Evolution of the Neobladder: A Critical Review of Open and Intracorporeal

Neobladder Reconstruction Techniques

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Abstract

Orthotopic neobladder is an attractive alternative to the ileal coundit following radical cystectomy. Robotic cystectomy is gaining popularity although the uptake of neobladder reconstruction is low, with the majority of cases being constructed extracorporeally via a mini-laparotomy. Minimally invasive cystectomy using the robotic platform facilitates intracoporeal neobladder reconstruction and several techniques have been described. In this review we discuss issues relating to patient selection, and describe existing techniques of open surgical neobladder reconstruction, and their evolution to suit an intracorporeal approach. A Medline search for publication from Jan 1970 to Sept 2015 with the following keyword search criteria was performed: radical cystectomy, robotic cystectomy, intracorporeal, neobladder, orthotopic bladder reconstruction, surgical technique, patient selection and ureteric-ileal anastomosis.

Key words

Bladder cancer

Bladder reconstruction

Neobladder

Radical cystectomy

Urinary diversion

Introduction

Although the ileal coundit diversion is the most common reconstruction after radical cystectomy, studies have shown that in the suitable patient, an orthotopic neobladder may offer better quality of life by maintaining patient body image and facilitating near normal voiding (1). The development of robotic assisted radical cystectomy (RARC) and intracorporeal orthotopic neobladder represents an evolution of minimal access surgery which was previously not possible using conventional laparoscopic techniques. Although RARC was first reported over a decade ago, neobladder reconstruction following robotic cystectomy has been achieved in the main by conversion to open mini-laparotomy. A recent randomised controlled trail between RARC with extracorporeal urinary diversion and open cystectomy reported that early complications and length of stay between the two treatment mordality are similar although blood loss was significantly lower and operating time was longer in RARC patients(2). However, arguably, the benefits of a minimally invasive approach can only be achieved by completion of urinary neobladder reconstruction with an intracorporeal approach (3). Contemporary series suggest that overall, intracorporeal neobladder is performed in less than 10% of cases although in a number of institutions, it has become the standard approach (3, 4). Factors contributing to the low uptake of intracorporeal reconstruction may include the technical complexity, prolonged operative time, and the requirement for steep Trendelenburg position. Several intracorporeal neobladder techniques have been described which replicate contemporary open techniques (5-7). However, simplifying the procedure remains a challenge and long term functional follow-up is essential for any variation over standard techniques.

This review will focus on established techniques of open neobladder reconstruction, and how they have been adapted to the developing field of robotic intracorporeal reconstructive surgery. The key elements of case selection and the optimisation of functional outcomes will be discussed, as well as opportunities for future research and development.

Search criteria

A literature search confined to publications in English from January 1970 to September 2015 was performed using the Medline electronic database. Keyword search criteria include: radical cystectomy, robotic cystectomy, intracorporeal, neobladder, orthotopic bladder reconstruction, surgical technique, patient selection and ureteric-ileal anastomosis. An additional manual search of references of relevant published articles was also performed. Only studies reporting established open reconstruction techniques and intracorporeal RARC techniques reporting on at least 10 patients were included.

Patient selection for open and robotic neobladder reconstruction

Oncological consideration

The factors that must be considered when selecting patients for both open and robotic neobladder reconstruction are similar, with the added fact that in robotic cases intra-peritoneal adhesions from previous abdominal surgery can make access to the peritoneal cavity difficult. The risk of tumour recurrence in the remaining lower genito-urinary tract should be given careful consideration when selecting patients for

bladder reconstruction. The presence of tumour in the prostatic urethra is a risk factor for urethral recurrence especially if present within the prostatic stroma (8). Disease at the bladder neck, multifocal tumour and carcinoma *in situ* (*cis)* are not contraindications for neobladder reconstruction in men (9). Ideally, resection biopsy of the prostatic urethra is performed prior to radical cystectomy and neobladder reconstruction (9). Alternatively, a urethral frozen section can be performed to confirm the absence of tumour during radical cystectomy, although the presence of *cis* may be missed in up to 33.9% of cases (10). Female patients with bladder neck and vaginal wall involvement have a 53% and a 60% risk of urethral and local recurrence respectively (11, 12). This group of patients should not be considered for orthotopic neobladder reconstruction, although heterotopic reconstruction with Mitrofanoff diversion may be an alternative.

