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5

Laparoscopic approach to vesicovaginal fistulae

S.R. Ramphal*

Urogynaecology and Pelvic Floor Unit, Department of Obstetrics and Gynaecology, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa



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The surgical repair of vesicovaginal fistula (VVF) over the last two decades has evolved from the transabdominal/transvaginal route to minimally invasive techniques of laparoscopy and robotic surgery. The indications for laparoscopic repair include supratrigonal fistulae, and stenotic/narrow vaginas that make vaginal access to the fistula site difficult. In the current published literature, comparable results have been reported with open surgery. The initial techniques were performed to simulate the open classic technique described by O'Connor, but with better imaging, exposure and magnification, the modified O'Connor (smaller cystotomy) and the extravesical approaches (no cystotomy) are being performed with comparable results. Difficulties such as depth perception, suturing and ergonomics together with the steep learning curve associated with laparoscopy have been overcome with the introduction of robotics. Reports on laparoendoscopic single site surgery (LESS) and transvesicoscopic VVF repairs with successful outcomes have been published, but studies on a large number of patients are needed to establish their effectiveness. Difficulties of managing suturing have been circumvented with the usage of the barbed suture; however, more data are required to establish its efficacy. Although the laparoscopic/robotic approach of a VVF repair offers numerous advantages, the best chance of success is achieved with the first surgical attempt using an approach that the surgeon is familiar in performing.

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* Department of Obstetrics and Gynaecology, Private Bag 7, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa.

E-mail address: ramphals1@ukzn.ac.za.

Introduction

Vesicovaginal fistula (VVF) is a major health problem and is responsible for significant social, psychological and physical morbidity. In low-resourced countries, the aetiology is predominantly obstetric related and often results from neglected prolonged obstructed labour, whereas in well-resourced countries, the aetiology is predominantly related to surgical interventions. Fistula is one of the most dreadful complications encountered in obstetrics and gynaecology, and to the physician, it is a constant reminder of an undesired outcome, which has long-term medico-legal implications.

The incidence of injuries to the urinary tract is increasing as more complex surgical procedures are being performed. The overall incidence varies between 0.5% and 1.5%, and injuries to the bladder are more common than that to the ureter [1]. VVF is the most common type of urological injury, and hysterectomy is the most common surgical procedure resulting in VVF formation in well resourced countries with a reported incidence of 75.4% [2].

It is well known that the best opportunity for the successful closure of the fistula is during the first surgical attempt, and with each successive attempt, the failure rate increases. Fistula size, location, timing from the antecedent event, quality of surrounding tissue and surgical skills are pivotal for successful outcomes. The surgical approach for repair can be abdominal, vaginal and recently laparoscopic with or without robotic assistance. The transvaginal route is associated with less morbidity, faster recovery and allows the surgeon to perform other transvaginal procedures at the same time. The abdominal route is indicated when there is poor vaginal access, high supratrigonal fistula (common with hysterectomies), a narrow vagina, if ureteric re-implantation is contemplated or other abdominal procedures are required. To date, there is still controversy with regard to the best surgical approach for fistula repair, and the approach is often based on the surgeon's preference, location and complexity of the VVF [3]. Surgeon's preference is often based on training, experience and mentorship, and with laparoscopy becoming popularised in recent decades, surgeons are now performing laparoscopic VVF repairs more frequently.

For a successful VVF repair, irrespective of the approach, the surgeon must follow the fundamental treatment principles of fistula surgery, which include good visualisation, adequate exposure, good dissection with healthy margins, tension-free approximation of the fistula edges, non-overlapping of the suture lines, good haemostasis, watertight closure and adequate post-operative bladder drainage [4]. The laparoscopic approach is a minimally invasive option that allows for a transabdominal approach with less morbidity. It is well established that laparoscopic surgery is associated with decreased convalescence, shorter hospital stay, less pain relief requirements, quicker recovery time and the aesthetic advantage of small scars. Furthermore, the laparoscope can visualize areas where the naked eye cannot see and, together with the magnification, it will allow for more precise surgery; hence, it is ideal for VVF repair.

