based on layers of fistula closure, to review the potential necessity of omental flaps during laparoscopic VVF repair, and to discuss conventional criteria for a good VVF.

Methods

Protocol and Registration

Methods of analysis and inclusion criteria were specified in advance and documented in a protocol.

Eligibility Criteria

VVF was defined as an abnormal fistulous tract extending between the bladder and vagina resulting in the continuous, involuntary discharge of urine into the vagina. We included publications on laparoscopic or robotic VVF repair of any study design and for patients of all ages. Studies investigating vaginal or open laparotomy approaches to VVF repair were excluded.

Information Sources

We searched Medline with English language restrictions from 1994 to March 2014. Additional eligible studies were sought by a hand search of reference lists from primary articles and relevant reviews. We conducted our searches on March 10, 2014 and applied English language restriction. We also included our study of 44 patients undergoing laparoscopic VVF repair [16].

Search

We used the following search strategy to search all databases: laparoscopy, vesicovaginal fistula, and robotic (Table 1). We restricted the database from January 1994 to March 10, 2014.

Study Selection

Two reviewers (JRM and OC) independently screened titles and abstracts and reviewed the full text of potentially relevant articles. Disagreements between reviewers were resolved through discussion.

Data Collection Process

We developed a data extraction sheet and refined it accordingly. One reviewer author (OC) extracted the

Table 1

PubMed search strategy

(((((“laparoscopy”[MeSH Terms] OR “laparoscopy”[All Fields] OR “laparoscopic”[All Fields]) AND (“vesicovaginal fistula”[MeSH Terms] OR (“vesicovaginal”[All Fields] AND “fistula”[All Fields]) OR “vesicovaginal fistula”[All Fields])) OR ((“robotics”[MeSH Terms] OR “robotics”[All Fields] OR “robotic”[All Fields]) AND (“vesicovaginal fistula”[MeSH Terms] OR (“vesicovaginal”[All Fields] AND “fistula”[All Fields]) OR “vesicovaginal fistula”[All Fields]))) AND (“vesicovaginal fistula”[MeSH Terms] OR (“vesicovaginal”[All Fields] AND “fistula”[All Fields]) OR “vesicovaginal fistula”[All Fields])) OR ((“laparoscopy”[MeSH Terms] OR “laparoscopy”[All Fields] OR “laparoscopic”[All Fields]) AND (“vesicovaginal fistula”[MeSH Terms] OR (“vesicovaginal”[All Fields] AND “fistula”[All Fields]) OR “vesicovaginal fistula”[All Fields]) AND (“surgery”[Subheading] OR “surgery”[All Fields] OR “surgical procedures, operative”[MeSH Terms] OR (“surgical”[All Fields] AND “procedures”[All Fields] AND “operative”[All Fields]) OR “operative surgical procedures”[All Fields] OR “surgery”[All Fields] OR “general surgery”[MeSH Terms] OR (“general”[All Fields] AND “surgery”[All Fields]) OR “general surgery”[All Fields]))) AND ((“1994/01/01”[PDAT]: “2014/12/31”[PDAT]) AND English[lang])

following data from included studies and the second author checked the extracted data (JRM). We resolved disagreements through discussion between the 2 review authors.

Data Items

The primary outcome measures were postoperative cure rate, extra-versus transvesical techniques, interposition flap versus no flap, and the number of layers performed for the fistula closure. We also reviewed the length of time to follow-up, operative time, length of hospital stay, and postoperative complications. Other information extracted from each study was as follows: (1) characteristics of trial participants (including number of patients, etiology of VVF, prior VVF repair, robotic or laparoscopic approaches, operative time, estimated blood loss, length of hospital stay, follow-up time, and complications) and the study's inclusion and exclusion criteria, (2) surgical technique (including

Fig. 3

Literature search selection.

