Urinary diversion after pelvic exenteration for gynecologic malignancies

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ABSTRACT

Pelvic exenteration combines multiple organ resections and functional reconstruction. Many techniques have been described for urinary reconstruction, although only a few are routinely used. The aim of this review is to focus beyond the technical aspects and the advantages and disadvantages of each technique, and to include a critical analysis of continent techniques in the gynecologic and urologic literature. Selecting a technique for urinary reconstruction must take into account the constraints entailed by the natural history of the disease, patient characteristics, healthcare institution, and surgeon experience. In gynecologic oncology, the Bricker ileal conduit is the most commonly employed diversion, followed by the self-catheterizable pouch and orthotopic bladder replacement. Continent and non-continent diversions present similar immediate and long-term complication rates, including lower tract urinary infections and pyelonephritis (5–50%), ureteral stricture (3–27%), urolithiasis (5–25%), urinary fistula (5%), and more rarely, vitamin B_{12} deficiency and metabolic acidosis. Urinary incontinence for the ileal orthotopic neobladder (50%), stoma-related complications for the Bricker ileal conduit (24%), difficulty with self-catheterization (18%) for the continent pouch, and induction of secondary malignancy for the ureterosigmoidostomy (3%) are the most relevant technique-related complications following urinary diversion. The self-catheterizable pouch and orthotopic bladder require a longer learning curve from the surgical team and demand adaptation from the patient compared with the ileal conduit. Quality of life between different techniques remains controversial, although it would seem that young patients may benefit from continent diversions. We consider that centralization of pelvic exenteration in referral centers is crucial to optimize the oncologic and functional outcomes of complex ablative reconstructive surgery.

INTRODUCTION

Pelvic exenteration is a challenging procedure mainly performed in cases of persistent or recurrent locally advanced gynecological malignancies after radiotherapy. First described in 1948 by Alexander Brunschwig as a palliative procedure in a patient diagnosed with recurrent cervical cancer,[1] it was later applied to other types of pelvic tumors, such as colorectal cancer or lower urinary tract malignancies.[2] Parallel to the advances in surgery and rehabilitation, organ reconstruction later complemented pelvic exenteration. With the decrease of morbidity and mortality, and development of extension of the surgical principle from palliative to curative, surgical complexity has increased.[3] Improvement in long-term 5-year overall survival rates to 40% after pelvic exenteration[4] has recently drawn attention to organ reconstruction and preservation of body image, including urinary, digestive, vaginal, and pelvic floor reconstructions.[2]

At the time of the first pelvic exenteration, few reconstructive techniques were applied.[1] Ureterosigmoidostomy[5] and wet colostomy[1] were used for urinary diversion until 1950, when Bricker first reported the ileal conduit diversion.[6] To date, ileal diversion remains the most commonly performed urinary reconstruction. A continent self-catheterizable pouch[7] and orthotopic ileal neobladder[8] have also been used. A number of publications have evaluated the outcomes of urinary reconstruction in gynecological cancers. Many publications and meta-analyses merged gynecological, colorectal, or urological cancers in both male and female patients, although they show different prognosis and baseline characteristics. Most were single institution or retrospective series. The aim of this review is to focus on the technical aspects of the urinary diversion and to include a critical analysis of the continent techniques in the gynecologic and urologic literature.

METHODS

Research was carried out in the PubMed and Embase database, The Cochrane Central Register of Controlled Trials, and the Web of Science, employing the combination of the following medical subjects heading (MeSH): 'urinary diversion', AND 'pelvic exenteration', 'ileal conduit', 'life quality', 'post-operative complications', 'gynecologic neoplasm', 'urologic neoplasm', 'pelvic cancers', 'continent urinary reservoirs', 'colonic urinary reservoirs', 'colorectal cancers', 'reconstructive surgical procedures', 'urologic surgical procedures', 'post-operative care'. The most relevant publications were selected, including original articles, reviews, meta-analyses, and books. There were no language or publication date restrictions.

Pre-operative Evaluation and Patient Selection

The choice of urinary reconstruction technique requires a thorough pre-operative assessment with

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Table 1 Pre-operative, peri-operative, and post-operative considerations