To date, the literature on laparoscopic VVF is limited but is gaining interest in recent years. The first reported case of laparoscopic VVF repair was published in 1994 [5], and in a systematic review of the literature by Miklos et al., it was identified that most articles published reviewed outcomes of case reports and case series without standardisation of techniques, outcomes or follow-up. There were no randomised controlled trials, and in their review of 44 articles, only two studies had more than 15 patients. This made the comparisons of surgical techniques for VVF challenging and difficult to interpret [6]. Efficacy of laparoscopic VVF repair ranges from 86% to 100% in studies including 10 or more patients [7–11]. Principles and surgical techniques common to most series addressing laparoscopic VVF are discussed in the following:

- 1 Clinical assessment to support the diagnosis of VVF.
- 2 Pre-operative excretory urography (imaging of the upper tracts) to rule out ureteric involvement.
- 3 Cystoscopy to assess size, site, proximity of fistula to ureters and condition of surrounding tissue before definitive surgery.
- 4 Timing of laparoscopic repair

Ideally, surgical intervention should be done after a minimum period of 2 months after the injury. Spontaneous closures are reported if a VVF is small, and catheter drainage is initiated before

epithelialisation [12]. There is no consensus with regard to how long one should wait for a closure, but traditionally, a period of 3 months is allowed for the inflammation to settle. Most VVFs that develop after abdominal hysterectomies tend to be small, and the inflammatory reaction is not severe, thus bringing the notion of 'waiting for the inflammation to settle' into question. In addition, many of the patients are emotionally distressed, socially compromised and are not willing to wait. Furthermore, some patients have intra-abdominal adhesions, and with prolonged waiting, adhesions become thick, organised and fibrosed, thus making the surgery more hazardous. Nagraj et al. reported on a series of 13 patients who underwent laparoscopic VVF repair within 2–4 weeks after initial surgery [11]. The mean size of the fistula was 18 mm (14–31 mm), and at a mean follow-up of 21 months, only one failure was reported. In a retrospective review of five women who underwent immediate laparoscopic non-transvesical repair without omental interposition, Lee et al. reported no recurrences after a median follow-up of 56 weeks [12]. The median interval between total abdominal hysterectomy and fistula symptom onset was 24 days (14–30 days). The fistula size was on average 6 mm (5–9 mm) and all fistulae were supratrigonal. Their technique utilised both intracorporeal suturing for the bladder defect and transvaginal suturing of the vaginal defect. Zhang et al. reported on 18 patients who had undergone their laparoscopic VVF repair within 10–28 days after the intervention that caused the fistula. Sixteen patients had an abdominal hysterectomy, and the remaining two experienced obstetrical trauma during delivery. The location of the fistula was supratrigonal in all cases, and the mean size was 19.7 mm (12–30 mm) [10]. All patients were cured at the first attempt with no recurrence at a mean follow-up of 22.7 months (3–45 months). Hence, in selected patients with fistula that developed from the surgical intervention, immediate laparoscopic repair is an acceptable management strategy.

5 Cystoscopy and stenting

After administration of general anaesthesia, the patients are placed in a low lithotomy position using stirrups. Cystoscopy is performed, and both ureters are stented with double J stents. A single-ended ureteric catheter of a different colour from that of the double J stents is inserted through the fistula into the vagina by using the cystoscope and retrieved at the level of the introitus. This facilitates the identification of the fistula site when operating laparoscopically. If difficulty is encountered in passing the catheter, then an O'Shaughnessy curved forceps is passed from the vagina through the fistula into the bladder and the stent retrieved into the vagina.

6 Laparoscopic intraperitoneal access

Intraperitoneal access is achieved with a Veress needle and primary trocar entry from the left upper quadrant [12]. Two 5 mm accessory ports are placed at the iliac fossa level, allowing for adhesiolysis, enterolysis and vault access. Adhesions involving the bowel and omentum in the pelvis, in particular at the vault, are not an infrequent occurrence, and these need to be carefully removed to gain access to the fistula site. Omental length must be considered during the freeing of adhesions as this could be used as an interpositional graft later in the surgery. The left upper quadrant allows for both a panoramic and zoom views when required. Once the pelvis is free of adhesions, then the telescopic port can be relocated to the umbilicus. A 10 mm port is placed midway between the symphysis pubis and umbilicus, which allows for suturing.

7 Energy source

There are very little data on the preferred energy source for VVF surgery. Ultrasonic energy has been used for adhesiolysis, enterolysis and deliberate cystotomy [7,10,13]. However, when the bladder is dissected from the vaginal wall, especially at the site of the fistula, it is advisable to use scissors without energy as this avoids devitalised edges that may compromise the repair.