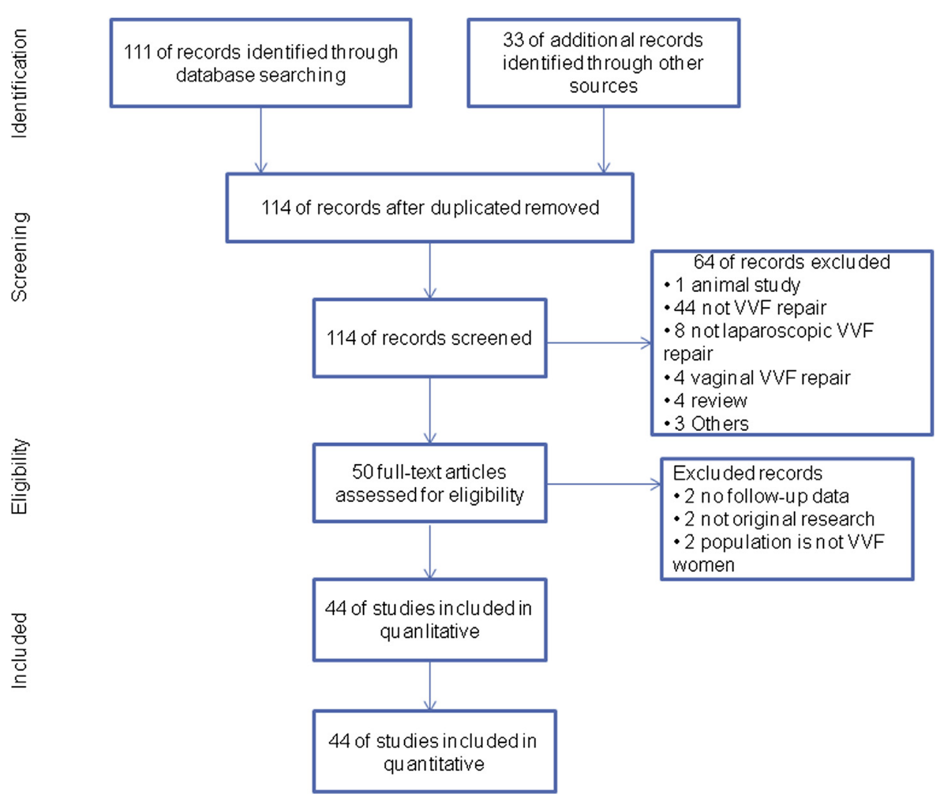


Table 2

Summary of included studies evaluating the laparoscopic VVF repair

Author, year	No. of patients	Type of study	Study period	Age (range)	Etiology	Prior repair	Timing of repair
Miklos & Moore, 2015 [16]	44	Case series	1998–2014	46.5 (31–72)	Hysterectomy (41), mesh (2), spontatneous (1)	11 patients –vaginal (12), abdominal (4)–3 w/omentum	N/A
Dutto & O'Reilly, 2013 [17]	1	Video case report	N/A	56	TAH	None	N/A
Nagabhushana et al, 2013 [18]	1	Case report	March–November 2012	28	N/A	N/A	N/A
Garcia-Segui, 2012 [19]	4	Case series		42 (38–47)	Hysterectomy (4)	None	
Kurz et al, 2012 [20]	3	Case series	N/A	40–64	TAH (3)	None	Immediate
Miklos & Moore, 2012 [21]	1	Case report	N/A	52	TAH	Twice (at the time of TAH and abdominal with omental flap)	20 wk
Miklos & Moore, 2012 [22]	1	Case report	N/A	37	TAH	3 times (2 Latzko, fibrin glue)	12 wk
Rogers et al, 2012 [23]	2	Case report	N/A	42 and 51	TAH (2)	None	N/A
Roslan et al, 2012 [24]	1	Case report	August 2011	72	TAH	None	12 wk
Simforoosh et al, 2012 [25]	5	Case series	August 2010–December 2011	45.6 (44–48)	TAH (4), radical hysterectomy (1)	None	Immediate to 3 wk
Sirithanaphol et al, 2012 [14]	5	Case series	October 2008–December 2010	42 (33–53)	TAH (4), C/S (1)	None	≥20 wk
Utrera et al, 2012 [26]	9	Case series	January 2006–January 2008	45 ± 13	TAH (9)	None (8), transvaginal (1)	88 wk
Zhang et al, 2012 [27]	18	Case series	November 2007–October 2011	37.6 (27–51)	TAH (16), OB trauma (2)	None	Immediate
Abdel-Karim et al, 2011 [28]	5	Case series	N/A	47 ± 4	TAH (4), C/S (1)	None	≥12 wk
Abdel-Karim et al, 2011 [29]	15	Case series	N/A	35.2 ± 9.5	TAH (6), C/S (5), OB trauma (3), myomectomy (1)	None	≥12 wk
Gupta et al, 2010 [30]	12 vs 20 open	Retrospective cohort	August 2006–June 2008	27.1 (16–46)	Obstructed labor (6), hysterectomy (4), C/S (2)	Abdomininal (8), vaginal (4)	24 wk (12–56)
Lee et al, 2010 [31]	5	Case series	October 2007–March 2009	47 (40–51)	TAH (5)	None	24 (14–289) days
Rizvi et al, 2010 [32]	8	Case series	2004–2008	36 (24–49)	Hysterectomy (5), C/S (3)	2 patients –(abdominal & vaginal), abdominal	14 (8–32) wk
Gozen et al, 2009 [33]	3	Case series	N/A	34–48	Hysterectomy (3)	None	≥12 wk
Gregorio et al, 2010 [11]	1	Case report	N/A	50	TAH	None	32 wk
Porpoglia et al, 2009 [34]	4	Case series	January 2007–July 2008	43–60	Hysterectomy (4)	None	N/A
