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Surgery in Motion

Best Practices in Robotic-assisted Repair of Vesicovaginal Fistula: A Consensus Report from the European Association of Urology Robotic Urology Section Scientific Working Group for Reconstructive Urology

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Abstract

Context: Surgical repair of a vesicovaginal fistula (VVF) has been described extensively in the literature for several decades. Advances in robotic repair have been adopted since 2005.
Objective: A consensus review of existing data based on published case series, expert opinion, and a survey monkey.
Evidence acquisition: This document summarizes the consensus group meeting and survey monkey results convened by the European Association of Urology Robotic Urology Section (ERUS) relating to the robotic management of VVF.
Evidence synthesis: Current data underline the successful robotic repair of supratrigonal nonobstetric VVF. The panel recommends preoperative marking of the fistula by a guidewire or ureteral catheter, and placement of a protective ureteral JJ stent. An extravesical robotic approach usually provides a good anatomic view for adequate and wide dissection of the vesicovaginal space, as well as bladder and vaginal mobilization. Careful sharp dissection of fistula edges should be performed. Tension-free closure of the bladder is of utmost importance. Tissue interposition seems to be beneficial. The success rate of published series often reaches near 100%. An indwelling bladder catheter should be placed for about 10 d postoperatively.
Conclusions: When considering robotic repair for VVF, it is essential to establish the size, number, location, and etiology of the VVF. Robotic assistance facilitates dissection of the vesicovaginal space, harvesting of a well-vascularized tissue flap, and a tension-free closure of the bladder with low morbidity for the patient being operated in the deep pelvis with delicate anatomical structures.
Patient summary: Robotic repair of a vesicovaginal fistula can be applied safely with an excellent success rate and very low morbidity. This confirms the use of robotic surgery for vesicovaginal fistula repair, which is recommended in a consensus by the European Association of Urology Robotic Section Scientific Working Group for reconstructive urology.

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1. Introduction

A vesicovaginal fistula (VVF) is defined as a pathological anatomical junction between the dorsal bladder wall and the anterior vagina. The pathophysiological mechanism for this abnormal anatomic connection is a necrosis of both organ walls as a result of ischemia. Descriptions of VVF go back to the 11th dynasty in Egypt [1].

The clinical manifestation of women suffering from a VVF is continuous urinary leakage through the vagina. Typically, the degree of incontinence is proportional to the size of the fistula [2]. VVF creates hygienic, social, infectious, psychological, and sexual problems. The vagina may become inflamed and ulcerated [3], which is why VVF should always be treated. The main risk factors for VVF consist of (1) surgery and (2) prolonged labor; in well-resourced countries, VVFs are most often caused by an iatrogenic unperceived injury of the dorsal bladder wall during hysterectomy or sometimes during sling placement for incontinence. The estimated incidence for these procedures ranges around 0.3–2% in well-resourced countries [4]. Other causes include pelvic irradiation or malignant disease [5]. In contrast, VVFs in low-resourced countries are predominantly caused by cephalopelvic disproportion leading to prolonged labor. This disproportion then causes an ischemia of the vaginal wall by tearing or shearing of the vesicovaginal space. Commonly, VVFs due to prolonged labor appear to be larger because of a broader area of injury coming from a cephalopelvic disproportion. These VVFs are usually more complex and located deeper in the pelvis. They may include urethral loss, rectovaginal fistula formation, anal sphincter incompetence, as well as osteitis pubis [6]. The overall prevalence of VVF in low-resourced countries is considerably higher, making VVF a relevant health issue. In African countries such as Ethiopia, the prevalence is estimated to be 1.5 per 1000 women [7]. Obviously, there is an increased incidence of VVF in low-resourced countries, indicating limited access to obstetric intervention, in particular among the rural poor population [8].

Although VVFs are the most commonly diagnosed fistulae of the urinary tract, there is no standardized algorithm for their management [5,9,10]. O'Conor [11] once described the transabdominal, suprapubic, extraperitoneal access with a cystostomy. This approach allowed good mobilization of the bladder and exposition of the Retzius space. The first published laparoscopic repair of VVF was in 1994 by Nezhat et al [12]. The transabdominal approach was first described by von Dittel in 1893 [13]. The first robotic repair was published in 2005 [14]. Meanwhile, a variety of studies are available on robotic VVF repair with different techniques. For instance, some authors routinely place JJ in order to protect the ureters during surgery [15–17], while others do not [18–20]. Some are convinced of putting a flap onto the excised fistula [21], while others are not [22]. Even the repair with fibrin sealant has been described [10]. Finally, the surgical approach (eg, vaginal or abdominal, laparoscopic, or with robotic assistance) is often chosen according to location, complexity, and surgeon's preference [23]. Thus, there are a variety in techniques for the management of VVF.