It remains controversial whether the extent of disease in the pelvis should be a consideration when selecting type of urinary diversion. The Pasadena Consensus Panel specify that the extent of tumour should be a consideration, whilst the 2012 International Consultation on Bladder Cancer suggested that the extent of pelvic disease should not preclude neobladder reconstruction (9, 13). Based on the evidence available, it is the authors' view that the decision to offer neobladder to patients with locally advanced disease should take T stage and nodal status into account. The 5 year overall survival (OS) and cancer specific survival (CSS) for patients with >T2N0 disease is 53% and 62% respectively, and for patients with node positive disease, OS and CSS drops to 32% and 40% respectively (14). Although, neobladder reconstruction is described in cases of advanced stage and nodal disease, the decision to offer neobladder reconstruction must also balance the time for the neobladder to mature into an effective reservoir against the time to

recurrence. The mean time to disease recurrence is 10 months and the majority of deaths will be within 2 years (14, 15).

Erectile dysfunction is common in men after conventional cystoprostatectomy, even if nerve sparing techniques is employed (16). Prostate sparing surgery, or prostate capsule sparing surgery might offer an option for preservation of potency with case series reporting day time and night time continence rates of 96% and 82% respectively as well as preservation of erectile function in 90% of cases (17). In addition to other standard investigations, it is recommended that prior to undergoing prostate sparing cystectomy such men have a PSA measurement and transrectal ultrasound guided prostate biopsies to exclude prostate cancer (17). However, caution is advised when considering this technique in men with benign prostatic hyperplasia due to the potential risk of high pressure chronic retention, which may leading to renal impairment if intermittent catheterisation is not performed (7). In females with ≤pT2 disease located away from vagina and uterus pelvic organ preservation may enhance functional outcomes without compromising oncological safety (18) .

Patient factors

Compromised renal function is a contraindication for open or robotic neobladder reconstruction. It is well known that prolonged contact of urine with the interposed bowel segment leads to increased absorption of ammonia, which in turn results in a net positive balance of hydrogen ions. Patients with poor renal reserve are unable to excrete the increased load of hydrogen ions, which results in hyperchloremic metabolic acidosis. Clinical features of dehydration, lethargy, nausea, vomiting and

seizures can develop if the acidosis goes untreated (19). Although, there is no absolute cut off, it is generally accepted that a glomerular filtration rate (GFR) of 50ml/min is a threshold below which neobladder reconstruction should not be performed (20). Similarly, hepatic impairment may lead to hyperammonemia due to an inability of the liver to metabolise the increased levels of ammonium that are absorbed by the neobladder (21). This can result in encephalopathy and for that reason, hepatic impairment is also a contraindication.

Other contraindications include inflammatory bowel disease, especially Crohn's disease, although patients with ulcerative colitis may be considered for an ileal neobladder. The option for neobladder reconstruction in cases with pure ulcerative colitis may be in conflict with the requirement for small bowel ileal-anal pouch formation following total colectomy resection.

Relative contraindications include previous pelvic radiation, previous bowel resection, urethral stricture, poor external urethral sphincter function and previous radical prostatectomy. Patients with poor external sphincter function can be considered for artificial urinary sphincter insertion if they have a strong preference for neobladder reconstruction. Increasing age is not a contraindication to neobladder reconstruction but a careful assessment of comorbidity and physical and cognitive status is important (22). It is essential that patients are engaged with the care program required to manage their neobladder, which includes intermittent self-catheterisation. Failure to adequately empty the neobladder may result in rupture, which is why cognitive impairment, insufficient physical dexterity and unwillingness to perform self-intermittent catheterisation are all relative contraindications.

Intestinal segment for bladder reconstruction

The ideal bladder substitution should maintain a low pressure during the filling phase, have high compliance with good continence. The reservoir should empty on voiding, be impermeable to solutes and protective of the upper urinary tract. Unfortunately, at present there is no bladder substitute that is able to fulfil all the above requirements.

