Complications associated with urinary diversion

Richard E. Hautmann, Stefan H. Hautmann and Oliver Hautmann

Abstract | Radical cystectomy (RC) with subsequent urinary diversion has been assessed to be the most difficult surgical procedure in the field of urology. No randomized trials have been performed to compare the outcomes of noncontinent conduit diversion, neobladder construction and continent cutaneous diversion. Almost all studies are of level 3 evidence, meaning the recommendations given in this Review are of grade C only. Until recently, significant disparity in the quality of surgical complication reporting, as well as the lack of universally accepted reporting guidelines, definitions and grading systems, have made it impossible to compare the surgical morbidity and outcomes of RC. There is a clear case for the standardized reporting of complications. The Clavien system is a straightforward and validated instrument that has already been successfully adopted by several urological centers. Surgical morbidity following RC is significant and, when strict reporting guidelines are incorporated, much higher than previously published. Complications can occur up to 20 years after surgery, emphasizing the need for more long-term studies to determine the full morbidity spectrum. In general, renal function after construction of continent detubularized reservoirs compares favorably with ileal conduit diversion, although the literature is insufficient to recommend one over the other. The challenge of optimum care for elderly patients with comorbidities is best mastered at a high-volume hospital by a high-volume surgeon.

Hautmann, R. E. *et al. Nat. Rev. Urol.* **8**, 667–677 (2011); published online 1 November 2011; doi:10.1038/nrurol.2011.147

Introduction

Radical cystectomy (RC) with urinary diversion has been assessed to have the highest relative value of any urological procedure in terms of difficulty of the surgery.[1] Diversion procedures are also the most difficult laparoscopic and robotic procedures to perform—more so if the diversion is performed intracorporeally. The risk associated with RC and urinary diversion is based not only on the technical challenges of the procedure but also on the nature of the patients who tend to require it. The incidence of bladder cancer increases with advancing age; thus, the responsibility of providing optimal surgical treatment for elderly and frail patients is common among urologists. Improved patient rehabilitation is possible with neobladders compared to other types of diversion. In this context, there must remain continued emphasis on refining the surgical technique of RC and urinary diversion, in order to provide the best possible level of safety for the patient.[2]

Although RC and urinary diversion are two steps of the same operation, published studies uniformly report the complications of RC but ignore that the majority of these complications are related to the diversion.[3–5] This might seem semantic, but it is not—complications can be caused by the RC, the underlying disease, the excluded gut segment or the diversion itself. The incidence of early complications (defined as occurring either during the hospital stay or within 90 days of surgery) has been reported retrospectively to be in the range of 20–57%.[6–16]

In this Review, we will discuss the reconstructive options after RC and the outcomes and complications associated with the available diversion options.

Reporting the outcomes of urinary diversion

Evidence-based medicine

Evidence-based decision making seeks to balance the potential benefits and harms of health-care interventions. Breau *et al.*[17] found significant deficiencies in the reporting of adverse events in randomized controlled trials in the urologic literature. These findings suggest the need for standardized reporting of harm in urological studies. Improvements in the reporting of adverse events would permit a more balanced assessment of interventions and would enhance evidence-based urological practice.

Unfortunately, randomized controlled studies comparing noncontinent ileal conduit diversion to neobladder or continent cutaneous diversion have not been performed. A few randomized trials that examine other aspects of urinary diversion have been reported, such as the type of ureteroileal anastomosis. Consequently, almost all studies used in this report are of level 3 evidence, which is defined as 'good quality retrospective case control studies or case series'. Therefore, the recommendations given herein are of grade C only, meaning expert opinion is delivered without a formal analysis.[18]

Competing interests
The authors declare no competing interests.

University of Ulm, Boschstrasse 4a, D-89231 Neu-Ulm, Germany (**R. E. Hautmann**). Department of Urology, Klinikum Luedenscheid, University of Bonn, Paulmannshoeher Strasse 14, D-58515 Luedenscheid, Germany (**S. H. Hautmann**). Department of Trauma Surgery, University of Malaya Medical Center, 50603 Kuala Lumpur, Malaysia (**O. Hautmann**).

Correspondence to: R. E. Hautmann richard.hautmann@uni-ulm.de

Key points

- Radical cystectomy (RC) and subsequent urinary diversion has been assessed to be the most difficult surgical procedure in the field of urology
- No randomized trials have been performed to compare the outcomes of noncontinent conduit diversion, neobladder construction and continent cutaneous diversion
- Significant disparity in the quality of surgical complication reporting has made it impossible to compare surgical morbidity in patients who have undergone RC; there is a clear case for the standardized reporting of complications
- Overall, the perioperative surgical morbidity following RC and urinary diversion is significant and, when strict reporting guidelines are incorporated, much higher than previously published
- Complications can occur up to 20 years after surgery, emphasizing the need for close monitoring of these patients and more long-term studies to determine the full morbidity spectrum
- Evidence suggests an association between volume and outcome in cystectomy procedures; the challenge of optimum care for elderly patients with comorbidities is best mastered at high-volume hospitals by high-volume surgeons