The current consensus paper focuses on robotic VVF repair. We first summarize the existing data by a narrative review. Moreover, we created a survey monkey (SM), which consists of questionnaires sent by e-mail. The scientific group of the European Association of Urology Robotic Section (ERUS) sent two SMs from July to December 2017 to all participants of the ERUS meeting 2017, in order to provide a standardized algorithm for robotic reconstruction of VVF.

2. Evidence acquisition

A review of the published literature related to VVF was performed in September 2018 using Medline and Web of Science. The keywords "robotic-assisted vesicovaginal fistula" and "da Vinci vesicovaginal fistula" were used across these search fields: surgical series and comparative studies evaluating VVF repair. Studies on open repair were excluded from our review. Intra- and perioperative techniques and outcomes were evaluated and summarized in a narrative review.

The systematic review and personal experience of expert surgeons provided the context for the development of individual presentations by the attendees of the ERUS congress 2017. To all ERUS 2017 participants, a standard e-mail with selected questions concerning robotic VVF repair was sent by the European Association of Urology (Table 1).

3. Evidence synthesis

3.1. *Preoperative evaluation*

3.1.1. *Etiology of VVF and impact on repair*

The etiology of VVF has an impact on the surgical approach. Whenever there is a urinary discharge through the vagina after hysterectomy or obstetric surgery, a VVF should be

Table 1 – Questions of the survey monkey sent to the ERUS participants.

Approximately, how many robotic VVFs are being performed each year at your department?
What are the main reasons for VVF at your department?
Do you also perform VVF repair by vaginal approach?
How do you visualize the VVF intraoperatively?
Do you routinely insert the ureteral stent in order to protect the ureter(s)?
Which graft do you mainly use to cover the VVF after being excised?
With how many layers do you close the vagina?
What suture material do you use to close the vagina?
With how many layers do you close the bladder?
What suture material do you use to close the bladder?
For a simple VVF, how long is the bladder catheter left postoperatively?

ERUS = European Association of Urology Robotic Urology Section; VVF = vesicovaginal fistula.

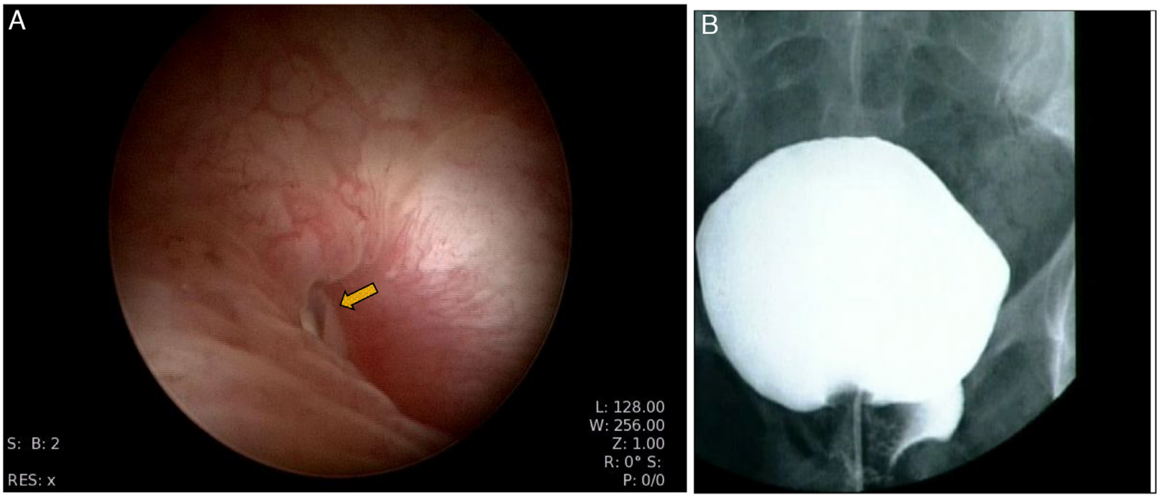

Fig. 1 – (A) Simple vesicovaginal fistula with single fistula tract (arrow) and (B) corresponding cystogram.

suspected [24,25]. Compared with a VVF provoked by prolonged labor, an iatrogenic fistula is located higher in the pelvis and is therefore supratrigonal. The mechanism for a VVF consists of a thermal injury leading to a necrosis of the posterior bladder wall. Once the process of necrosis has started, an inflammatory process leads to the production of collagen and perifistula fibrosis. This damage might occur during mobilization of the vagina, for example, during hysterectomy. The reported incidence varies from 0.02% to 1.2% depending on the approach to hysterectomy [26,27]. Thus, surgery is the most important risk factor for VVF in well-resourced countries [28]. In a recent review, 62.7% of postoperative VVF were due to hysterectomy performed by any route, 12.7% were associated with other types of pelvic surgery such as colorectal, urological, or gynecological procedures, whereas 13% develops after radiotherapy [28]. Other reasons include infection, foreign bodies, or pelvic malignancy [29].