8 Transvesical versus extravesical approach

There is still debate with regard to whether the conventional transvesical approach is superior to the more recent extravesical approach for VVF repair. The classic transabdominal technique described by O'Connor involves bivalving the bladder with a subsequent transvesical approach [14]. The advantage of this technique is the ability to identify and visualise the fistula tract with a 0° telescope, and the cystotomy allows for dissection towards the fistulous tract and subsequently its complete dissection. Sotelo et al. in their publication advocated the transvesical approach. They operated on 15 patients, and at a mean follow-up of 26.2 months, all but one patient was continent. They performed cystoscopy and utilised the light to reduce the size of the laparoscopic bladder cystotomy [7]. Zhang et al. adopted the transabdominal transvesical approach using the harmonic scalpel to incise the posterior bladder wall. The incision was carried downwards until the fistula tract was reached, thus allowing for a wide dissection of the intervesicovaginal plane so that the bladder can be easily separated from the vagina. Under direct vision and using laparoscopic scissors, the bladder wall was separated from the vagina, and the vesicovaginal space was extended laterally to allow for a tension-free suturing. The vagina was closed with a single layer of vicryl 2-0 (Ethicon). An omental interposition graft was anchored to the vagina, and the bladder closure was performed in two layers: the mucosal layer with a continuous 3-0 synthetic absorbable suture and a second seromuscular interrupted layer using 2-0 synthetic absorbable suture. Continence was achieved in all 18 patients in their series [10]. Chibber et al., in their series of six patients who underwent laparoscopic VVF repair by the transvesical approach, recorded cure and no voiding dysfunction in all patients [15]. A modified laparoscopic abdominal VVF repair – ‘Mini-O'Connor’ technique was described by Rizvi et al., where a limited cystotomy of less than 2 cm size is made close to the fistula tract. Eight patients were operated using this technique, and at a mean follow-up of 29 months, all were continent. The authors concluded that a small cystotomy had the potential to decrease the operative time and reduce bladder spasms [16].

The laparoscopic extravesical VVF repair was first described by von Theobald et al., in 1998 [17] and popularised by Miklos and Moore [18]. The technique involves the bladder being filled in a retrograde manner with normal saline until the vesicovaginal reflection is adequately identified. The vesicovaginal space was dissected using endoscopic scissors until the stent in the fistula was seen, thus confirming the entry of the fistulous tract. Dissection between the bladder and vagina was then continued using a firm instrument in the vagina, and this allows for a firm backstop. The tract was excised from both the vagina and bladder, and the dissection was continued approximately 1–2 cm distal to the fistula. A single layer of vicryl 2-0 suture was placed in an interrupted figure-of-8 fashion to close the vagina. A double-layer closure using vicryl suture 3-0 was placed in a figure-of-8 fashion to secure the bladder. After the first layer of closure, the bladder was retrogradely filled with 300–400 ml of fluid, and the leakage area is resutured until there was no leak observed. Thereafter, a second-layer closure was performed. A suprapubic catheter was used for 2–3 weeks post-operatively [18]. The authors reported a success rate of 98% (42 out of 43 patients) at a mean follow-up of 17.3 months (3–64 months). Das Mahapatra and Bhattacharyya in their series of 11 patients who underwent the extravesical laparoscopic approach achieved continence in 10 patients at 6 weeks post repair visit [8].

To date, there are no randomised or comparative trials that compare transvesical and extravesical laparoscopic VVF repairs. The extravesical approach is a less invasive and less traumatic approach, and because a deliberate bladder incision is avoided, there is a theoretical risk of less failure with the repair. Furthermore, proponents of the extravesical approach argue that bivalving the bladder is associated with the theoretical risk of voiding dysfunction, reduced bladder capacity and increased operative time due to bleeding and extended suture repair [9,19].

The main benefit of the laparoscopic transvesical VVF repair is the localisation of the fistula tract in an otherwise scarred area. With the extravesical approach, the localisation of the VVF site may be technically challenging. Concurrent endoscopic guidance to assist with the localisation of the dissecting plane and fistula site at laparoscopy has been reported [20]. In a series of four patients, Garcia-Segui used vaginal transillumination to locate the fistula and reduce the size of the bladder opening during laparoscopic repair without intentional cystotomy. Fistula was located using a cystoscope inserted through the vagina and placed over the fistula. The emitted light guides the laparoscopic

dissection into the plane between the vagina and bladder just above the fistula. This allows for an incision to be made towards the vaginal portion of the fistula without the need for a large cystotomy for localisation [20]. Sotelo et al. utilised the light from the cystoscope to assist in their dissection. The vagina is retracted posteriorly with a sponge retractor, and the light from the cystoscope becomes clearly visible through the bladder in the vicinity of the VVF. The posterior bladder wall is then incised vertically with a harmonic scalpel in the proximity of the VVF [6].