The most popular intestinal segment used for neobladder reconstruction is Ilium, followed by ileal-caecal and colon. The use of stomach and jejunum have been reported, but are considered technically impractical options. A sufficient length of intestinal segment must first be detubularized in order prevent peristaltic contractions and allow a large volume (500ml), low pressure reservoir. Urodynamic assessment comparing the pouch pressures of different bowel segments indicates that ilium is more compliant and less contractile, resulting in improved continence rates than either colon or stomach (23). Table 1 lists the different intestinal segments summarises their advantages and disadvantages.

Refluxing or Non-refluxing ureteric-ileal anastomosis?

Table 2 presents a variety of reconstruction techniques that have been developed with the aim of preserving renal function by minimising ureteric reflux and anastomotic stricture. Anti-reflux techniques attempt to replicate the competency of the native ureteric implantation and prevent the reflux of high levels of bacteria that are present within the neobladder, and which may lead to ascending pyelonephritis and renal impairment (24, 25). Urodynamic studies have reported neobladder pressures of up to 150 cmH$_2$O during voiding in patients with the anti-reflux Kock

neobladder, which over the long term in the absence of an anti-reflux mechanism would be detrimental to renal reserve (26). However, high voiding pressures have not been confirmed by others authors, and voiding scintigraphy studies in patients with freely refluxing uretero-ileal anastomosis have confirmed the absence of ureteric reflux (27).

The initial Kock neobladder, T pouch and Le Duc anastomosis reported stricture rates as high as 10.4-29% (28-30). Moreover, data from a randomised trial report that patients with an anti-reflux anastomosis had a significantly higher stricture rate compared to refluxing anastomosis (31). A another randomised trial by Skinner and colleagues showed that there was no difference in three years postoperative renal function or risk of urinary tract infection between the T pouch and Studer neobladder although T pouch patients had a much higher re-intervention rate due to uretero-ileal stricture and afferent limb stenosis (32). It is well established that undiagnosed uretero-ileal strictures will result in a decline in renal function and early intervention in patients receiving the T pouch may have prevented any significant decline. However, not all anti-refluxing anastomosis report high stricture rates. The Abol-Enein & Ghoneim pouch and the I pouch have a stricture rate of between 2.1-3.8% (33, 34). However, given that there is no benefit in performing anti-refluxing anastomosis, freely refluxing anastomosis has become the anastomosis of choice.

An alternative to anti-reflux implantation is a long afferent limb, which is postulated to be advantageous if a refluxing uretero-ileal anastomosis is performed (35). However, techniques with direct uretero-ileal anastomosis to neobladder have not been shown to have an adverse effect on upper tracts and renal function (36, 37). It is reasonable to postulate that the most important factor in preserving upper tract integrity appears to be the low pressure afforded by the formation of a large volume

pouch using an adequate length of detubularised and folded bowel (37). Long term outcomes with particular reference to renal preservation have not supported the requirement for anti-reflux ureteric implantation in open surgery, and consequently have not been adopted for robotic surgery.

Refluxing uretero-ileal anastomosis is typically performed by either a Bricker or Wallace anastomosis. Type of anastomosis performed is dependent on surgeon preference. Proponents of the Wallace technique perceive that it has a lower stricture rate compared to the Bricker anastomosis although there is a higher risk of bilateral ureteric obstruction in the event of a stricture, tumour recurrence or renal calculi. A recent meta-analysis on retrospective cohort series report that there is no difference in stricture rates between Bricker and Wallace anastomosis (38).

Open neobladder reconstruction

The two most popular neobladder reconstruction techniques include the Studer ileal afferent limb neobladder and the Hautmann 'W' neobladder. Other techniques include the Kock ileal neobladder, T- pouch, Padua ileal neobladder and the Abol-Enein and Ghoneim's 'W' neobladder. All neobladders adhere to Laplace's law and are spherical in configuration; cross folded and have a good capacity to promote low intraluminal pressure. Functional outcomes of these techniques are summarised in Table 3.