Shah, 2009 [35]	25	Case series	June 2003–November 2008	N/A	Hysterectomy (16), obstetric trauma (9)	None	≥2 wk
Abreau et al, 2008 [36]	8	Case series	N/A	N/A	TAH (7), ureterolithotripsy (1)	Abdominal (2), vaginal (1), endoscopic fulguration (1)	N/A
Erdogru et al, 2008 [37]	1	Case report	N/A	37	Cesarean-hysterectomy	1 patient–(abdominal & transvaginal)	40 wk
Hemal et al, 2008 [38]	7	Case series	August 2006–October 2007	N/A	Hysterectomy (3), ob trauma (4)	Transabdominal (8), transvaginal (5)	≥12 wk
Otsuka et al, 2008 [39]	7	Case series	Febuary 2004–March 2006	52.8 (37–74)	Hysterectomy (6), endometriosis surgery (1)	3 patients–abdominal (2), endoscopic fulguration (1)	≥28 wk
Das Mahapatra & Bhattacharyya, 2007 [40]	11	Case series	1991–2004	N/A	TAH (7), obstetric trauma (4)	None	≥12 wk
Nagraj et al, 2007 [41]	12	Case series	Febuary 2001–November 2005	37.2 (20–55)	TAH (13)	None	≥2 wk
Tiong et al, 2007 [42]	1	Case report	N/A	44	TAH (1)	None	12 wk
Schimpf et al, 2007 [43]	1	Case report	N/A	41	TAH	None	
Sears et al, 2007 [44]	1	Case report	N/A	47	TAH	None	3 years
Modi et al, 2006 [45]	1	Case report	N/A	38	TVH	None	10 wk
Patankar et al, 2006 [46]	1	Case report	N/A	52	Hysterectomy	None	12 wk
Sundaram et al, 2006 [47]	5	Case series	N/A	N/A	Hysterectomy (4), myomectomy (1)	None	≥12 wk
Wong et al, 2006 [48]	2	Case series	N/A	N/A	TAH (1), cesarean-Hysterectomy (1)	2 patients –transvaginal (2)	
Chibber et al, 2005 [49]	6	Case series	January 2000–April2004	N/A	TAH (6)	2 patients-transvaginal (2)	≥6 wk
Melamud et al, 2005 [50]	1	Case report	N/A	44	TVH	None	N/A
Sotelo et al, 2005 [51]	15	Case series	August 1998–March 2004	N/A	Hysterectomy (14), obsterics trauma (1)	4 patients–abdominal (3), transvaginal (1)	≥8 wk
Ou et al, 2004 [52]	2	Case series	June 1994–September 2002	N/A	Hysterectomy (2)	None	≥4 wk
Nabi et al, 2001 [53]	1	Case report	N/A	40	TVH	Transvaginal (1)	10 mo
Miklos et al, 1999 [8]	1	Case report	N/A	36	TAH (1)	Transvaginal (2)	10 wk
von Theobold et al, 1998 [7]	1	Case report	N/A	49	TAH (1)	None	16 wk
Phipps, 1996 [54]	2	Case series	N/A	35, 49	Hysterectomy (2)	None	6, 8 wk
Nezhat et al, 1994 [55]	1	Case report	N/A	45	Endometriosis surgery	None	12 wk

C/S = cesarean section; EBL = estimated blood loss; LESS = laparoscopic single-site surgery; N/A = not available; OR = operative time; TAH = total abdominal hysterectomy.