In the review by Miklos et al., 19 studies (103 patients) using an extravesical approach were compared to 22 studies (256 patients) adopting the transvesical approach for laparoscopic fistula repair. The success rates of the transvesical and extravesical techniques were 95.9% and 98.0%, respectively (relative risk, 0.98; 95% confidence interval, 0.94–1.02). It appears that both approaches are acceptable provided the surgeon is conversant with the technique [6]. If the technical steps for fistula repair are adhered to at all times, an anticipated successful outcome is achieved.

A modified technique of the extravesical approach was described by Lluca et al. in a case report for the treatment of a supratrigonal VVF. The fistula exit orifice in the vaginal cuff was identified, and a urinary Foley catheter was introduced into the fistula. The bulb was inflated, and the catheter was sealed with 0 silk suture against the vaginal fistula site. The tube was then sectioned approximately 5–6 cm from the bulb, leaving the closed end inside the vagina. A gauze pack was inserted in the vagina to preserve the pneumoperitoneum. The vaginal cuff was opened laparoscopically, and the catheter end was placed into the abdominal cavity using laparoscopic graspers. The urinary bladder was dissected, separating it from the anterior wall of the vagina until the end of the knotted catheter was found. The catheter was pulled; this assisted in the separation of the bladder from the vagina with the aim of cutting the entire circumference of the bladder fistula and obtaining adequate margins. The catheter was then removed, and the bladder was repaired in two layers and the vaginal cuff in a single layer. The authors reported success in this case, but the technique needs to be used in a larger number of patients to evaluate its efficacy and acceptability [21].

9 Bladder repair

There are only minimal data with regard to the number of layers of bladder repair with fistula surgery. In the review by Miklos et al., data were pooled from 44 studies on patients who underwent laparoscopic fistula surgery. Continence was achieved in 141 of 146 patients (95.6%) who underwent a single-layer closure as compared to 90 of 92 patients (97.85%) who underwent a two-layer closure. It appears that there is no significant difference regardless of whether the bladder is closed in one or two layers [6]. This supports the fact of a good apposition with a tension-free repair of the bladder together with continuous drainage post-operatively as the hallmark of successful fistula repair.

10 Suture choice

The most common suture material used for laparoscopic VVF repair is polyglactin/vicryl 2-0 or 3-0 [7–11,18]. Recently, there are reports on the usage of barbed sutures for laparoscopic VVF repairs to overcome the problems related to suture and surgical knots that increase operative time [21,22]. Despite these successful outcomes, studies on a larger number of patients are needed to draw conclusions.

11 Interposition grafts

The literature is always suggestive of higher cure rates with the use of interposition grafts in VVF repairs. The need for interposition grafts for open transabdominal VVF repairs has been evaluated. Evans et al. retrospectively reviewed 37 women who underwent transabdominal repairs. In 12 cases where interposition flaps were used, continence was achieved in all cases. In the remaining 25 cases where no graft was utilised, continence was achieved in 16, confirming a 64% success. The authors recommended interposition grafts in transabdominal repairs of VVF, even in cases of benign fistulae with well-preserved surrounding tissue [23]. The graft works on two theoretical premises: it functions

as a barrier and fills dead space and introduces vascularity and lymphatics to improve tissue growth and maturation, thus reinforcing the repair [2,6].

Recently, the use of grafts in non-irradiated patients is in question [24,25]. In a publication from India by Goyal et al. that evaluated a retrospective analysis of 252 cases, small fistulae using a layered closure technique without interpositional flaps had a success rate of 97.5%, challenging the liberal use of flaps [25]. Specific to laparoscopic VVF repair, Miklos and Moore in their series of 43 patients showed a 98% cure rate without interpositional grafts. They commented that 'It is our opinion that omental, peritoneal and sigmoid fat interposition grafts are not as viable as a Martius muscle flap because they lack thickness and vascularity, thus minimising their viability' [18]. Lee et al. reported successful closure in five patients (after undergoing total abdominal hysterectomies) with VVF of less than 1 cm without grafts at a median follow-up of 56 weeks. An extravesical approach with a double layer of bladder suturing was utilised [12]. Furthermore, Abdel-Karrim reported a 100% success rate in 15 patients who underwent laparoscopic repair with omental grafts [9]. The authors commented that 'interposition of healthy well-vascularised flaps between the bladder and vagina plays an important role for successful repair of VVF as it ensures isolation of the two suture lines and provides a good blood supply to the relatively unhealthy tissues.'