Pre-operative evaluation			Peri-operative considerations	Post-operative care
Patient	**Disease**	**Healthcare institution**		
► Age ► Previous treatments ► Radiotherapy ► Urinary continence ► Co-morbidities ► Social relationships ► Sexual function ► Body image ► Stoma acceptance ► Socioeconomic status	► Primary tumor ► Tumor size ► Curative vs palliative ► Bladder neck preservation ► Autonomic innervation ► Intestinal length ► Vascularization ► Extent of the resection	► High-volume institution ► Prehabilitation program (ERAS) ► Experienced stoma therapist ► Physical medicine and rehabilitation physician ► Sexologist ► Psychotherapists ► Interventional radiology ► Urologic endoscopy	► No bowel preparation ► Pre-operative stoma positioning ► Immunonutrition ► Flap association (omental J-flap vs pedicled flap) ► Reduction of intra-operative bleeding ► Protective maneuvers to avoid tumor spillage ► Absorbable sutures/stapler devices ► Adequate imaging	► Stoma therapist supervision ► Stoma management ► ERAS recovery ► Renal function monitoring ► Ionic and metabolic balance ► CT urography±opacification 10–12th day ► Post-void residual volume measured by catheterization

patients to assure that there is a detailed discussion of the risks associated with the procedure and also to engage patients in the decision-making process. The reconstruction should be tailored to each patient and the extent of the pelvic resection should also be adapted accordingly. The main points determining the choice of the technique have been structured in the three following subsections (Table 1).

Patient

A patient's age, tobacco smoking, and co-morbidities are important to consider, as well as social and psychological aspects. Active elderly women may benefit from continent reconstruction while young women might object to the constraints of continent diversion. Expectations for social relationships, sexuality, professional life, and recreational activities should also be also taken into account as body image or stoma care must not hamper a patient's quality of life.[9] Stoma acceptance is influenced by gender, culture, and geographic origin.[10] One must also consider patient autonomy, family support, the possibility of self-catheterization, stoma management, and patient compliance as it pertains to post-operative constraints. Socioeconomic factors may also determine the type of reconstruction because the cost of self-catheterization materials is not always covered by health insurances. It is important to consider baseline urinary continence as pre-existing stress urinary incontinence due to sphincteric incompetence would be a contraindication to an ileal orthotopic neobladder.[11]

Disease Type

The choice of urinary reconstruction technique is often dependent on the type of disease and previous treatments. Continent diversions are usually proposed for patients with a favorable prognosis—such as those with an isolated pelvic relapse after a long disease-free interval, or in cases of radiation-induced vesicovaginal fistula—since the learning curve may be extensive. Nevertheless, continent diversions may also be considered in some patients undergoing palliative surgery. It is also important to take into consideration the extent of local and regional resection and the involvement of key structures, such as the urethra and bladder neck. Clinical examination under general anesthesia is helpful in selected cases. The limitations related to the use of an intestinal segment for reconstruction as well as the preservation of the autonomic innervation of the pelvic floor should also be considered. Pre-operative imaging, including contrasted-enhanced MRI and PET/CT is crucial for the decision and should be analyzed by the surgeon assisted by a dedicated radiologist and nuclear medicine physician.

Healthcare Institution

Patients should be referred to high-volume tertiary centers where they may benefit from the multidisciplinary expertise of the surgical team and anesthesiologists and the structure and planned post-operative management of extensive tumor resection and complex pelvic reconstruction. Pelvic exenteration performed at high-volume institutions has been shown to have reduced post-operative mortality[12] with higher rates of R0 resection, improved overall survival, improved control of the cost of surgery,[13] and ultimately, a better quality of life.[14 15]

Urologists may contribute to the insertion, replacement, and removal of pigtail stents by endoscopic procedures in cases of ureteroenteric stricture, ureterohydronephrosis, or urinary fistula. Interventional radiologists may also be required for percutaneous insertion of a nephrostomy catheter in cases of unsuccessful insertion of pigtail stents by endoscopy or with hemodynamically unstable patients.

Pre-operative evaluation and optimization of the nutritional status by physiatrist, and stoma education by a stoma therapist, are required to prepare for recovery. For all the techniques that comprise a urostomy (Bricker, Miami pouch, double-barreled wet colostomy), the stoma position must be determined pre-operatively by the stoma therapist according to a standardized process[16] that has been shown to reduce stoma and peristomal complications, compared with unstructured preparation.[17] It also helps to develop a confident relationship with the stoma therapist that later contributes to patient's autonomy in self-catheterization, stoma management, and early recognition of complications. Along the same line, pre-operative visits with psychotherapists, sexologists, and advocacy groups for patients with cancer are highly beneficial. Lastly, the recent literature strongly supports the benefits of the Enhanced

Recovery After Surgery (ERAS) program under the supervision of the physiatrist of the institution.[18 19]

SURGICAL TECHNIQUES

Urinary diversions are either directly exteriorized to the skin (cutaneous diversions) or indirectly through a digestive segment. Cutaneous diversions, such as ureterostomy and nephrostomy, which are considered diversion and not reconstructive procedures, will not be discussed in this review.