Approach	Transvesical vs extravesical	No. of bladder closure layers	No. of vaginal closure layers	Interposition	Bladder test (mL)	Bladder testing dye	OR time (min)	EBL (mL)	Length of stay (days)	Drainage time (days)	Cure rate (%)	Average follow-up (mo)	Complications
Conventional	Extravesical	2	1	None	300–400	Inidgo carmine	N/A	39 (0–450)	1.1 (1–3)	14–21	43/44 (97.73%)	17.3 (3–64)	None
Robotic	Extravesical	2	2	Omental	No	No	N/A	N/A	2	10	1/1 (100%)	6	None
LESS	N/A	N/A	N/A	N/A	N/A	N/A	180	N/A	3	14	1/1 (100%)	N/A	Wound infection
Conventional	Extravesical						160 (120–186)			21	4/4 (100%)		None
Robotic	Extravesical	1	1	Peritoneal	Yes (N/A)	No	N/A	N/A	5	14	3/3 (100%)	42	None
Conventional	Extravesical	2	1	None	400	Inidigo carmine	N/A	N/A	N/A	14	1/1 (100%)	24	None
Conventional	Extravesical	2	1	None	400	Inidigo carmine	N/A	N/A	N/A	14	1/1 (100%)	24	None
Robotic	Transvesical	1	2	Omental	No	No	N/A	N/A	2	10–14	2/2 (100%)	12	None
LESS	Transvesical	1	1	None	200	No	170	Minimal	5	14	9/9 (100%)	6	None
Conventional	Transvesical	1	1	Omental (4), none (1)	No	No	134 (100–185)	300 (250–370)	4 (3–6)	14	4/5 (80%)	8 (2–15)	None
Conventional	Transvesical	N/A	N/A	Omental	No	No	229 (150–300)	66 (30–100)	4.4 (4–6)	18–34	5/5 (100%)	24.4 days (28–34)	None
Conventional	Transvesical	1	1	Omental	200	No	150	N/A	4.7	10	1/1 (100%)	32	UTI (1)
Conventional	Transvesical	1	2	Omental	Yes (N/A)	No	135 (75–175)	95 (50–200)	5 (4–7)	14	18/18 (100%)	22.7 (3–45)	None
LESS	Extravesical	2	1	Omental	250	No	198 ± 27.7	90 ± 25	2	21	5/5 (100%)	8 (4–12)	None
Conventional	Extravesical	1	1	Omental	300	No	172 (145–210)	110 ± 17	3 (2–5)	21	15/15 (100%)	19	None
Robotic vs open	Transvesical	1	1	Omental, peritoneal, or epiploic appendices of the sigmoid colon	No	No	140 (110–180)	88 950–200)	3.1 (2–5)	14–21	12/12 (100%) vs 90% (open)	N/A	None
Conventional	Extravesical	2	1	None	250	No	95 (85–115)	N/A	5 (5–17)	14	5/5 (100%)	56.1 (26.6–74)	None
Conventional	Transvesical	1	1	Omental	75	No	145 (110–160)	60 (40–100)	4	14	8/8 (100%)	29 (5–50)	None
Conventinal	Transvesical	1	1	Peritoneal	300	No	164 (141–195)	333 (250–400)	6	10	3/3 (100%)	20 (14–30)	None
Conventional	Transvesical	N/A	N/A	Perirectal fat	No	No	210	N/A	8	15	1/1 (100%)	18	None
Conventional	Transvesical	2	1	Omental	Yes (N/A)	No	103 (95–120)	80 (50–100)	3 (2–4)	8	4/4 (100%)	14.5 (10–21)	None