In the systematic review by Miklos et al., 184 of 191 patients (96.3%) who had a graft in laparoscopic VVF repair were cured as compared to 52 of 53 patients (98%) without a graft. The authors correctly advocated that an omental flap is not a substitute for proper dissection, apposition and closure of a fistula [6]. An omental interposition graft provides an additional layer between the bladder and vagina and takes limited time with little morbidity and should be advocated if there is a doubt. Other tissue and synthetic materials have also been described as a flap between the bladder and vagina including colonic epiploic appendix [26] and peritoneal inlay [27]. In the initial report of robot-assisted laparoscopic repair, Melamud et al. utilised fibrin glue as an interposition graft between the bladder and vaginal closure [28]. In a case report by Erdogru et al., a fleece-bound sealing system (TachoSil) was used as a tissue barrier during laparoscopic VVF repair in a patient with recurrent fistula. At a 6 month follow-up, the patient was continent [29].

12 Assessing for watertight seal

Miklos et al. commented that the only way to determine good tissue approximation in a VVF repair is to objectively test the integrity of the suture line by performing a watertight sealing. In their review, 21 of 44 studies tested the integrity of the suture line. By combining the data in all these studies (of 260 patients), 133 of 134 patients (99%) who had the bladder test were continent as compared to 103 of the 110 (94%) patients who did not have the test. Patients who received bladder fills ≤ 200 ml had an overall success rate of 100%, whereas those who received bladder fills of 250 ml or more had an overall success rate of 97.7–100%. Patients who did not receive a retrograde bladder fill after VVF repair had a cure rate of 80–100%.

Patients who received a bladder test had a 6% higher success rate than those who did not [6]. Standardisation of the technique to determine a watertight seal has never been defined. Studies differ with regard to the volume and type of fluid. Most bladder instillations used saline, whereas others used saline and dye. Miklos et al. recommend at least 300 ml of retrograde bladder fill to test the integrity of the suture line and the usage of some type of contrast (povidone or methylene blue) to visually improve identifiable small leaks [6].

13 Bladder drainage

Continuous bladder drainage post VVF repair is critical for optimal outcomes. However, no studies have compared different catheter types or duration of drainage following fistula repair. Most studies do not describe their catheter practice, but with laparoscopy, there is a tendency to favour the urethral route with a small number of studies adopting the suprapubic route [18]. Bladder drainage ranges from 7 to 21 days, but most series recommend a minimum of 14 days [6].

Patient selection

Patient selection for the laparoscopic repair of VVF is critical when we seek for good outcomes. It is well established that the transvaginal VVF repair is the least invasive approach because it serves as a natural orifice with the least disturbance to the abdominal and peritoneal cavity. A high supratrigonal fistula can be challenging to a vaginal surgeon, and the laparoscopic approach is an excellent option. A narrow or scarred vagina might hinder vaginal access to the fistula and may be better approached laparoscopically. In the pooled data by Miklos et al., 260 patients from 44 studies were evaluated and 210 of the cases (80.8%) had undergone a hysterectomy. Forty-three cases (16.5%) were secondary to obstetrical trauma. However, the cases with obstetric trauma were not related to neglected or obstructed labour [6]. Furthermore, most patients with fistulae who have undergone laparoscopic repairs can be classified as simple or uncomplicated, and with improved surgical skills, better equipment, instrumentation and optics, one can anticipate surgeons starting to operate on complex cases.

Laparoscopic repair of recurrent fistula

With regard to the laparoscopic repair of recurrent VVF, there are no case series that exclusively address this topic. Much of the data are case reports [30,31] or cases that are included in case series of laparoscopic VVF repairs [7,18]. Miklos et al. published the first report of laparoscopic VVF repair in a patient with failed Latzko partial colpocleisis fistula repair following a hysterectomy. Bladder and vagina were sutured separately, an omental patch was anchored to the anterior vaginal wall and bladder was drained for 21 days. The patient was fistula free at 6 months following surgery [30]. In the series by Sotelo et al., four of the 15 patients had previous fistula surgery (by open abdominal approach in three and vaginal approach in one patient). One of the patients underwent three previous attempts and another underwent two failed procedures. In their series, there was one failure, but the patients' characteristics were not mentioned [7]. Wong et al. reported on two patients who had failed prior Latzko repairs. The O'Connor technique was adopted with the bladder being bivalved to the fistula site. The fistulous tract and adjacent fibrotic tissue were excised, and the bladder and vagina were closed separately with single layers of full-thickness interrupted vicryl 2-0 sutures. An omental interposition graft was used, and at a follow-up of 41 months in the first patient and 39 months in the second patient, there was no fistula recurrence [32]. Miklos and Moore reported on a successful laparoscopic approach without the use of an omental flap in a patient with multiple recurrences of a VVF. They used an extravesical dissection technique and layered closure without bivalving the bladder [33]. With recurrent fistula, one can anticipate adhesions and technically more challenging surgery. A laparoscope provides good access, and with magnification, one can aim for more precise surgery.