3.1.2. Preoperative imaging

The correct fistula identification is the most crucial step in their management. The workup includes pelvic examination with speculum and cystoscopy. In some cases, a fistula tract might be seen during clinical examination or by cystoscopy (Fig. 1 and 2), although VVF can be very difficult to diagnose. When imaging modalities are not available, a "double dye test" might be helpful to better understand the fistula location [30]. Preoperative understanding is of paramount importance in order to understand the number of fistulae ("hidden fistula"); their size, location, and

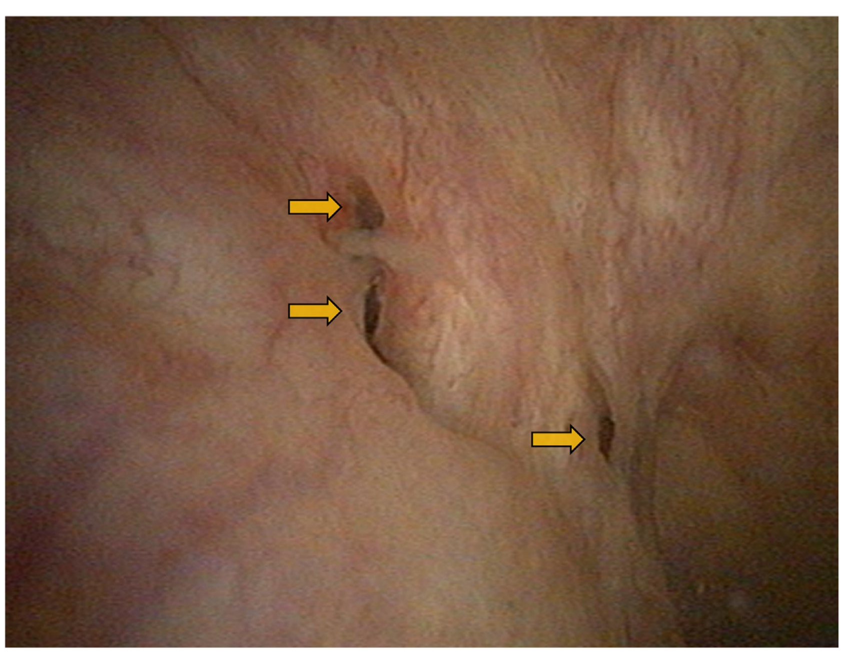

Fig. 2 – Complex vesicovaginal fistula with multiple fistula tracts on the left bladder wall (arrows).

Table 2 – Current VVF classification systems.

Author
Lawson [34]
Goh [35]
Waaldijk [36]
Panzi
Sims [3]
Mahfouz
Moir
McConnachie
Bird
Gray
Hamlin and Nicholson
Arrowsmith [6]
Tafesse
WHO

VVF = vesicovaginal fistula.

distance from the ureteral orifices; as well as possible fistula branching. Although the majority of VVFs are caused by iatrogenic injury, prolonged labor, or radiation, VVFs caused by malignancy should be ruled out by tissue biopsy. In addition, a computed tomography (CT) scan with cystogram is helpful in locating the fistula exactly (Fig. 1). On magnetic resonance imaging (MRI), VVFs usually show a wall enhancement if the tissue is active or in a healing process [31], and sometimes, a healing VVF has a central granulation tissue [32].

Patients with multiple fistulae should always prompt the suspicion of hidden fistulae. Whether MRI is helpful in detecting these hidden fistulae remains unclear so far.

VVFs should be graded according to their location ("supratrigonal" or "trigonal"), size, and etiology. However, the most challenging step often remains the location of the fistula during surgery. Often, the fistula is located at the trigone close to the ureteral orifice [33].