Studer neobladder

The Studer neobladder is popular due to its relatively simple construction. Excellent long term continence rates are reported and the afferent limb can be tailored for cases with short ureters (35). A segment of the terminal ilium approximately 55cm in length, 25 cm from the ileo-caecal valve is used to construct the neobladder. 40cm of the selected segment is detubularized and folded into a U configuration, leaving a proximal 15 cm afferent limb segment into which the ureters are implanted using Bricker or Wallace technique. It has been argued that this afferent limb can reduce the risk of urinary reflux secondary to intra-abdominal pressure (39).

Hautmann neobladder

The Hautmann neobladder involves the formation of a large capacity, 'W' configuration spherical reservoir using 70 cm of terminal ilium incised at its anti-mesenteric border and constructed with a running absorbable suture (36). Refluxing ureteric anastomoses are performed. The 'W' configuration results in complete detubularization of bowel which promotes excellent continence rates, but can increase the risk of late urinary retention due to its large capacity (40, 41). This is particularly more common in women patients where the risk of urinary retention is up to 50% at 5 years compared to 11% in men (42). Hence, women should be counselled on the high possibility of intermittent catheterisation use. Short ureters require a modification of the original W neobladder leaving one end of the ileal segment longer to facilitate a tension free uretero-ileal anastomosis.

Kock ileal reservoir / T pouch neobladder

The Kock ileal neobladder uses approximately 60 cm of ilium, from which two 22cm segments are placed in a 'U' configuration, with a proximal 17 cm intussuscepted nipple valve (43). This anti-reflux valve is fashioned by intussuscepting the afferent limb which is fixed by two staples. Long term follow-up has revealed that a significant number of patients present with bilateral hydronephrosis or chronic renal failure secondary to afferent nipple stenosis, thought to be due to an impaired blood supply, or stone formation on the staples (28). The Kock technique has been replaced by the T-pouch ileal neobladder that was developed by Stein et al (29). The T- pouch technique uses the same U configuration as the Kock except the intussuscepted segment is replaced with a tapered afferent ileal segment in which the mesenteric segments (Windows of Denver) are opened and held in position by small Penrose drains. The afferent portion is then anchored to the two ileal 'U' shaped segments and the two ileal flaps fold over the afferent segment to create an anti-reflux mechanism. As there is little evidence for the requirement for an anti-reflux mechanism, coupled with increased technical demands, it is likely that neither the Koch or 'T' pouch will receive global adoption.

Padua ileal neobladder

First described in 1987, the 'Vescica Ileale Padovana' is a technique that only utilises 40 cm of ilium (44). Urodynamics studies report good functional outcomes and ileal tone is maintained preventing over-distension which results in satisfactory bladder emptying (45). The ilial segment is isolated and incised along the anti-mesenteric border and a funnel created inferiorly to promote drainage into a tension free

urethrointestinal anastomosis. The proximal loop of the detubularized ilium is folded in a reverse 'S' configuration and sutured on its sides to create an ileal cup. The ureteroileal anastomosis is performed using a serous-lined extramural ureteral replantation as described by Abol-Eneim and Ghoneim (see below) (34). The ureteric end is spatulated for the anastomosis, which is then stented. The anterior aspect of the neobladder is then folded downwards and sutured with a running absorbable suture.

Although using a shorter segment of ilium is attractive as it reduces the risk of metabolic and gastrointestinal complications such as diarrhoea and vitamin B12 deficiency, this has to be balanced against the potential risk of higher storage pressure and impaired continence due to a smaller bladder capacity.

Zhang et al. described a similar reconstruction using 40 cm of ileum described as the 'N' reservoir (46). The main difference is the absence of the extramural reimplantation in favour of a direct uretero-reservoir anastomosis, which in a recent report of urodynamic studies was associated with low voiding pressures.