Modified laparoscopic approaches

Recently, laparoendoscopic single-site surgery (LESS) for the extravesical repair of VVF has been reported [34,35]. The benefits of LESS are the improved cosmesis and decreased incision site morbidity because only a single incision is made. Abdel-Karim et al. in their series of five patients used the TriPort (Olympus, Tokyo, Japan) and pre-bent instruments (HiQ LS hand instruments, Tokyo, Japan) and the EndoEYE LTF VP camera (Olympus, Tokyo, Japan) for their single-site repair. In this series, four patients had a hysterectomy for benign conditions and one patient had a caesarean section. The fistula tracts were identified and excised extravesically by a sharp dissection, and the vagina was closed with a single layer of vicryl 3-0 and the bladder was closed with two layers of vicryl 3-0. Operative time was on an average 198 min (170–240 min) and the length of hospital stay was 2 days for all the patients, and after an average follow-up of 8 months, all patients were continent [34]. Mahadevappa et al. performed surgery on 10 patients with a single-site entry using conventional instruments. The procedure entailed a 2–3 cm semi-circular incision in the groove between the umbilicus and lower abdominal wall. Three ports were inserted at different levels through this single incision, and extravesical repair was conducted. The mean operative time was 182.5 min (150–250 min). At a mean follow-up of 13.2 months

(6–30 months), all patients had successful outcomes with normal voiding and no recurrence [35]. In both these studies, there were no major intra-operative or post-operative complications. This surgical access appears safe and feasible with less morbidity but requires greater skill than conventional laparoscopy because of the confined operative space requiring increased ergonomic manoeuvrability. Loss of triangulation is the major handicap. In experienced hands, this may be an alternative to laparoscopic VVF repair, but prospective comparative studies with conventional laparoscopy and a larger group of patients are needed to confirm its place.

A transvesicoscopic repair in four patients with VVF following laparoscopic hysterectomy for benign conditions was reported by Nerli and Reddy [36]. An initial cystoscopy was performed using insufflation of gas, and the bladder was fixed to the anterior abdominal wall under cystoscopic guidance. A 5 mm endoscopic port was placed into the bladder under cystoscopic guidance in the midline, halfway between the pubic symphysis and umbilicus. Two more ports were placed 5 cm laterally and inferior to the endoscopic port on either side. The cystoscope was then removed and the urethra catheterised. The vagina was subsequently packed with betadine soaked swabs to prevent gas leakage. The bladder was dissected off the vagina, edges were excised and the vagina sutured vertically and the bladder closed horizontally using vicryl 4-0. The ureters were catheterised using 5F infant feeding tubes and brought outside the bladder for drainage. The infant feeding tubes were removed after 7 days, and the catheter was removed after 2 weeks. At a follow-up range from 8 to 17 months, all patients were continent with voiding reported as near normal, and all were satisfied with the surgical outcome. The fistula repair was done with gas distension of the bladder, and an obvious disadvantage of this approach is the inability to interpose omentum between the bladder and vagina. The advantage of this technique is the avoidance of entry into the peritoneal cavity, with anticipated less injury to intra-abdominal structures, less ileus, avoidance of peritoneal drains and less bleeding.

Llueca et al. published their initial experience with intravesical mini-laparoscopic repair of VVF with a surgical principle similar to that performed by Nerli and Reddy [37]. Their technique was carried out in two women who did not respond to conservative treatment with continuous bladder drainage. The repair was performed transvesically with 3 mm instruments and a 5 mm 30° telescope (by extraperitoneal approach). The vesical layer was separated from the vagina by dissection with scissors, and the mucosal vaginal ring and affected vaginal area were cut with scissors to create fresh surgical edges. The bladder and vaginal wall defects were closed in two layers with two separated continuous barbed, resorbable 3-0 sutures (V-Loc 90 Absorbable Wound Closure Device; Covidien, Norwalk, CT, USA). The integrity of the bladder was checked by filling it with 300 ml of saline solution. The mean operative time was approximately 100 min, blood loss was not significant and a Foley catheter was left in place for 14 days. At 6 weeks following surgery, patients were continent and bladder integrity was confirmed with imaging. A challenge to both these approaches is the ability to triangulate the laparoscopic instruments and the suturing of the layers of the vagina and bladder, and studies on larger number of cases are needed to establish the effectiveness of these techniques in the long term.