3.1.3. *Classification of VVF*

Table 2 summarizes the current VVF classification systems. Several attempts have been made for risk stratification according to their risk to relapse—recurrent VVF is the most common complication after fistula repair. There are currently a couple of risk scores or classifying systems, but the clinical usefulness remains to be discussed. Older systems such as the one by Lawson [34] simply include a rough location of the fistula (such as "juxtaurethral" or "juxtavaginal"). More recent classification systems such as that by Goh [35] include the distance from the external urinary meatus to the distal edge of the fistula (from >3.5 to <1.5 cm), the diameter, as well as the degree of fibrosis. Waaldijk [36] included the size, involving the urethra and the closing mechanism (type I not involving closing mechanism vs type II involving closing mechanism). It is reasonable that a more extended VVF with an increased perifocal fibrosis, involvement of other anatomical strictures (such as the urethra), or a VVF after irradiation has a greater risk of recurrence than those without "risk factors." Notably, most of the current classification systems have poor to fair performance with an area under curve of 0.60–0.63 [37]. In addition, there are other important clinical, metabolic, technical, and anatomical variables that might need to be involved in a classification system. There is also evidence that moderate to severe perifistula fibrosis as well as the presence of multiple fistulae has been reported to affect the recurrence rate of VVF negatively [20]. The size of the fistula seems to be another risk factor: some studies have reported lower success rates for fistulae >1 cm [38] or >3 cm [19], while other authors found no difference for fistula size but for bladder capacity, urethra involvement, fibrosis, and prior surgery [39]. From a practical point of view, the ability to mobilize local tissue for a tension-free cover of the lesion is probably one of the most important factors influencing the success rate. Commonly reported recurrence rates vary between 0% and 30%.

Factors influencing the success rate of VVF repair include size, location, prior fistula repair, clinical experience and skills of the surgeon, perifistula fibrosis that depends on the etiology and clinical course of VVF, and the quality of surrounding tissue such as peritoneum or sigmoidal epiploic appendices.

VVFs due to irradiation and malignant condition are usually more difficult to treat. One of the most frequent malignant conditions is cervical cancer. The incidence depends on the tumor stage and involvement of the bladder, and varies between 3% and 48% 3–25 mo after irradiation [40–42].

3.1.4. *Complex fistula*

A complex VVF is characterized by multiple previous surgeries, a large size, or in case of multiple fistulae, a demanding underlying disease. Some complex VVFs have a high degree of perifistula inflammation and fibrosis, whereas others lack interposition tissue. Some complex VVFs are located low in the pelvis and might involve the urethra. Other complex VVFs include those after malignancy, such as cervical cancer with an altered pelvic anatomy after previous surgery. Pelvic irradiation or endometriosis can complicate treatment, and needs to be considered for the surgical approach. MRI might be a useful diagnostic tool for complex fistulae. These fistulae often show wall enhancement or sometimes central granulation tissue on MRI [31,32].

3.2. *Step-by-step procedure for robotic VVF repair*

The first robotic-assisted repair was published in 2005 [14]. During the past couple of years, several reports for robotic VVF repair have been published [10,14–17,43–47]. Since then, several case series have been published with a reported success rate of 100% in most series [16,17,21,44,48,49]. Table 3 summarizes studies on robotic VVF published to date.

The quality of dissection on one side and the correct suture on the other side are crucial steps along with urine drainage after surgery. Table 4 depicts the principal steps of robotic VVF repair. We sent a SM to the participants of the ERUS congress 2018. Overall, 82 surgeons replied to the survey.

Table 3 – Studies on robotic VVF published to date.

Author (year)	*n*	Etiology	Time point of repair	Prior repair	Trans- or extravesical	Patient position	Location (size, mm)	Fistula identified & marked by	Bladder closure	Vaginal closure	Flap used	JJ	SR (%)
Körner et al (2020)	13	HE, 1 after radiation	NS	NS	Extravesical	Trendelenburg 30°	13.2	Selec-Tip catheter	Biosyn 4/0 running suture	Biosyn 4/0 running suture	TachSil	+	84.6
Nobrega et al (2019)	1	HE, rectosigmoidectomy, radiation	NS	None	Transvesical	NS	NS	Vaginal probe	Transverse suture in 2 layers	Transverse suture in 2 layers	None	–	100
Osman et al (2018)	32 [a]	Surgery (eg, cesarean delivery), 1 motor vehicle accident	3 d to 3 yr	NS	NS	NS	(2–50)	NS	2 layers		NS	NS	71.4
									–				
Medina et al (2018)	2	NS	NS	NS	Transvesical	Trendelenburg	NS	Guidewire	2 layers	1 layer	Omentum	+	100
									2/0 V-Loc	3/0 V-Loc			
Matei et al (2017) [33]	5	Surgery for ovarian/ uterine cancer	NS	NS	Transvesical	NS	Trigone (5)	NS	2 layers	1 layer	NS	+	100
									PDS 2/0	PDS 2/0			
									Poliglecaprone				
Kelly et al (2018) [45]	1	Lap. HE	3 mo	None	Extravesical	NS	Vaginal apex	Cystoscopy	2 layers	1 layer	No	+	100
								3 mm ureteric stent	2/0 Vicryl	2/0 Vicryl			
Machen et al (2017) [10]	7	HE in 9 out of 11 patients	NS	6 out of 7 patients	Transvesical	Trendelenburg	NS	Cystoscopy	2 layers	1 layer	No, Tisseel	+	100
								5F catheter	4/0 Monocryl	2/0 Vicryl			
									2/0 Vicryl				
Jairath et al (2016) [15]	8	HE, 1 obstetric	3 mo	1 out of 8 patients	Extravesical	NS	Supratrig.	NS	2 layers	1 layer	Omentum	+	100
							Trigonal (13)						
Watts et al (2017) [18]	1	Abdominal HE	6 wk	None	Extravesical	"Robotic position"	Supratrig.	Cystoscopy	2 layers	3/0 V-Loc running suture	Omentum	NS	100
							(2)	5F catheter	3/0 Stratafix				
Martini et al (2016) [22]	1	Abdominal HE	2 mo	None	Extravesical	NS	NS	Cystoscopy	2 layers	1 layer	No	+	100
								5F catheter	3/0 Monosyn				
Bora et al (2017) [46]	30	Abdominal HE (90%)	NS	9 out of 30 patients	Transvesical	Trendelenburg 30°	Supratrig.	Cystoscopy	V-Loc running suture	1 layer polyglactin 2/0	Omentum, appendix epiploica, peritoneum	+	93.3
							Trigonal & cervicovesicouterine (10.4)	Terumo, gauze in vagina					
Agrawal et al (2015) [47]	10	Abdominal/vaginal HE	NS	3 out of 10 patients	Transvesical	Trendelenburg 30°	Supratrig.	NS	2 layers	1 layer	Bladder adventitia, colonic epiploica, peritoneum	+	100
									3/0 barbed suture	3/0 barbed suture			