Ureterosigmoidostomy

Ureterosigmoidostomy was first described in 1931 by Coffey[5] as a reconstructive procedure after cystectomy for bladder cancer and vesical exstrophy in patients with a healthy colon with optimal fecal continence. It offers a natural reservoir of large capacity to store urine (up to 500 mL) with high rates of urinary continence (90%). However, it increases the risk of secondary cancer, with up to 2–15% of patients developing colorectal carcinoma at long-term evaluation.[20] In low-income countries, it is a valid alternative for patients who have a limited access to healthcare services.[21]

Double-barreled Wet Colostomy

First described in 1948 by Brunschwig,[1] double-barreled wet colostomy was adapted in 1989 by Carter[22] to reduce severe complications, such as pyelonephritis and metabolic imbalance. The modern procedure associates a terminal colostomy and the construction of a urinary reservoir with a 15 cm segment of the sigmoid colon, exiting at the same stoma site. The thick muscular layer of the sigmoid pouch facilitates the construction of anti-reflux valves for ureteric anastomoses (Figure 1A). Double-barreled wet colostomy does not require bowel anastomosis, therefore reducing the risks of leakage.[23 24] Compared with two independent stomas, one for urinary diversion and the other for fecal diversion, double-barreled wet colostomy was reported to improve immediate post-operative recovery, with lower risk of urinary or bowel leak, shorter operative time, and shorter hospital stay.[23 25]

In addition, the quality of life of patients who underwent double-barreled wet colostomy compared with those who underwent other diversions, evaluated by the European Organization for Research and Treatment of Cancer quality of life questionnaire (EORTC QLQ-C30), showed better scores in the group with double-barreled wet colostomy for global health, emotional and social functioning, including less insomnia, fatigue, and gastrointestinal disorders.[24] In contrast, no differences were observed in acute renal failure, electrolyte abnormalities, bacteremia, and pyelonephritis.[23 25] Double-barelled wet colostomy is the preferred technique for combined fecal and urinary diversions in patients diagnosed with unresectable pelvic tumors or extensive fistulas. It can also be offered with curative intent in selected cases.

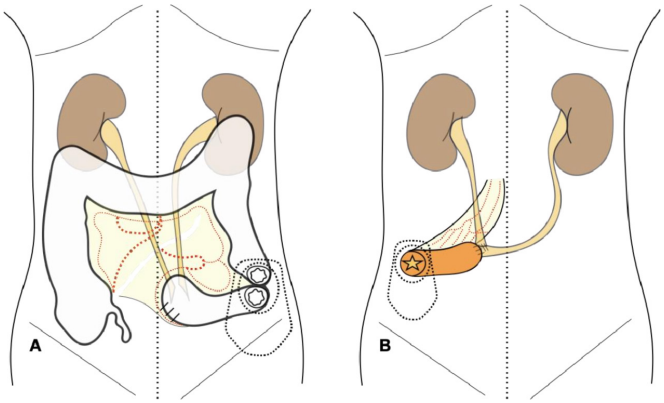

Figure 1 Schematic illustration of the main incontinent urinary reconstructions. (A) Double-barreled wet colostomy. (B) Bricker ileal conduit.

Bricker Ileal Conduit

First described in 1950 by Eugene Bricker,[6] this incontinent urinary diversion of low surgical complexity and complication rates[26] is the most frequently performed diversion worldwide.[27] To perform the conduit, a 20 cm segment of ileum in isoperistaltic orientation is harvested at least 15 cm away from the ileocecal valve to prevent vitamin B_{12} and bile salt malabsorption. The ureters are anastomosed to the proximal end of the conduit while the distal end is used for the stoma (Figure 1B). There are two alternatives for performing ureteroenteric anastomosis, either separate or joined. In the classic Bricker's description, ureters are spatulated, before end-to-side separate anastomosis to the anti-mesenteric aspect of the loop (Figure 2A),[28] whereas in the Wallace's technique, they are anastomosed head-to-head (Wallace I, Figure 2B) or head-to-tail (Wallace II, Figure 2C)[29 30] and connected to the proximal end of the ileal loop. These adaptations were developed to control the risks of stricture observed in the Bricker technique. However, the benefit of the Wallace anastomosis remains unclear. Of note, single-center series reported higher rates of stricture with the Bricker method than with the Wallace techniques (25.3% vs 7.7%, respectively),[31] while a recent meta-analysis compared these two techniques and reported low and comparable risks of ureteroenteric stricture with the Bricker and the Wallace anastomosis (3% and 2%, respectively).[32] We prefer the Wallace I technique as it simplifies the ureteroileal anastomosis.