Abol-Enein and Ghoneim's 'W' neobladder

Abol-Enein and Ghoneim described a 'W' shaped ileal neobladder with anti-reflux properties comprising of a serous lined extramural tunnel (34, 47). 40 cm of ilium is isolated and arranged into a 'W' configuration. The ureters are positioned in the medial flap troughs and the mucosa is closed in front to form a serous-lined anti-reflux intestinal tunnel. Long term outcomes show that reflux was observed in 3% of patients, and the rate of uretero-ileal anastomotic structure is low (34). However, this ureteroileal anastomotic technique requires ureters of considerable length is not

suitable for grossly dilated ureters. Further, creating an extramural tunnel using ilium can be challenging compared to colonic neobladders due to a less well defined muscularis externus layer.

Robotic assisted intracorporeal neobladder reconstruction

Over more than two decades, numerous techniques for the construction of continent urinary reservoirs have been described for open radical cystectomy. Some of these techniques have been modified for robotic surgery with surgeons seeking to replicate principles that have proven successful in open surgery. The robotic intracorporeal neobladder continues to evolve, and efforts to simplify the technique and reduce the operative time will continue to be necessary to command widespread adoption.

To date, no techniques for bladder reconstruction using colonic segments in robotic procedures have been described (Table 4) (5-7, 48). All techniques describe a refluxing uretero-ileal anastomosis. Jonsson et al. describes the initial step of urethro-ileal anastomosis having identified a section of 60 cm of ileum which will spare at least 12 cm of terminal ileum (Figure 1D) (49). The lack of tactile feedback mandates careful manipulation of intestine to the deep pelvis in a steep Trendelenburg position. Goh and colleagues describe the formation of the urethro-ileal anastomosis after isolation and detubularization of the bowel segment (Figure 1C) (6) and Pruthi and colleagues described complete pouch formation followed by anastomosis but in a limited series of cases (Figure 1B) (48). In our experience, manoeuvring the intestinal segment to urethra and completing the urethro-ileal anastomosis can be demanding, especially in obese patients. Accordingly our

preference is to complete the urethra-ileal anastomosis at an early stage before resecting the bowel segment (7).

Goh and colleagues (Figure 1C) and Jonsson and colleagues (Figure 1D) describe a robotic modification of the Studer reservoir using 60 cm of ilium (6, 49). At our institute, we performed a detubularized cross folding Pyramid neobladder without an afferent limb using 50 cm of ilium (Figure1A) (7).

Although described as a small series, Pruthi and colleagues (Figure 1B) describes a 'U' shaped neobladder which does not involve cross-folding (48). The lack of cross-folding may result in a higher intraluminal pressure which may compromise renal function. However, no long term follow-up data has been reported regarding renal function preservation. This neobladder is constructed using a stapling device rather than absorbable sutures and traditionally most surgeons are reluctant to use staples due to the risk of calculi formation. However in practice, neobladder calculi have not been noted as a problem with the use of modern stapling devices. (50, 51). While long term follow-up is needed, the relatively simple and fast technique of intracoporeal stapling using contemporary devices remains attractive.

All intracorporeal neobladders that have been described in the literature incorporate a 3 cm spatulated uretero-ileal anastomosis without anti-reflux mechanism either using the Bricker or Wallace technique. Long term follow up data on renal function and stricture formation is available for similar techniques in open surgery, which is widely accepted to translate to outcomes for intracorporeal neobladder. The Pyramid neobladder incorporates a direct ureter to neobladder anastomosis as described by others, with the option of forming a long afferent loop that can be used in patients with short ureters. Urodynamic studies performed in patients with a similar

neobladder configuration constructed using open techniques confirms low neobladder pressures at 12 months (37). The advantage of this simplified intracorporeal reconstruction technique is shorter operative time and reduced duration of steep Trendelenburg.

Long term follow-up data for preservation of renal function and functional outcomes are limited given the novelty of intracorporeal neobladder reconstruction. Techniques described by Goh and colleagues and Jonsson and colleagues attempt to replicate the Studer neobladder while the Pyramid neobladder is an evolution of a previously described open ileal neobladder technique (37). Hence, intracorporeal reconstruction should adhere to principles and open reconstruction techniques which have stood the test of time.