Table 3 (*Continued*)

Author (year)	*n*	Etiology	Time point of repair	Prior repair	Trans- or extravesical	Patient position	Location (size, mm)	Fistula identified & marked by	Bladder closure	Vaginal closure	Flap used	JJ	SR (%)
Dutto and O'Reilly (2013) [21]	1	Abdominal HE	NS	None	NS	Trendelenburg 30°	Supratrig.	Cystoscopy	2 layers	2 layers	Perisigmoid fat	+	100
								Foley catheter	"2/0"	"3/0"			
Kurz et al (2012) [53]	3	Abdominal HE	NS	None	Extravesical	Trendelenburg 25°	Supratrig.	Cystoscopy	3/0 Biosyn	2/0 Vicryl	Peritoneum	+	100
								5F catheter					
Rogers et al (2012)		Article ordered	Article ordered	Article ordered	Article ordered	Article ordered	Article ordered	Article ordered	Article ordered	Article ordered	Article ordered		
Hemal et al (2008) [44]	7	HE/obstetric	7 mo	7	Transvesical	Trendelenburg 60°	Supratrig. (30)	Cystoscopy + Foley catheter	2 layers	1 layer	Omentum, peritoneum, colonic epiploica	+	100
									Polyglactin	Polyglactin			
Schimpf et al (2007) [17]	1	Abdominal HE	3 mo	None	Extravesical	Trendelenburg	Supratrig.	Cystoscopy	2 layers	2/0 Monocryl	Colonic epiploica	+	100
								5F catheter	3/0 Vicryl				
Sears et al (2007) [48]	1	Abdominal HE and subsequent sacrocolpopexy	6 mo	None	NS	NS	Supratrig. (5)	NS	2 layers	1 layer	Omentum	NS	100
									3/0 polyglactin	2/0 polyglactin			
Sundaram et al (2006) [16]	5	Abdominal HE	3 mo	None	Transvesical	Trendelenburg	(3.1)	Cystoscopy	2 layers	2 layers	Omentum	+	100
								5F catheter	3/0 Vicryl	3/0 Vicryl			
Melamud et al (2005) [14]	1	Vaginal HE	NS	Bladder suture at the time of HE	Transvesical	Trendelenburg	Supratrig.	Cystoscopy	2 layers	1 layer	Fibrin glue	+	100
									3/0 absorbable braided suture	Absorbable braided suture			

HE = hysterectomy; JJ = double J stenting or ureteral catheters; Lap. Laparoscopic; NS = not stated; SR = success rate; supratrig. = supratrigonal; VVF = vesicovaginal fistula.
[a] Seven by robotic surgery.