Continent Self-catherizable Pouch: Miami Pouch

First described in 1988 by Bejany,[33] the continent self-catheterizable pouch requires harvesting a 25 cm segment of the right colon for the reservoir and a 15 cm segment of the ileum for the valve. Continent cutaneous diversions provide a continent valve that allows intermittent self-catheterization (usually every 4–6 hours) and a low-pressure reservoir made of a detubularized digestive segment. The stoma usually accommodates a Foley catheter with a size of 14 French units and it is frequently placed for cosmetic reasons at the umbilicus, although it can be adapted to patient's preferences. Continence is driven by the differences in pressures between the low-pressure compliant colonic reservoir and the narrow and contractile distal ileum, together with the anti-reflux mechanism of the ileocecal valve.

Various bowel segments may be used for continent reservoirs, such as the ileum in the Indiana[34] and Mainz pouches,[35] and the cecum in the Miami pouch, which is the continent diversion mainly used by our team[36] (Figure 3).

Orthotopic Ileal Neobladder

First described by Lilien and Camey in 1984,[37] the orthotopic ileal neobladder is the urinary reconstruction that most closely resembles

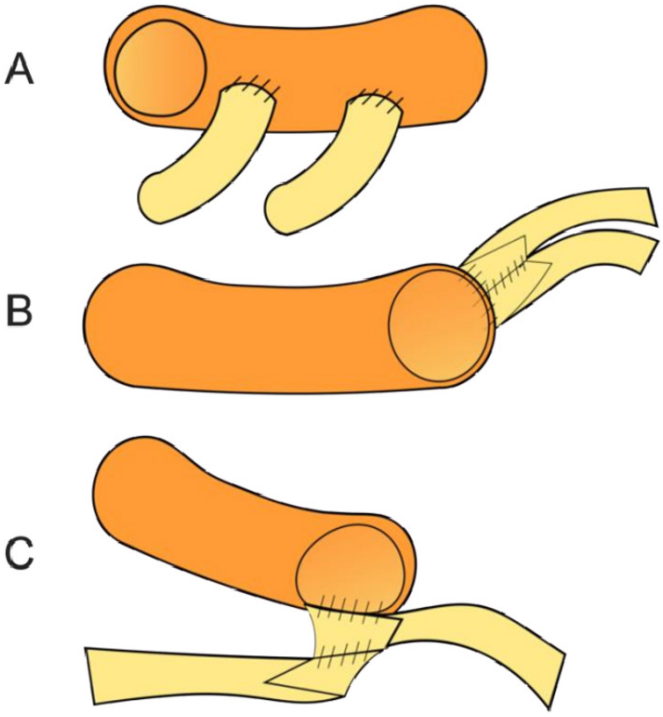

Figure 2 Ureteroenteric anastomotic techniques for the ileal conduit. (A) Bricker anastomosis. (B) Wallace I technique (head-to-head anastomosis). (C) Wallace II technique (head-to-tail anastomosis).

the native bladder, and it can be considered only when the urethra and the bladder neck can be spared. While there is a large experience on orthotopic neobladder within the field of urology, the largest series published in gynecologic oncology included only six patients.[11]

Pre-operatively, attention should be paid to patient selection on the basis of physical examination, absence of stress urinary incontinence, urodynamics, ability to understand and perform intermittent self-catheterization, and the patient's expected compliance with post-operative instructions. Whenever possible, the dose delivered to the bladder neck should be minimized by optimal placement of the brachytherapy sources.[38]

The principle is to create a low-pressure reservoir using 50 cm of ileal length anastomosed to the bladder neck. The ileal loop

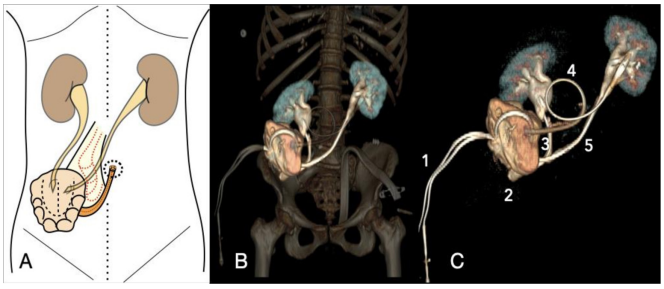

Figure 3 Continent self-catheterizable Miami pouch. (A) Schematic picture of the urinary reservoir. (B) 3D CT reconstruction at the 10th post-operative day. (C) Components of the reconstruction: 1 ureteral stent; 2 colonic reservoir; 3 tapered ileum; 4 Foley catheter; 5 ureter. (*3D reconstruction courtesy of Dr Erwan Gabiache*)