A combined vaginal and vesicoscopic collaborative repair of complex VVF was reported by Grange et al. Nine cases of complex fistulae, which included four ureteric reimplantations, were operated by a urologist (bladder repair and ureteric implants by percutaneous cystoscopic approach), and the vaginal repair was done by the urogynaecologists (by vaginal approach). The operative time ranged from 150 to 420 min, and there was no significant blood loss and no reported intraoperative complications. At a mean follow-up of 30 months, there was only one failure [38].

Challenges of laparoscopic VVF repairs

Laparoscopic surgery is a minimally invasive option that allows for a transabdominal approach with less morbidity. The main drawback is the steep learning curve associated with laparoscopy and the technical skills of intracorporeal and extracorporeal suturing [39,40]. Surgical time, costs of equipment and instrumentation and surgical experience are some of the challenges with regard to performing laparoscopic repair. Furthermore, many of these patients have fistulae of surgical origin and have a low

threshold to initiate medical litigation. The above factors do not allow the learning curve one needs to master the surgery.

Robot-assisted laparoscopic repair

Robot-assisted laparoscopic surgery offers the benefits of laparoscopy together with stereotactic vision and the familiarity of wrist movements associated with open surgery. Robotic surgery allows for instruments with increased degrees of freedom, improved dexterity, improved depth of perception with three-dimensional vision, motion scaling, higher magnification and improved surgeon ergonomic position during prolonged operations. It is possible to repair VVF laparoscopically with robotic-assistance while maintaining the basic surgical principles of fistula reconstruction [41]. It has been touted that the main benefit over conventional laparoscopy is the decreased learning curve associated with robotic surgery [17]. Melamud et al. were the first to report the combination of laparoscopy and robot-assisted laparoscopy for VVF repair [28]. Schimpf et al. were the first to describe a robot-assisted laparoscopic VVF repair without a cystotomy. The vagina was closed with a single layer of absorbable suture, and the bladder was sutured with two layers of 3-0 polyglactin. At 3 months of follow-up, the patient was continent [42]. A number of articles have featured a pure robot-assisted laparoscopic approach [27,43–45]. The surgical technique in the majority of patients included ureteral stents and a fistula catheter placed at the start of the procedure. Transabdominal port placement utilised a single camera port, two 8 mm robotic ports and two additional assistant ports. The transvesical technique with a cystotomy is the common approach. The four publications [27,42–44] included a total of 16 cases with a reported cure rate of 100%. Furthermore, most robot-assisted laparoscopic techniques tend to use interposition grafts. Operative times in robot-assisted laparoscopic cases vary from 110 to 330 min. Presently, although one can argue that fistula repair with robot-assisted surgery appears to be feasible, it is difficult to establish its place or potential advantages over standard laparoscopy in the surgical management of VVF.

Comparison of laparoscopy/robotic VVF repair with open approaches

At present, there is no randomised prospective trial that evaluates the superiority of one approach over another with regard to VVF repairs. Furthermore, there is no head to head study that compares laparoscopic VVF repair with the open abdominal surgery. This may be unlikely to occur because of the limited numbers of urinary fistulae and the difficulty in controlling the different variables, especially surgical expertise. In a review by Hillary et al., it was reported that similar success rates occur for vaginal and abdominal approaches, for transvesical and transperitoneal techniques and for repairs with and without interposition grafts [2]. However, the authors caution on the level of evidence and comment that 'It must be emphasised that these reports were reviewing non randomised cohorts; it is likely that the particular approach used in individual cases was selected based on the preoperative evaluation and dependent on individual surgical bias and it is not therefore valid to carry out a direct comparison of outcomes' [2].

Reports on laparoscopic repairs have demonstrated efficacy with acceptable outcomes in primary supratrigonal VVF [7–11]. Three retrospective studies have been published on the comparison of laparoscopic and robot-assisted laparoscopic VVF repairs with conventional techniques. Ou et al. compared six transabdominal open VVF repairs with six transvaginal repairs and two laparoscopic VVF repairs. The only failure was in the transvaginal group [46]. In a retrospective analysis on the comparison of outcomes between laparoscopic and open surgical repair for VVF, Ghosh et al. compared 13 patients in each arm. The mean fistula size was comparable; however, the mean blood loss (58.69 ± 6.48 ml in group 1 and 147.30 ± 19.24 ml in group 2), mean hospital stay (4 days in group 1 and 13 days in group 2) and analgesic requirement (261.53 ± 29.95 mg in group 1 and 617.30 ± 34.43 mg in group 2) were more favourable and statistically significant in the laparoscopic group. Although these numbers are small and inadequate to draw conclusive comparisons, it shows that laparoscopic VVF repair is associated with reduced morbidity and a shorter hospital stay [47].