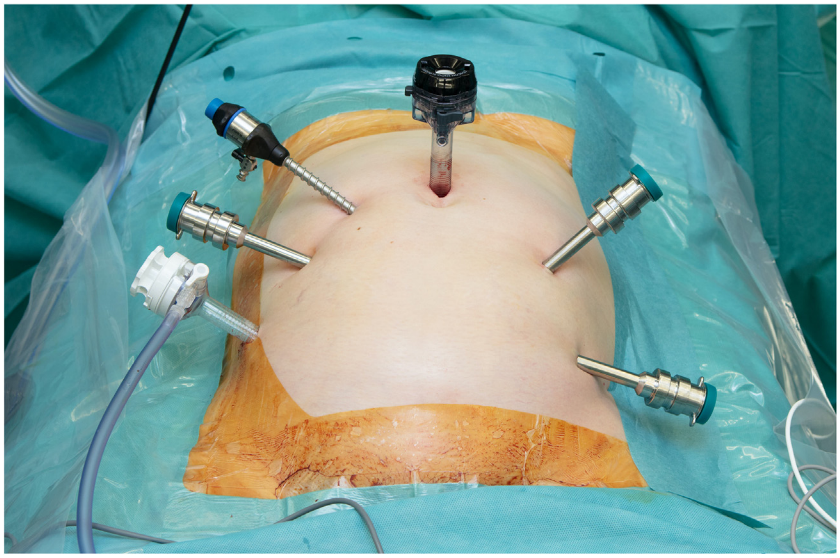

Fig. 3 – Port placement for robotic fistula repair.

Table 4 – Principal steps of VVF repair.

Performing cystoscopy; consider JJ placement if required
Marking VVF by placing a guidewire or a 5 F catheter into the VVF. If possible, extract guidewire/catheter through the vagina
Separation of bladder and vagina. Exposure of the fistula track by exposing the guide wire
Excision of the fibrotic tissue. Obtain histological specimen
Multiple-layer closing of the vagina and bladder: suture healthy tissue in a tension-free manner
Test of water tightness of the bladder
Tissue interposition such as peritoneal flap, omentum, or appendix epiploica
Insertion of bladder catheter

VVF = vesicovaginal fistula.

3.2.1. Step-by-step procedure

The patient is placed in a low lithotomy position. Eighty-five percent of the survey responders agreed to administer a single-shot antibiotic prophylaxis (eg, 2 g cefazolin intravenously at the start of anesthesia). First, cystoscopy is performed to identify the fistula. During cystoscopy, a Fogarty catheter or a guide wire can be placed in the fistula. Ureteral stents should be placed in order to protect the ureteric orifices. The operation might also be started with the colposcopy in lithotomy position and insertion of a 5 F Fogarty catheter through the fistula into the bladder using a vaginal speculum. For easier identification of the vagina and dissection of the vesicovaginal space, a gauze sponge stick might be inserted into the vagina. The operation is then continued in a low lithotomy position with a 25° Trendelenburg tilt. For standardized patient positioning, a goniometer can be used. The abdomen and the vagina are disinfected using povidone-iodine. After establishing the pneumoperitoneum via the 12-mm camera port, all ports are installed according to the scheme of radical prostatectomy: one 8-mm da Vinci port the left and another at the right of the umbilicus, one 12-mm Versaport in the right lower quadrant (3-cm craniomedial of the anterior iliac spine), and one 5-mm port is installed at the right of the camera port 3 cm proximally (Fig. 3). One half (55%) of the survey responders were quoted to use the fourth arm during VVF repair, which facilitates preparation. The fourth arm might be useful for holding the bladder upward during dissection of the vesicovaginal space.

Sharp and blunt dissection is then performed in order to expose the vesicovaginal space or the vaginal stump after hysterectomy. Good exposure of the vesicovaginal space is crucial in order to visualize the fistula marked with a guidewire. The bladder might subsequently be opened for preparation toward the fistula, in order to finally resect the fistula completely including perifistular scar and inflamed tissue (Fig. 4). The next and most important step is mobilization of the bladder wall circumferentially to provide a tension-free closure. This is of utmost importance for preventing fistula recurrence. Before closure of the bladder, a flap such as the adjacent peritoneum is mobilized to use it as a vital layer between the vaginal and bladder sutures (Fig. 5). The suturing of the vagina is performed using 2-0 Vicryl. The bladder is finally closed using 4-0 Biosyn in two layers. After performing a final leakage test of the bladder, all the ports are removed.

3.2.2. Interposition tissue

There is no randomized study comparing VVF repair with and without interposition tissue. A few authors report no flap interposition [22,33,50]. A variety of intra-abdominal interposition tissues can be used to cover the fistula area. These include peritoneal, omental, pedicled rectus myofascial, or buccal flaps [51], or perisigmoid epiploic tissue [21]. Even a buccal mucosal graft has been described [52]. In addition, robotic repair offers additional reconstructive procedures such as bladder augmentation or ureteral reconstruction if needed. The robotic approach often includes VVF repair with a peritoneal flap inlay [53–