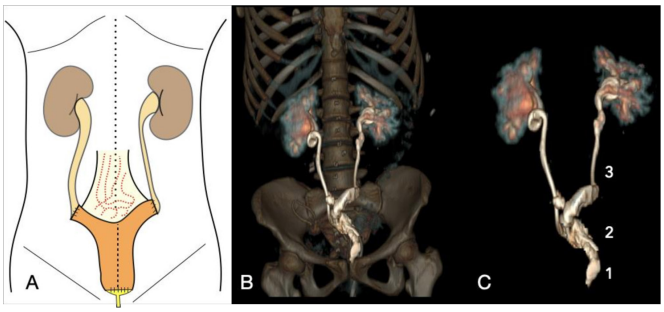

Figure 4 Y-shaped ileal orthotopic neobladder. A) Schematic picture of the neobladder. (B) 3D CT reconstruction at the 10th post-operative day. (C) Components of the reconstruction: 1 bladder neck; 2 ileal reservoir; 3 ureter. (*3D reconstruction courtesy of Dr Erwan Gabiache*)

is harvested at least 15 cm from the ileocecal valve to prevent vitamin B_{12} and bile salt malabsorption. The ileal loop is then detubularized on its anti-mesenteric axis and reorganized into a low-pressure 400–500 mL reservoir of diverse architectures: Y-shape (Figure 4),[38 39] Z-shape (Foch), W-shape (Hautmann), C-shape (Camey II), and J-shape (Studer).[40] The neo-bladder is first anastomosed to the two ureteral stumps and then connected to the bladder neck. In the Le Duc technique, the terminal ureter is tunneled through a sulcus created in the ileal mucosa[41] to prevent reflux towards the upper tract. However, the direct ileoureteral anastomosis is easier, faster, and the rate of long-term stenosis and hydronephrosis is lower than with the Le Duc technique.[42 43]

Alternatively, the orthotopic bladder may be created by using the right colon and the terminal ileum. This technique, also known as the Budapest pouch,[44] combines a reservoir that is made with a detubularized segment of the ascending colon, and the distal ileum, which is employed for the ureteroenteric anastomoses. The cecum is anastomosed with the bladder neck, and interestingly, in cases of leakage, the reconstruction can be transformed into an ileocecal conduit.[45] Single or double pigtail ureteral stents are inserted to facilitate healing of the anastomoses, and an intra-operative X-ray examination is optional to check the correct positioning of the stents in the renal pelvis. Complications include urinary retention requiring self-intermittent catheterization, metabolic acidosis, and vitamin B_{12} deficiency.

Peri-operative Care and Follow-up

Pre-operative mechanical bowel preparation, oral antibiotic bowel preparation, or post-operative antibio-prophylaxis are no longer recommended because they did not reduce complication rates (Table 1).[46] However, mechanical preparation is still applied at our institution for Miami pouch as a colon free of fecal material facilitates surgery. Urine outflow should be closely monitored. To prevent urinary obstruction or anuria by cellular debris, the stent should be gently flushed by 5 mL of sterile saline twice a day for the first few days. Of note, the volume output by the left stent in the Miami pouch is usually less abundant than from the right one, since part of the urine from the left kidney falls directly into the pouch through the perforations on the shaft of the stent and it is drained by the Foley catheter placed in the pouch. In contrast, the right ureter and the

right stent are shorter compared with the left side, and as a result, almost all the volume of urine drains directly through the stent.

There is no consensus on the timing of ureteral stent removal. In patients at high risk of fistula, CT urography and removal of stents can be postponed up to 3 months after the surgery. In our institution, for continent and incontinent diversions, CT urography with pouch opacification is performed between the 10th and the 12th post-operative day to rule out incomplete wound healing. Pigtail stents are then removed and the patient is observed for several days to initiate self-catheterization for the Miami pouch or the Valsalva maneuver for orthotopic neobladder reconstruction. Ultrasound measurement of post-void residual volume employing non-invasive devices is not accurate for urinary reservoirs, and after ileal orthotopic neobladder, direct catheterization should be preferred to obtain post-residual volume measurements.[47]

Urinary cultures before stent removal were used routinely in the past, although they mostly demonstrate asymptomatic colonization by enteric germs that do not warrant any treatments. Colonic mucosa, and to a lesser extent small bowel, may secrete a significant volume of mucus in response to the irritation of urine. This secretion may be particularly abundant in the Miami pouch where it can result in ureteral or reservoir obstruction, both complications that are controlled in the post-operative period by regular irrigations. After discharge, regular monitoring is essential, including physical examination with a renal function panel every 3 months and serologic levels of vitamin B_{12} yearly.

COMPLICATIONS

Pelvic exenteration represents one of the most morbid procedures in gynecology oncology, with a 90-day mortality rate of 2.2% and a 30-day complication rate of 67%.[48] Surgical complexity, pre-operative hemoglobin, co-morbidities burden,[48] tumor site,[49] and previous radiotherapy[50] are the main risk factors for developing major post-operative complications, which are observed in 27% of patients.[48] The main complications and advantages and disadvantages of each technique are summarized in Tables 2 and 3, respectively.