Conventional	Transvesical	1	1	Omental	No	No	145	180–200	4.5	14	19/22 (86.36%)	N/A	Conversion due to dense adhesion (3)
Conventional	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7/8 (87.5%)	N/A	Lower limb compartment syndrome (1), 1 conversion
Conventional	Transvesical	1	1	Fleece-bound sealing system	Yes (N/A)	No	185	50	3	21	1/1 (100%)	6	None
Robotic	Transvesical	2	1	Omental	Yes (N/A)	No	141 (110–160)	90	3 (2–4)	14	7/7 (100%)	12	None
Conventional	Transvesical (5), extravesical (2)	1	1	Omental	No	No	280 (130–420)	N/A	7.2 (2–20)	28	7/7 (100%)	11 (2–24)	UTI (1), Compartment syndrome (1)
Conventional	Extravesical	1	0	Omnetal	No	Yes (N/A)	192 (180–222)	125	(4–14)	14	10/11 (90.91%)	>3	None
Conventional	Transvesical	1	1	Omental	No	No	130 (110–160)	N/A	4.5 (3–7)	15 (14–16)	11/12 (91.67%)	21 (6–36)	Laparotomy (1)
Conventional	Extravesical	1	1	Omental	150	No	260	100	1	21	1/1 (100%)	6	None
Robotic	Extravesical	2	1	Omental	No	No	245	N/A	1	N/A	1/1 (100%)	3	None
Robotic	Extravesical	2	1	Omental	No	No	N/A	N/A	N/A	N/A	1/1 (100%)	N/A	None
Conventional	Transvesical	1	2	Omental,	Yes (N/A)	No	170	50	2	14	1/1 (100%)	3	None
Conventional	Extravesical	1	1	None	No	No	155	60	3	14	1/1 (100%)	9	None
Robotic	Transvesical	2	2	Omental	200	Povidone-iodine	233 (150–330)	70	5 (4–7)	10	5/5 (100%)	6	None
Conventional	Transvesical	1	1	Omental	No	No	347 (262–432)	<100	2	21	2/2 (100%)	40 (39–41)	None
Conventional	Transvesical	1	1	Omental	No	No	220 (190–280)	N/A	3	21	6/6 (100%)	3–40	None
Robotic	Transvesical	2	1	Fibrin glue	Yes (N/A)	Indigo carmine	280	50	3	14	1/1 (100%)	4	None
Conventional	Transvesical	2	1	Omental	No	No	170 (140–240)	N/A	3 (2–5)	10.4 (9–15)	14/15 (93.33%)	26.2 (3–60)	Enterotomy (1), Enterocutaneous fistula (1), Epigastric artery injury (1)
Conventional	Extravesical	2	0	Omental	No	No	N/A	N/A	2–12	14–20	2/2 (100%)	N/A	None
Conventional	Extravesical	1	1	Omental	200	Povidone-iodine	190	N/A	4	21	1/1 (100%)	9	None
Conventional	Extravesical	1	1	Omental	300	No	N/A	<50	N/A	21	1/1 (100%)	6	None
Conventional	Extravesical	1	0	Omental	No	Methylene blue	70	<100	8	7	1/1 (100%)	6	None
Conventional	Extravesical	1	0	Omental	No	No	160	N/A	8	10	2/2 (100%)	3–6	None
Conventional	Transvesical	1	1	Peritoneal	No	No	85	100	1	10	1/1 (100%)	10	None