The data summarized in Table 1 emerged from the recent joint International Consultation on Urological Diseases (ICUD)–European Association of Urology (EAU) consultation on bladder cancer and was based on almost 16,000 diversion procedures performed in three continents (Africa, North America and Europe), representing a well-balanced combination of pioneering institutions, high-volume centers and surgeons, low-volume institutions, a leading pediatric urology institution and the Swedish registry for bladder cancer.[2]

Contemporary use of diversion techniques

The types of urinary diversion fall into three major categories: noncontinent cutaneous diversion (a conduit constructed from ileum or colon), continent cutaneous diversion, and continent orthotopic diversion, also known as the neobladder. As the name for the first category implies, this method is noncontinent, requiring an external collection appliance similar to that for bowel diversions such as ileostomy or colostomy. The second category is a continent diversion that consists of a large internal reservoir constructed from a bowel segment (ileum or colon) and a continent stoma at the skin level that requires catheterization to drain urine. Finally, orthotopic diversion also has a large internal reservoir; however, the continence method is derived from the orthotopic position that allows the use of the native urethral sphincter.

Three of the 11 institutions involved in the ICUD–EAU consultation had experience with all types of diversion (Bern, Kassel and Ulm; Table 1). Although anal diversions have no contemporary role in the US in adults, they are of value in pediatric patients and in the third world, where urine collecting devices, bags, and catheters are very expensive or unavailable. Continent cutaneous diversions have a secondary role; even former pioneering institutions such as the University of Southern California, with a 25.8% continent cutaneous diversion rate between 1971 and 2001, use it with decreasing frequency. In the contemporary era (2000–2010), the University of Southern California report a neobladder rate of 74.2% compared to only 5.3% for continent cutaneous diversion (Table 1). Overall, conduit diversions (42.2%) and neobladders (38%) are the standard procedures at the centers included in the consultation.

Population-based data from the USA[19] and from the Swedish registry for bladder cancer (Table 1) show a neobladder rate in the range of 15%. With increasing hospital volume for RC, the rate of neobladder and continent diversion approaches 75%, which addresses both the impact of hospital volume for RC on the use of continent reconstruction and the question of neobladder construction being a new parameter for measurement of quality of care. These data are a further argument for the centralization of RC and urinary diversion procedures (see later).

Analysis of the data presented in Table 1 highlights a key question: what criteria should be used to define the limits for low, intermediate and high annual hospital volume and surgical case-load? In most publications, a single RC per year is defined as a low annual surgical case-load, two RCs per year is defined as intermediate and three or more RCs per year is considered high. Even though two cases per year represents 100% more than one RC per year, from a practical point of view both represent a very low case-load. Furthermore, a surgeon who performs three or four RCs is defined as a high-volume surgeon—these limits seem to have been chosen arbitrarily. In fact, on further examination, the cutoffs used in these papers were based on tertiles, which means only a third of patients in these population-based studies underwent RC by a surgeon who performed at least three surgeries per year. The ICUD–EAU committee considers a minimum of 25 RCs per year, performed by not more than two surgeons, to be the criterion for a high-volume center.[2]

Lack of standardized reporting

Common measures for surgical outcome of RC and urinary diversion reported in the literature include estimated blood loss, operative time, analgesic use, length of hospital stay, time to return to work, perioperative death, and hospital costs. Few studies report on readmission rates, reoperation rates, intensive care stays or additional interventional radiologic procedures.[20]

A recent evaluation revealed that the majority of series reporting RC morbidity did not use a formal complication reporting system, did not utilize grading systems other than to categorize complications as 'major' or 'minor', did not account for comorbidities, and did not define complications. Consequently, it is difficult to compare data between studies and most certainly leads to an underestimation of morbidity for the procedure.[20] In an analysis of population-based data, Konety *et al.*[7] reported at least one complication other than death occurring in 28.4% of patients. However, the observed rate in studies using standardized reporting is more than double that, reaching between 58% and 64%.[3,21]

Given that most complications develop in a time-dependent fashion, they should be reported using the Kaplan–Meier method for time-dependent events,

Table 1 | Contemporary use of diversion techniques

Center and time period	*n*	Type (%)						
		Neobladder	Continent cutaneous diversion	Conduit diversion	CU or TUUC	Anal	No diversion or unknown	Other
Ann Arbor								
1995–2004	643	45.1	1.4	53.5	0	0	0	0
2000–2009	962	40.0	2.0	58.0	0	0	0.9	0
Bern								
1985–1999	611	51.5	1.5	42.5	1.6	2.5	0	0.4
2000–2010	708	51.0	8.0	39.0	1.5	0.5	0	0.1
Kassel								
1994–2010	765	30.2	6.8	60.5	0.7	2.0	0.1	0
University of Southern California								
1971–2001	1,359	51.6	25.8	22.3	0	0	0	0.3
2000–2010	1,012	74.2	5.3	20.2	0	0	0.3	0
Lund								
2000–2004	119	28.6	31.1	40.3	0	0	0	0
2004–2009	134	6.0	30.6	63.4	0	0	0	0
Mainz								
1968–1980	335	0	0	55.0	0	45.0	0	0
1981–1990	593	2.0	33.0	41.0	0	15.0	0	9
1991–2000	982	6.0	39.0	41.0	0	12.0	0	2
2001–2010	1,023	15.0	24.0	53.0	0	4.0	0	4
Mansoura								
1980–2004	3,157	39.1	3.5	34.4	0	23.1	0	0
Norwich								
2002–2009	246	10.6	0	89.4	0	0	0	0
Swedish registry								
1997	158	19.0	19.0	55.0	0	0	7	0
2003	221	17.0	12.0	70.0	0	0	1	0
2006	208	9.0	6.0	80.0	0	0	5	0
2008	229	15.0	4.0	81.0	0	0	0	0
Ulm								
1986–2009	1,613	66.0	0.4	22.0	10.0	1.3	0.2	0
Vanderbilt								
2000–2007	789	35.5	0.4	63.5	0	0.1	0	0.5
Total	16,867	38.0	10.4	42.2	1.2	7.5	0.1	0.8