Early Complications

Early complications are common to all urinary diversions and highlight the potential complexity of the surgery: bleeding, deep venous thrombosis, fistula, leakage, respiratory complications, or abdominal collection. Special attention should be paid to lower urinary tract infection, pyelonephritis, and pouchitis, since their prevalence is high, occurring in about 23% of patients.[26] Lower urinary tract infections are usually produced by enteric bacteria, and their clinical features include atypical symptoms, such as abdominal pain, diarrhea, or ileus. The infection of the pouch, known as pouchitis, is a rare but severe complication that may be prevented with regular pouch irrigations. Of note, asymptomatic bacteriuria is found in more than half of patients with continent urinary reservoirs and these cases do not require antibiotics.[51]

Anastomotic urinary leak can occur with any technique at any time, although it is more frequent during the early post-operative period. The risk of fistula between the reservoir and the vagina is specially increased in cases of orthotopic urinary reconstruction, and it may affect up to 5% of patients after radical cystectomy for bladder cancer. In gynecological malignancies, this risk has not been established due to limited experience with this technique.[52] In some cases, anastomotic leak or fistula may be caused by inappropriate reservoir irrigations. For this reason, it is strongly recommended that patients have an oral fluid intake of at least 2 liters per day to dilute the intestinal mucus and to perform the irrigations with gentleness.

A vesicovaginal fistula is usually suspected by a continuous and unremitting urinary leakage through the vagina that can be confirmed by CT urography or alternatively, with a bladder filling test with diluted blue dye. Patients at high risk of fistula (previous pelvic irradiation, tobacco, diabetes, obesity) should be identified, and one might consider postponing stent removal for up to 3 months.

The complications derived from the empty space left in the pelvis after removing the pelvic organs are known as 'empty pelvic syndrome' or 'pelvic burn syndrome', which includes the risk of fistula, pelvic collection, chronic infection, osteomyelitis, and organ prolapse.[53] To reduce these complications, it is highly recommended to perform during the urinary reconstruction an omental J-flap, perforator flap,[54] or musculocutaneous flap,[55] to restore pelvic anatomy and also to provide healthy autologous tissues to fill and restore the pelvis. In addition, such tissues may be employed to cover bowel and urinary anastomoses, decreasing the risk of fistula, abscess, intestinal obstruction, and bowel perforation.[3]

Late Complications

Classic late complications of continent and incontinent reconstructions include vitamin B_{12} deficiency, metabolic acidosis, ureteral stricture, and urolithiasis with a higher risk of lithiasis in continent diversions.[56] Urinary calculi may originate from the upper urinary tract or initiate in the reservoir caused by the digestive mucus and the frequent colonization of ureolytic bacteria such as *Citrobacter*, *Klebsiella*, or *Enterococcus*. In addition, hyperchloremic hypokalemic metabolic acidosis may also facilitate stone formation

Table 2 Main complications for each type of diversion[20 26 70 77]

Type of reconstruction	Ureteral stricture	Lithiasis	Urinary infection	2° cancer	Continence	
					Daytime	Night time
Ureterosigmoidostomy	10–20%	Rare	10–20%	2.58%	92–100%	
Double-barreled wet colostomy	2–11%	7%	3–13%	0.23%	Not applicable	
Ileal conduit	11–14%	9–15%	16–23%	0.02%		
Self-catheterizable continent pouch	3–27%	5–10%	15–50%	0.14%	92%	
Ileal orthotopic neobladder	4–11%	8–25%	5–50%	0.05%	50–97%	36–83%

Table 3 Summary of the main diversion techniques with principal advantages and disadvantages