transvesical vs extravesical technique, number of bladder closure, number of vaginal closure, interposition flaps, bladder test, and bladder dye test), and (3) outcome (failure vs cure and follow-up time). Cure was defined as no urinary leakages from the vagina at postoperative follow-up. Cure rate of VVF repair was the primary measure of treatment effect.

For the studies included we assessed results reported, such as possible author biases and patient attrition. Data were analyzed using SAS statistical software (version 9.3; SAS Institute Inc., Cary, NC).

Results

Included Studies

Our search yielded 114 citations, with 64 abstracts excluded because they were not VVF repair procedures or were vaginal or abdominal approaches, animal studies, and others. After reviewing the full article, we found 44 of 50 articles that met all inclusion criteria (Fig. 3). Study quality assessment to detect selection, performance, attrition, detection bias, and conflict of interest were conducted. In most studies, there was no comparison of laparoscopic VVF repair with other VVF repair procedures, with only 1 study comparing open with robotic-assisted VVF repair. Most studies were observational case reports and case series with similar objective outcomes. All 44 studies defined no evidence of continuous urinary leakage from the vagina as the objective outcome of success.

Overall, 44 articles fulfilled the inclusion criteria accounting for 256 patients (Table 2): 9 articles of robotic-assisted approach, 3 laparoscopic single-site surgery, and 32 conventional laparoscopic approaches. Table 3 describes the study characteristics: most participants were in their forties (range, 16–72 years), the most common cause of VVF was hysterectomy, and m ost patients underwent a primary VVF repair at least 12 weeks after the initial surgery.

Nineteen studies used an extravesical technique (n = 103), 22 studies a transvesical (conventional) O'Conor technique (n = 146), and 1 study described using both techniques. Postoperative follow-up ranged from 1 to 74 months. Sixteen studies had primary outcome follow-up ≥ 12 months. The overall success rate of laparoscopic VVF repair across all studies was 80% to 100%. The success rates of transvesical and extravesical techniques were 80% to 100% and 97.67% to 100%, respectively (relative risk [RR], .98; 95% confidence interval [CI], .94–1.02). The success rates of single and double layers of bladder closure were 80% to 100% and 93.33% to 100%, respectively (RR, .98; 95% CI, .94–1.03). In 35 studies the patients receiving an interposition flap, including omental, peritoneal, fibrin glue, and fleece-bound sealing system, had a success rate between 80% and 100%. In 6 studies patients did not receive an interposition graft and reported a 97.67% to 100% success rate.

Table 3

Patient characteristic pooling data (n = 260)

	No./total patients (%)
Age, yr (range)	16–72[a]
Etiology of VVF	
Hysterectomy, radical hysterectomy	210/260 (80.77)
Obstetrical trauma	43/260 (16.54)
Other, e.g., endometriotic resection, mesh, myomectomy, urethrolithotripsy	7/260 (2.69)
Interval from index surgery	Immediate to 88 wk
Approach	
Conventional	217/257 (81.32)
LESS	7/257 (27.24)
Robotic	33/237 (12.84)
Technique[b]	
Transvesical	146/248 (58.87)
Extravesical	102/248 (41.13)
Bladder closure layers[b]	
Single	146/238 (61.34)
Double	92/238 (38.66)
Vagina closure layers[b]	
None	16/238 (6.72)
Single	195/238 (81.93)
Double	27/238 (11.34)
Interposition[c]	
None	53/244 (21.72)
Omental	182/244 (74.59)
Other, i.e., peritoneal, fleece-bound system	9/244 (3.69)
Bladder test[c]	134/244 (54.92)
Bladder testing dye[c]	64/244 (26.23)
Operative time, min (range)	70–432
Estimated blood loss, mL (range)	0–450
Length of hospital stay, days (range)	1–20
Drainage time, days (range)	7–28
Follow-up period, mo (range)	1–20
Postoperative complications	
Conversion	5/260
UTI	2/260
Wound infection	1/260
Enterotomy	1/260
Enterocutaneous fistula	1/260
Compartment syndrome	2/260
Epigastric a. injury	1/260

LESS = laparoscopic single-site surgery; UIT = urinary tract infection.
[a] The range of patient ages is 16–72 years and is based on ages reported in 80% of the trials.
[b] Missing data = 19.
[c] Missing data = 13.

Retrograde bladder filling, testing the integrity of the suture line, was described in 47.73% of studies (21/44) with 23.81% of studies (6/21) revealing a retrograde fill of 200 mL or less, 38.10% (8/12) describing 250 mL or more, and 33.33% (7/21) not mentioning the amount of fluid used. Patients receiving bladder fills ≤ 200 cc had an overall success rate of 100%, whereas those receiving bladder fills of 250 mL or more had an overall success rate of 97.67% to 100%. Patients undergoing a bladder fill and integrity test at any volume had a VVF cure rate of 97.67% to 100%. Patients not receiving a retrograde bladder fill after VVF repair had a cure rate of 80% to 100%. From pooling data, patients who received a bladder test after VVF repair had a 6% higher success rate compared with those who did not (99.25% vs 93.64%; RR, 1.06; 95% CI, 1.01–1.12; Table 4).