Steps to overcome difficulties in intracorporeal neobladder reconstruction

One of the most challenging parts of intracorporeal neobladder reconstruction is the urethra-ileal anastomosis. A tension free anastomosis is essential to prevent anastomosis and stricture. Careful dissection of the junction of the prostatic apex and external sphincter after dorsal venous complex ligation allows preservation of maximum membranous urethral length which has been shown to improve continence in radical prostatectomy (52). Prior to bowel segment isolation, careful identification of the segment of ileal for neobladder reconstruction with the longest mesentery is essential to ensure that the ilium loop can reach the urethra. If necessary, multiple transverse mesenteric serosal incisions can be made to achieve additional length in the order of several centimetres but care should be taken to avoid damaging mesenteric vessels. Manoeuvres using rubber sloops can facilitate traction on the

bowel segment. Suturing using barbed sutures such as V-Loc can minimise the risk of urinary leak by preventing slippage and allows the appropriate tension to be applied (53).

Future prespectives

The benefits of RARC remain controversial. The recently published Pasadena consensus panel systemic review concluded that RARC was associated with significantly lower blood loss and transfusion rates but higher cost compared to open cystectomy although there was no difference between postoperative mortality and morbidity (54). This is echoed by a randomised control trial of extracorporeal RARC versus open cystectomy by Bochner and colleagues (55). However, none of the patients in this study had intracorporeal division and the need for a mini-laparotomy for urinary diversion in the RARC arm may have negated any advantages of minimal invasive surgery. Another randomised trial with the aim of recruiting 320 patients comparing open RC and RARC with extracorporeal diversion is under way (56). However, arguably, the greatest benefit for patients will be those with intracorporeal urinary diversion although currently, there is a void of evidence to support this.

Conclusions

Although, many techniques and different intestinal segments have been tried and tested, the ileal neobladder appears to be technically feasible, whilst offering reliable functional outcomes. The shift towards robotic intracorporeal neobladder has led to the development of simplified techniques combined with a desire to preserve functional outcomes and prevent complications. The advent of dissolvable bowel

staplers may shorten operating time but it is unproven if it reduces the stone formation rates compared to conventional staplers.