A retrospective study has compared robot-assisted laparoscopic VVF repair with traditional open techniques. Gupta et al. evaluated robot-assisted laparoscopic versus open abdominal repair for recurrent VVF. Twelve robot-assisted laparoscopic cases were compared with 20 open cases, and there were no significant statistical differences in success rates (100% vs 90% - $p > 0.05$). Mean blood loss (mean 88 vs 170 ml) and mean hospital stay (mean 3.1 days vs 5.6 days) were significantly less ($p < 0.05$) in the robot-assisted group. There were no significant differences in complication rates or utilisation of interposition flaps between the two groups. They concluded that robotic VVF repair is a better option for recurrent fistulae in view of its reduced morbidity, but the cost is a limiting factor to its widespread acceptance [26].

Conclusion

To date, no absolute consensus has been reached regarding the best approach for treating VVF. Choice of surgical intervention is based more on individual surgeon preference than on evidence-based criteria. In the last two decades, laparoscopy has come to the forefront and is an alternative to laparotomy for many urogynaecology conditions, including VVF repair. The indications for simple uncomplicated VVF repair using the open transabdominal route is dwindling and being replaced by laparoscopic and robot-assisted techniques. With experience, surgeons are now performing recurrent fistula surgeries by minimally invasive techniques. In the available published literature, comparable results have been obtained with open surgery. The initial laparoscopic techniques were performed to simulate the open classic technique described by O'Connor; however, with better imaging and laparoscopic exposure with magnification, the modified O'Connor (smaller cystotomy) and the extravesical approaches (no cystotomy) are being performed with comparable results. Some authors have carried out laparoscopic surgery through a single incision (LESS) and by an extraperitoneal intravesical mini-laparoscopic approach with success. Robotic surgery with the agility of instruments, better viewing and ergonomic advantages is associated with a shorter learning curve and may be the intervention of choice for young, enthusiastic surgeons. However, the major drawback is the cost.

Difficulties in managing suturing with laparoscopy have been circumvented with usage of the barbed sutures, but more data are required to establish its efficacy. The decision on laparoscopic surgical approach, technique, layers of bladder closure, usage of interposition grafts and duration and route of catheterisation remains controversial, and choices are based more on surgeon's experience and comfort levels rather than evidence. Randomised controlled trials that address different aspects of laparoscopic VVF repair is the ideal one, but this is difficult for a small number of patients and the controlling of different variables.

However, it must be remembered that the maximum chance for the success of a VVF repair is achieved not only with the first repair but also with an approach that the surgeon is conversant with and knows how best to perform. With a widespread use of laparoscopy and the cosmetic demands of patients who are compromised by surgically induced VVF, laparoscopic/robotic intervention will become the surgical choice of VVF in the future.

Practice points

- Laparoscopic surgery for VVF is feasible and associated with good surgical outcomes.
- Indications for laparoscopic repair include supratrifurcated VVF, scarred and narrow vaginas and difficulty in accessing the fistula site vaginally.
- Laparoscopic VVF repairs are technically demanding operations and should be done in centres of excellence by experienced surgeons.
- Robot-assisted laparoscopic VVF repairs may be beneficial for recurrent fistulae.
- The maximum chance for the success of a VVF repair is achieved with the first repair and an approach that the surgeon is conversant with and knows how best to perform.

Research agenda

- Randomised controlled trials to assess efficacy of grafts/flaps, superiority of extravesical versus transvesical approaches and success of VVF repair based on single or double layers of bladder closure need to be addressed.
- Treatment of VVF with robotic assistance continues to develop, but further research is necessary to fully understand and use this technology to treat this condition.
- Usage of barbed sutures for the bladder repair needs to be evaluated in the surgical outcome of laparoscopic VVF repair.
- Studies that address direct comparisons between the transabdominal VVF repairs, transvaginal VVF repairs and the minimally invasive laparoscopic/robotic techniques are required.
- Studies that evaluate suture line integrity with bladder fill at the end of surgical repair are needed. The type of fluid, volume and usage of contrast (dye) should be evaluated.
- Timing of definitive VVF surgery following surgical induced VVF needs to be addressed.

Conflict of interest

The author has no conflict of interest to declare.

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