All studies revealed a standard repair technique for their patients, with each study detailing between 1 and 4 layers of repair. Approximately 61.34% of patients (146/238) had single-layer bladder repair and 38.66% (92/238) were reported to have double-layer bladder closure. For vaginal closure, 6.72% (16/238) had no vaginal closure, 81.93 (195/238) had single-layer closure, and 11.34% (27/238) had double-layers closure (Table 4).

Discussion

The O'Conor transvesical technique was performed via laparotomy for more than 30 years before the first laparoscopic case was published in 1994 [55]. It was not until 1998 that von Theobold et al [7] described the first laparoscopic extravesical VVF repair. They described a simple dissection of the bladder away from the vagina and a single-layer bladder closure (because "closure of the vagina was not necessary") coupled with an omental J flap, which was a novel and unorthodox approach (i.e., a single-layer closure) to VVF repair but was successful in this single case study. A few months later, Miklos et al [8] described a laparoscopic extravesical technique using a 3-layer closure, a double-layer bladder and a single-layer vagina closure, with an intervening omental flap for a patient with recurrent fistula despite 2 Latzko procedures. Since then, 44 articles and case studies on laparoscopic/robotic-assisted laparoscopic VVF repairs have been published. A review of these studies reveals an almost equal distribution of articles written on both the laparoscopic transvesical and extravesical techniques.

Table 4

Success rate of laparoscopic VVF repair from pooling data (n = 260)

	Success rate	RR (95% CI)
Overall	248/257 (96.50)	
Technique		
Transvesical	140/146 (95.89)	.98 (.94–1.02)
Extravesical	100/102 (98.04)	
Bladder layer closure		
Single	140/146 (95.89)	.98 (.94–1.03)
Double	90/92 (97.83)	
Vaginal layer closure		
None	15/16 (93.75)	.97 (.85–1.11)
Single	188/195 (96.41)	Ref.
Double	27/27 (100)	.94 (.83–1.06)
Interposition		
Omental, peritoneal, etc.	184/191 (96.34)	.98 (.94–1.03)
None	52/53 (98.11)	
Bladder test		
Yes	133/134 (99.25)	1.06 (1.01–1.12)
No	103/110 (93.64)	
Bladder testing dye		
Yes	62/64 (96.88)	1.01 (.95–1.06)
No	174/180 (96.67)	

Despite the fact that half of these studies describe an extravesical approach, rarely are both procedures discussed in the same article, making it difficult to understand the difference between the 2 procedures. Until relatively recently [35,39,56], most VVF publications and reviews neither acknowledge nor distinguish the difference between the 2 techniques, transvesical (O'Conor) and extravesical. In fact, some experts have implicated that the extravesical technique is a modification of the O'Conor technique [12,13]. This extravesical approach is not a modification of the O'Conor technique because a cystotomy is not required to identify the fistula, but it still uses the basic principles of fistula repair as cited by Couvelaire in the 1950s [57].

It is often said that a number of things may affect the success of fistula repair, including number of previous surgical attempts, patient's health status, surgeon's experience [58], fistula size [59], fibrosis [60], and radiation exposure [61]. Probably even more important to a successful VVF repair are the technical steps of the surgery. Conventional wisdom suggests that the criteria for a good repair includes good visualization, good dissection, good approximation of the margins, tension-free watertight closure, use of a well-vascularized tissue flap, and adequate postoperative urinary drainage [62]. Others believe it is essential to place an interposition graft in an attempt to achieve the highest possible cure rate [62–64]. Although each of these principles sound logical and pragmatic for a successful VVF repair, they are based on supposition and little science.

We agree that good visualization, good dissection, and good approximation of the margins are important, but they are hallmark criteria of any *good* surgery. They also agree, as with any surgery, tissue repair should not be overly stressed or tensioned postoperatively because it could lead to a wound disruption or dehiscence. This is the role of a good dissection and mobilization of the vagina and bladder tissue before suturing their defects as well as adequate bladder decompression after VVF repair. Obviously, excessive bladder volumes could stress the suture line and instigate a bladder wound dehiscence. However, the need for an interposition flap and what constitute a good approximation and tension-free watertight closure are suspect.