Technique	First description	Surgical approach	Segments employed	Advantages	Disadvantages	Common complications	Educational video articles
Ureterosigmoidostomy	Coffey, 1931	▶ Open surgery ▶ Laparoscopic ▶ Robotic	Colon (rectum or sigmoid)	▶ No urostomy bag required ▶ Low cost ▶ No urostomy care learning required	▶ Ureteral reflux ▶ Colorectal cancer ▶ Overflow incontinence ▶ Colorectal cancer	▶ Infection ▶ Pyelonephritis ▶ Stone formation ▶ Ureteral stricture ▶ Fistula ▶ Vitamin B12 deficiency ▶ Bile salt malabsorption ▶ Renal function impairment ▶ Metabolic acidosis	Jamkar, 2015[78]
Double-barreled wet colostomy	Carter, 1989		Colon (sigmoid)	▶ Low cost ▶ Single stoma ▶ Shorter operative time ▶ Easy urostomy care learning	▶ Ureteral reflux ▶ Peristomal skin complications ▶ Parastomal hernia		Lago, 2020[79]
Ileal conduit	Bricker, 1950		Ileum (20 cm)	▶ Low cost ▶ Urostomy bag ▶ Easy urostomy care learning ▶ Few contraindications	▶ Peristomal skin complications ▶ Parastomal hernia		Martínez-Gómez, 2020[80]
Continent self-catheterizable pouch	Miami pouch (*Bejany 1988*) Indiana pouch (*Rowland 1985*) Mainz pouch (*Turoff 1986*) Roma pouch Kock pouch (*Kock 1978*) Roma pouch (*Panicci 2007*)		Right colon and distal ileum (15 cm)	▶ No urostomy bag required ▶ Few contraindications ▶ High rates of continence	▶ Pouchitis ▶ Pouch torsion ▶ Long urostomy care learning ▶ Intermittent self-catheterization (4–5 times/day) ▶ Difficulty for self-catheterization ▶ Patient engagement		Martínez-Gómez, 2018[36] Angeles, 2018[81]
Ileal orthotopic neobladder	Y-shape (*Fontana 2004*) W-shape (*Hautmann 1988*) J-shape (*Studer 1986*) Z-shape (*Botto 1994*)) C-shape (*Camey 1988*)		Ileum (50 cm)	▶ No urostomy bag required ▶ Low cost ▶ Native organ replacement	▶ Incomplete neobladder voiding (ineffective abdominal push) ▶ Eventual self-catherization ▶ Incontinence ▶ Limited indications ▶ Strong patient engagement		Martínez-Gómez, 2020[82]
Ileocecal orthotopic neobladder	Budapest Pouch (*Ungar 1998*)	▶ Open	Right colon and distal ileum (15 cm)				Căpîlna M, 2020[44]

by increasing the uptake of citrate at the proximal tubule, thereby reducing the excretion of citrate in urine, which plays a major role in the prevention of calcium stones nucleation. Non-absorbable staplers or sutures should be avoided as they increase the risk of stone formation.[57] Current treatments for urinary stones include ureteroscopy, extracorporeal shockwave lithotripsy, percutaneous nephrolithotomy, or laparoscopy.

Vitamin B_{12} is absorbed from the alimentation in the distal ileum, hence urinary diversions using the ileum may induce vitamin B_{12} deficiency. Most patients have chronic macrocytic anemia and this is reversible by supplementation, although severe complications, such as irreversible peripheral neuropathy and dementia,[58] may occur in cases of chronic depletion. Vitamin B_{12} reserves can last for several months, and therefore it is recommended that vitamin B_{12} serum levels are monitored yearly, from the sixth post-operative month onwards.[27]

The risk of metabolic imbalance or electrolyte abnormalities should be specially monitored with continent reservoirs. Metabolic imbalance is related to the production of ammonium by the urinary tract, which takes place in the sodium–proton exchanger (Na+/H+ exchanger) in the intestinal mucosa, resulting in a switch from chloride to bicarbonate. This generates a loss of bicarbonate and a gain of Cl– and H+, leading to hyperchloremic hypokalemic metabolic acidosis.[59] Physical symptoms consist of asthenia, anorexia, confusion and, in extreme cases, sleepiness and coma. Treatment consists of restoring the ionic balance by sodium bicarbonate and/or a solution of sodium/potassium citrate. Outpatient treatment is usually sufficient, although in severe cases, intensive care unit admission may be required.

The origin of strictures of ureteroenteric anastomoses is multifactorial, with ischemia, prior radiation, and chronic inflammation as predominant risk factors. It is therefore important during the ureteral dissection to pay attention to the viability and vascular support of the ureteral stump and ensure a wide spatulation at anastomosis. Most cases of stricture are managed conservatively, but in cases of severe renal insufficiency, solitary kidney, or endoscopic failure, nephrostomy tube and further reconstructive surgery may be warranted.[60]

Technique-related Complications

Rare complications are specific to the techniques of diversion.

Miami pouch torsion represents a life-threatening complication typically diagnosed by diffuse abdominal pain and an inability to self-catheterize. By rotating the pouch, the overfilling of the reservoir displaces the ileal efferent segment, leading to a cycle that can be resolved only by catheterization under flexible endoscopy or, in severe cases, by transabdominal ultrasound-guided needle drainage. This infrequent complication, that we observed at the beginning of our experience, is prevented by performing regular and complete emptying of the reservoir, by paying attention to chronic abdominal pain that may reveal latent distension, and by fixating the pouch with separate sutures to the abdominal wall during the surgery.