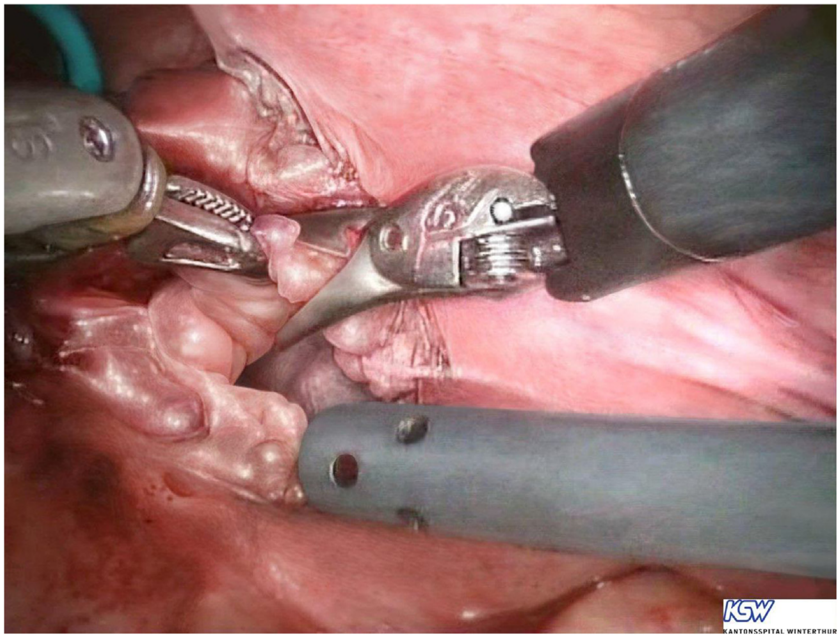

Fig. 4 – Complete resection of the fibrotic scar tissue around the fistula tract.

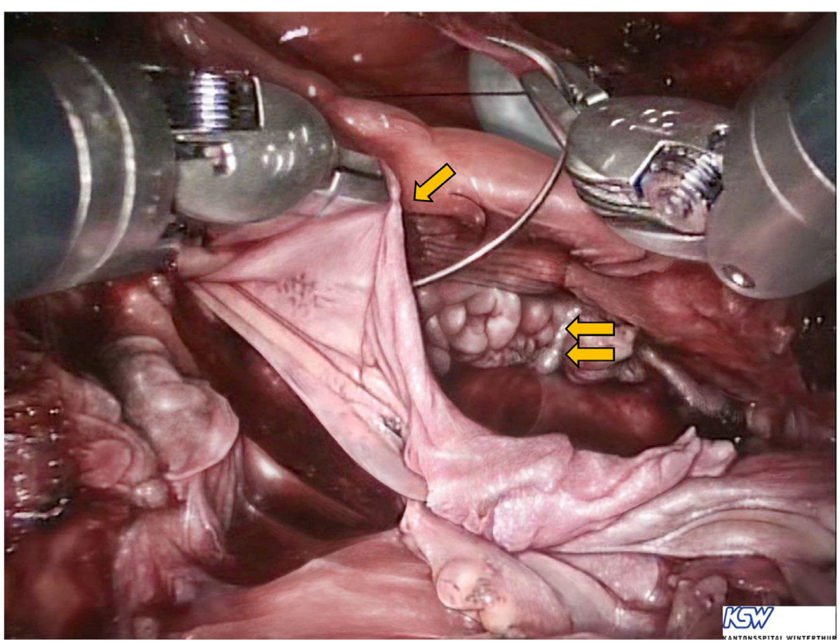

Fig. 5 – The peritoneal flap (arrow) is used to cover the space between the bladder and the vagina (colporrhaphy, double arrows).

55]. With the aggressive surgical approach for pelvic malignancies such as ovarian cancer, omentum might be missing in these patients. Tumor debulking often includes wide excision of the peritoneum with dissection of the bladder and ureters. Thus, in some patients, pedicled rectus myofascial flaps or perisigmoid epiploic tissue or even no flap might be used as interposition tissue [20].

3.2.3. *Leakage of pneumoperitoneum*

One of the problems encountered in robotic VVF repair is the leakage of pneumoperitoneum after opening of the bladder and vagina. To reduce air leakage, a sponge stick or a wet swab gauze might be inserted into the vagina. Other methods include the AirSeal system valveless trocar, which in general offers a more stable pneumoperitoneum [56].

3.3. Timing of fistula repair

There is no consensus on the optimal timing of surgery for VVF. In addition, the type, etiology, and duration of the fistula, as well as the metabolic situation of the patient need to be considered. Most fistulae will not close spontaneously and require operative closure. Nevertheless, spontaneous fistula closure has been reported in patients with a "small" fistula after prolonged labor [57]. The European Association of Urology guidelines for urinary incontinence suggest catheterization [58]. Historical data suggest spontaneous fistula closure of up to 20% [59]. The ERUS Reconstructive Panel recommends a trial with a catheter for attempting a conservative management of up to 12 wk. There is no minimum time for surgical treatment (robotic VVF repair) from initial diagnosis in order for the edema to resolve.