It is now accepted that short and intermediate term complications and oncological outcomes in extracorporeal RARC are at least equivocal to open cystectomy (54). However, there is still limited data on long term oncological outcomes and complications relating to urinary diversion as well as the perceived advantages of intracorporeal RARC. Further studies will be needed to address these issues.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Figure 1: Schematic of different robotic intracorporeal neobladder techniques. **A: Pyramid pouch.** Urethro-ileal anastomosis is performed followed by detubularisation of the ileum at its anti-mesenteric border. The posterior and anterior plate is then closed with absorbable sutures and the folded edge of the neobladder is closed from lateral to medial. Uretero-ileal anastomosis is performed using the Bricker technique **B: U shaped neobladder.** The endoscopic stapler is used at the anti-mesenteric border of the ileum. Uretero-ileal anastomosis is performed and the cranial end of the neobladder is closed with staples/ absorbable sutures and urethra-ileal anastomosis is performed using the Bricker technique. **C1 & C2: USC modified Studer neobladder.** Isolated 44 cm segment of ilium is detubularised while 15 cm is preserved for the afferent limb. The posterior plate is closed with absorbable sutures and rotated 90° counterclockwise. Urethro-ileal anastomosis is performed and the anterior suture line is closed followed by ureteroileal anastomosis using the Bricker technique. **D1 & D2: Karolinska modified Studer neobladder.** Ileum is isolated in a J configuration and urethra-ileal anastomosis is performed. Ilium is detubularised and posterior plate closure is performed. The anterior wall of the neobladder is folded to close the neobladder anteriorly with absorbable sutures. Uretero-ileal anastomosis is performed at the afferent limb in a Wallace fashion.
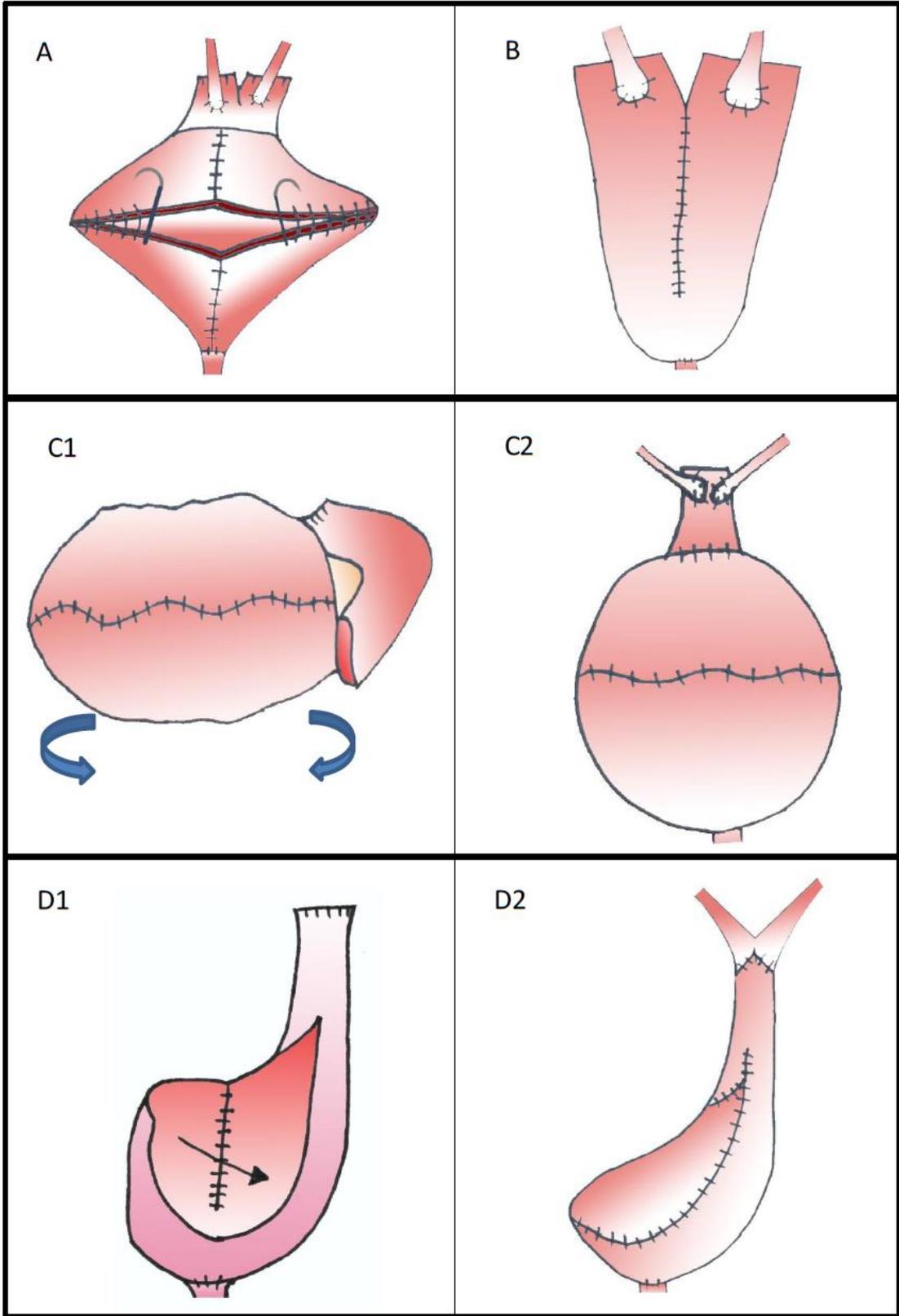
A

B

C1

C2

D1

D2

Table 1: Comparison of intestinal segments used for neobladder reconstruction

Intestinal segment	Advantage	Disadvantage	Intraluminal pressure at capacity (cm H_2O) (23)
Ilium/ ileocaecal	More compliant and less contractile than colon and stomach	Hypokalaemic hyperchloremic metabolic acidosis, fat and bile salt malabsorption, diarrhoea, Vitamin B12 deficiency, bone demineralisation	Ilium: 4±9 Ileocecal: 10±10
Colon	Option for patients with prior pelvic radiotherapy	Hypokalaemic hyperchloremic metabolic acidosis, significant mucous production, bone demineralisation, pyelonephritis, risk of adenocarcinoma at anastomosis	Colonic: 21±24 Sigmoid: 40±22
Jejunum	Option for patients who had pelvic radiotherapy	Hyperkalaemic hypochloremic metabolic acidosis, nausea/ vomiting	NA
Stomach	Option for patients who had pelvic radiotherapy, beneficial for patients with renal and/or liver dysfunction, low mucous production	Hypokalaemic hypochloremic metabolic alkalosis, haematuria- dysuria syndrome	23±15