The literature has always been suggestive of higher cure rates with the use interposition grafts during VVF repairs; however, definitive proof does not exist. Most recently, the use of interposition flaps has been questioned in nonirradiated patients [1,16,65]. In 2013 in a retrospective review of 49 patients without malignancy or a history of radiation therapy, the primary surgeon determined transvaginal repair of benign, recurrent VVFs without tissue interposition can be equally successful as primary repairs without tissue interposition [65]. In 2014, Miklos and Moore reported a 100% cure in 11 patients who previously failed VVF repair using a laparoscopic extravesical technique without an omental flap. These 11 women had a total of 17 previous VVF repair surgeries, 3 of which included interposed omental flaps [16].

An interposition graft for VVFs works on 2 theoretical premises: it functions as a barrier and it introduces vascularity and theoretically lymphatics to improve tissue growth and maturation. It has been our experience when operating on patients with failed VVFs with omental flaps, upon dissection of the vesicovaginal junction there was not only a lack of increased vascularity in the area but also no evidence whatsoever of an interposition graft. This finding brings into question the viability of the 2 theoretical benefits of an omental flap. From our results, omental interposition grafts have no different cure rate for VVF repairs compared with the no graft group. Perhaps the most important part of the surgery is the actual repair of the fistula (i.e., the bladder and the vagina) and not the addition of the interposed omentum.

In theory, a high success rate can be attributed to meticulous dissection and a multilayer closure that includes a double-layered bladder closure, as supported by Sokol et al [66], as well as aggressive testing of the bladder's suture line. In a study using 24 mongrel dogs, Sokol et al suggested that a double-layer closure of cystotomy is superior to a single-layer closure and may prevent fistula. Although a cursory review of the data suggests a trend revealing the more sutures that are used for fistula closure the greater the success rate of the VVF repair, these data are not statistically significant.

The only way to determine good tissue approximation in VVF repair is to objectively determine a watertight seal. A visual inspection of tissue approximation alone, without retrograde filling the bladder and stressing the suture line, is probably not the best measure of suture line integrity. However, standardization of the technique to determine a watertight seal has never been defined, and this is apparent in the lack of consistency found in the VVF literature. Our literature review reveals no documented test of bladder integrity in 45.08% of cases of VVF repair. The other 54.92% of patients had bladder testing with bladder capacities ranging from 75 to 400 mL. Most bladder fills used normal saline, and 26.23% of the studies reveal the use of saline and dye. We recommend using what is considered a normal bladder capacity, at least 300 mL at the time of bladder fill, to test the suture line integrity. They also recommend using some type of contrast (i.e., povidone or methylene blue), making small leaks easier to see.

Defining and comparing these 2 laparoscopic techniques of VVF repair with and without omental flaps is long overdue because there has been a lack of clarity in the literature. From pooling data, the surgical technique (transvesical vs extravesical), bladder layer closure, vaginal layer closure, interposition, and bladder testing dye showed no statistical differences. However, laparoscopic VVF repair with a bladder fill test had statistically significant higher success rate compared with those without a bladder fill test.

The limitations of this systematic review include differences in follow-up period and no randomized controlled trials. Most studies included in this review are case series and case reports. Therefore, meta-analysis could not be performed. Because most studies in the review are case reports and case series, there are possible biases, such as publication bias, selection bias, and its impact on the conclusions that can be drawn from the review. The reported success rates of both types of VVF repair are inherently falsely elevated compared with real-world success rates. The general success rate of VVF repair was approximately 90% [3]. As a result, a conclusion as to the best surgical technique of laparoscopic VVF repair cannot be drawn. Further randomized controlled trials should be conducted.

The decision on approach, technique, interposition grafts, and layers of closure remains controversial and a personal decision based on a surgeon's experience and comfort level. Vasavada and Raz [67] said it most eloquently: "The best chance for ultimate success of vesicovaginal fistula repair is achieved not only with the first repair, but also the approach most familiar to the surgeon." No matter the approach, we believe the most important aspect of the VVF repair remains adequate dissection, a watertight seal, and good postoperative bladder decompression to allow for tissue healing.

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