3.4. Intraoperative diagnosis of the VVF and protective JJ placement

Cystoscopy is the standard to visualize the VVF. A 5 F catheter or a guide wire can be placed through the VVF in order to mark the fistula channel and the inflamed tissue to be excised. The panel recommends placement of ureteral stents preoperatively, especially in the fistulae close to the ureteral orifices.

Some authors reported the use of intraoperative combined cystoscopy for fistula identification, with the cystoscope focusing on the fistula while the robotic camera light is switched off [60].

3.5. Postoperative management

The wound drain, even if placed, should be removed after 24 h if there is no evidence of bleeding or urinary leakage. The indwelling Foley catheter is left in the bladder for 10–14 d with open drainage; cystography is then performed prior to catheter removal. However, there is evidence that 7-d bladder catheterization is noninferior to 14-d catheterization [61]. Sexual intercourse is prohibited for 4 wk, and the ureteral catheters are cystoscopically removed after 4 wk.

3.6. VVF repair: general aspects and surgical approach

There is currently no consensus recommendation for VVF repair in terms of the surgical approach, for example, transvaginal or abdominal. Basically, there are two techniques that address the repair robotically. One is going directly in between the bladder and the vagina, and finding the VVF directly. The other technique opens the bladder at a higher point (away from the fistula) with or without continuing this opening up to the fistula tract (the O'Conor technique [11]), thus giving wider exposure; the dissection starts from normal tissue and advance to the scarred tissue. Both techniques have their advantages and disadvantages. However, the most important factor is the surgeon's experience.

The transvaginal approach has the advantage of low patient morbidity, low blood loss, minimal postoperative pain, and low postoperative bladder irritability [62–64].

For a VVF situated low in the pelvis, such as a deep obstetric fistula, the vaginal approach might be feasible. Some authors report similar success rates by vaginal techniques to those by abdominal approaches using a peritoneal flap, with or without a labial Martius flap [63,65]. The main exclusion criteria for the transvaginal approach are (1) major circumferential induration of the fistula, (2) a high fistula location where the transvaginal approach gives too little exposure, (3) fistulae involving ureters, and (4) the patient's wish for the transabdominal approach [62,66]. Combined transabdominal and transvaginal procedures have also been reported [67].

However, when a safe transvaginal fistula repair cannot be granted, the transabdominal approach is always an option. This technique provides maximum space for exact and thorough preparation of the bladder and vaginal wall, and easier identification of the scar and fistula tissue. Therefore, an abdominal approach provides a safe basis for complete excision of the inflamed fistula tissue, good bladder wall mobilization, and tension-free bladder closure. More recent techniques have become less morbid than the historical transvesical O'Conor [11] procedure even though there are "mini" variations [68,69].

The technical advantages of the robotic approach are furthermore underlined by its low morbidity; we observe that patients after robotic VVF repair recover immediately after surgery as compared with those after the open operation. The most difficult steps during the procedures are likely the ones that keep urological surgeons away from the laparoscopic approach, which include the tricky preparation of previously damaged tissue and the suturing. This is where robotic surgery gives maximum assistance as it provides optimal exposure to the fistula area, in particular, the possibility of wide excision of the fistula tissue.

The perifistula anatomy can be exposed exactly, and therefore access to the tissue interponate is easy to achieve. In contrast, access through the vagina as a natural orifice gives less working space and makes it difficult to prepare precisely, not to mention that many high fistulae are difficult to reach.

In a few cases, ureters can be affected by the fistula or have to be resected partially. In these cases, the operation can also be performed by the robotic approach, while a transvaginal access is futile. Moreover, the robotic system offers precise and easy suturing of the interposition tissue.

Some authors used flaps such as epiploic appendix of the sigmoid colon [17], omentum [16], epiploic appendix of the sigmoid colon or a peritoneal flap [44], or fibrin glue [14]. A similar functional result might be assumed in all these different ways, but randomized controlled trials are lacking. Separation of the suture lines of the bladder and vagina, and tension-free water-tight bladder closure are of utmost importance.

4. Conclusions

In summary, VVF is a rare but devastating complication mainly after pelvic surgery, in particular hysterectomy. Its repair is technically demanding, especially when treating complex fistulae. The VVF should always be marked, for instance, by a guidewire, and double J stenting of the ureters is highly recommended. Taken together, the robotic approach is very promising and successful in most cases of high supratrigonal fistulae, as it provides easy access to the perifistula tissue as well as to the surrounding tissue. Despite the small number of published series, robot-assisted laparoscopic closure of supratrigonal vesicovaginal fistulae is safe and highly effective. It might become a new standard in reconstructive urology.

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Study concept and design: All authors.
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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at doi:https://doi.org/10.1016/j.eururo.2020.06.029 and via www.europeanurology.com.

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