Table 2: Comparison between anti-reflux and freely refluxing urethro-ileal anastomosis

Technique	Author	Disadvantage	Number of patients	Median follow-up in months (range)	Stricture rate	Reflux rate
Anti-reflux techniques						
Studer isoperistaltic limb	Studer et al. (35)	Extra 20 cm of ilium used for isoperistaltic limb	482	32 (0.4- 208)	2.7%	Not reported
Le Duc technique- Embedded ureter in mucosal sulcus	Shaaban et al. (30)	High stenosis rate	40	18	1.5-29%	2.5%
Kock ileal reservoir- Intussuscepted nipple valve	Stein et al. (28)	Desusception, high stenosis rate, stone formation	802	73.2 (0-127.2)	10.4%- afferent anti-reflux nipple valve 2.2% uretero-ileal anastomosis	Not reported
T pouch- afferent flap valve	Stein et al. (29)	Stenosis rate, more complex reconstruction	209	33 (0-69)	10%	10%
Abol-Enein & Ghoneim- Extramural serous-lined tunnel (Bricker anastomosis)	Abol-Enein et al. (34)	Not suitable for dilated/ pathological ureters	450	35 (8-88)	3.8%	3%
I pouch- Sub-serosal tunnel (Wallace anastomosis)	Gakis et al (33)	May not be suitable for dilated/ pathological ureters	97	41 (3-107)	2.1%	1%
Refluxing technique						

Bricker technique- Separate ureteric-ilium anastomosis using interrupted sutures	Davis et al. (38)		212	27±5	5.8	
Wallace technique- Conjoined ureteric-ilium anastomosis using continuous sutures	Davis et al. (38)		258	26±5	3.9	

Table 3: Comparison between commonly performed open neobladder techniques

Technique	Author	Length of bowel (cm)	Number of patients	Median follow-up in months (range)	Continence		Intermittent catheterisation
					Day	Night	
Studer neobladder- afferent limb and 'U configuration'	Studer et al. (35)	55	482	32 (0.4- 208)	92.0%	79%	7.0%
Hautmann neobladder- 'W configuration'	Hautmann et al. (41)	70	383	Mean: 57 (10-137)	95.9%	95.0%	3.9%
T pouch- T shape with tapered afferent ileal segment	Stein et al. (29)	60	209	33 (0-69)	87.0%	72.0%	25.0%
Padua neobladder- Reverse 'S configuration'	Ferriero et al. (45)	40	46	48	90.0%	60.0%	2.2%
Abol-Enein & Ghoneim neobladder- 'W' configuration	Abol-Enein et al. (34)	40	450	35 (8-88)	93.3%	80.0%	2.0%

Table 4: Comparison between intracorporeal robotic neobladder techniques. M: male, F: female

Study	Length of ilium (cm)	Bricker/ Wallace	Shape	Detubula rised ilium	Afferent limb	Stapler use	Technique	Median operating time, mins	12 months continence	
									Day	Night
Jonsson et al. (49)	50	Wallace	Studer	X	X		Urethro-ieal anastamosis then NB reconstruction	420	97%	83%
Goh et al. (6)	60	Bicker	Studer	X	X		NB reconstruction then urethra-ileal anastamosis	450	75% (3 months)	
Pruthi et al. (48)	Not known	Bricker	U shape	X		X	NB reconstruction then urethra-ileal anastamosis	318		
Tan et al. (7)	50	Bricker	Pyramid	X			Urethro-ieal anastamosis then NB reconstruction	330	95% (6 months)	70% (6 months)