The risk of a second malignancy after urinary reconstruction is due to the chronic exposure of the intestinal mucosa to urine. The main histologic type is adenocarcinoma, which is particularly prevalent in ureterosigmoidostomy (2.6%) and ileocolonic neobladder (1.3%) with a latency period of at least 1 year after the diversion.[20]

Stoma complications such as mucosal ischemia, dermatitis, candidiasis, prolapse, hernia, or retraction should also be considered as they are frequently observed in patients with ileal conduit (24% of the patients).[61] Most complications may be managed conservatively by specialized nursing care and minimized by pre-operative and post-operative patient education.[62]

OUTCOMES

Most of the studies evaluating oncological safety, morbidity, and quality of life of the different techniques are based on urologic literature.[63] The experience in bladder cancer has demonstrated that in selected cases urethral preservation does not affect oncologic outcomes.[64] Optimal indications include isolated central disease of macroscopically complete resection. While orthotopic neobladder may ensure a high rate of daytime and night time continence (>80%) in women treated for bladder cancer,[26] lower rates (50%) are observed in patients with gynecological cancers.[11] Quality of life between different techniques was compared and the results are controversial. Two meta-analyses in patients with bladder cancer showed better health-related quality of life after ileal orthotopic neobladder than with ileal conduit,[65]—in particular, for young and fit patients.[66] On the other hand, other studies that included fewer patients found no major differences in quality of life between the two groups,[67 68] except for physical function and active lifestyle, which was better in the group who underwent an ileal orthotopic neobladder.[68]

In the gynecological literature, two recent studies reported comparable quality of life between continent and non-continent reconstructions 1 year after surgery.[15 69] These divergent findings among studies could be partially explained by differences in the duration of follow-up, the use of different standardized quality of life questionnaires, and the heterogeneity of the diseases included. Of note, regarding the Miami pouch, a retrospective study from a high-volume institution of patients primarily diagnosed with gynecological cancers, reported 93% overall continence.[70] Higher rates of post-operative complications, the learning curve, and comparable quality of life in comparison with incontinent diversions are often proposed to support the underuse of continent diversions, making non-continent diversions the dominant approach for most gynecologic oncologists.

In line with the urological literature where cancer-specific and functional outcome after radical cystectomy and reconstruction strongly correlate with surgeon and hospital volumes, we strongly advocate the development of accredited high-volume centers for the treatment of gynecologic malignancies. Indeed, a recent publication reported that radical cystectomy for bladder cancer was performed in 50% of the cases in low-volume centers (less than five cases per year) by surgeons who were not trained in all types of urinary reconstructions,[71] which had a major impact when deciding the technique employed for urinary reconstruction. As an example, in the United States less than 15% of patients undergo continent diversions, while in Germany the proportion of patients undergoing an ileal neobladder replacement is between 30% in urologic oncology centers and 75% at pioneering institutions. The experience gained along decades with continent diversions and the high patient accrual at these pioneering institutions have allowed

them to describe new surgical techniques, diffuse, innovate, and refine the different procedures.[72] Post-operative complications were demonstrated to be lower and functional outcomes better when continent diversion were performed by high-volume teams.[26]

The experience gained from the development of complex intracorporeal robotic or laparoscopic reconstructions, such as orthotopic neobladder in urology[73] or continent self-catheterizable pouch,[74] could pave the way to their introduction in selected cases in oncologic gynecology. The recent publication of the randomized RAZOR trial, which compared robotic-assisted radical cystectomy with open radical cystectomy in patients with bladder cancer, has demonstrated the non-inferiority of robotic surgery for 2-year progression-free survival with a reduction of peri-operative blood loss and length of stay at the expense of a longer operating time.[75] In gynecologic oncology, the results of the LACC trial demonstrated worse oncologic outcomes of minimally invasive surgery than with the open approach in early cervical cancer.[76] Therefore, the indications of pelvic exenteration and urinary reconstruction by minimally invasive surgery should be reserved to selected cases of gynecological cancers.

CONCLUSION

Pelvic exenteration is a demanding surgery where the constraints of two major procedures must be successively met: organ resection and functional restoration. After pelvic exenteration in gynecologic oncology, the literature does not support a hypothetical ideal urinary reconstruction, but emphasizes the need for personalization. Incontinent diversion represents a good option for unfit patients or for those unable to perform intermittent self-catheterization or refusing the constraints entailed by continent diversions. Although the post-operative complications of both types of reconstruction are comparable, quality of life issues support continent diversions in young and fit patients. We believe that patients requiring pelvic exenteration will benefit from high-volume referral centers in order to assure an approach by a multidisciplinary team focusing on pre-operative evaluation, procedure selection, patient education, and surgery, including specialized reconstructive approaches that are required for optimal results.

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