Abbreviations: CU, cutaneous ureterostomy; TUUC, transureteroureterostomy.

analogous to reporting tumor recurrence. This can easily be explained using the example of a series of incisional hernia procedures.[22] 41 hernias were observed in a total of 923 patients, which corresponds to 4.4%. By contrast, the Kaplan–Meier method revealed a 6.4% rate at 10 years, which is 45% higher than the observed rate in the same study.[22] The standardization of reporting long-term complications impacts statistical analysis, because only data on long-term complications that consider time-dependence are comparable. Otherwise, complications that occur early are over-represented while those that develop late might be under-represented as the number of patients decreases with time.

Until recently, the significant disparity in the quality of surgical complication reporting, as well as the lack of universally accepted reporting guidelines, definitions and grading systems, have made it impossible to compare surgical morbidity and outcomes in patients who have undergone cystectomy. Thus, there is a clear case for the standardized reporting of complications.

The Clavien system

The Clavien system is a straightforward and validated instrument that has already been successfully adopted by several urological centers.[3,21] Usually, complication rates for RC and urinary diversion are calculated by

Box 1 | Clavien grades (MSKCC modification)

Grade 0
No event observed

Grade 1
Use of oral medications or bedside intervention

Grade 2
Use of intravenous medications, total parenteral nutrition, enteral nutrition, or blood transfusion

Grade 3
Interventional radiology, therapeutic endoscopy, intubation, angiography, or operation

Grade 4
Residual and lasting disability requiring major rehabilitation or organ resection

Grade 5
Death of patient

simply dividing the absolute number of events by the total number of patients treated, regardless of time to complication onset. The Clavien system for classifying surgical complications was originally described for patients undergoing hepatobiliary surgery and has subsequently been validated in a general surgery population.[23] The Memorial-Sloan Kettering Cancer Center (MSKCC) modification defines the type, incidence, and severity of early postoperative morbidities after RC using 10 critical reporting elements.[21] The MSKCC modification of the Clavien system has proved to be a useful tool for classifying early complications by domain, such as genitourinary, gastrointestinal or infectious, and grade (Box 1).[21] The Clavien system focuses on the therapeutic consequences of a complication, emphasizing the level of intervention required to deal with it.[24] All complications from urology procedures should be classified according to their Clavien grade as part of the normal audit and clinical governance procedures.

Unfortunately, this system is less suitable for the reporting of long-term complications.[23] Early complications occur in a short, well-defined interval of 90 days after surgery. Stratifying any further than 90 days would provide no more meaning than the whole 90 days. By contrast, long-term complications can develop decades later.

The obvious strengths of this system are that it is standardized and has been validated. Despite this, it is generally acknowledged that there might be some subjectivity in how an individual surgeon records complications, and also in the interpretation of how particular complications should be graded. For example, Stolzenberg *et al.*[25] and Constantinides *et al.*[26] grade rectal injury during laparoscopic radical prostatectomy as a Clavien grade 1 complication because it can be managed intraoperatively, whereas Murphy *et al.*[27] classify it as a Clavien grade 3 complication because its repair under general anesthetic is a significant deviation from the planned procedure. Despite these limitations, it is a vast improvement on the present variable outcome reporting that currently exists in urology. Since 2008 the Clavien system has been used with increasing frequency for the reporting of complications in urology.[3,21,26,28] We believe the Clavien system should be used as standard.

Complications of urinary diversion

Perioperative complications

Regrettably, various definitions exist for the term perioperative. Evaluating complications over the 90-day postoperative period rather than the traditional inpatient stay only or 30-day postoperative period, allows the natural evolution of complications over time to be recorded, and has the potential to identify modifiable factors that can be targeted for quality improvement. Gastrointestinal complications, such as intermittent ileus or small bowel obstruction, persist as the second or third most common complication up until 90 days after surgery. Although they tend to be low grade (grade 1–2) by nature, they often require readmission. Infections and genitourinary complications are common, notably constituting 30–40% of high-grade complications reported after discharge.

Konety *et al.*[7] determined the morbidity and mortality of RC and urinary diversion in a population-derived sample in 2006. The in-hospital mortality rate was 2.57%, and at least one complication other than death occurred in 28.4% of patients. These rates are comparable to those previously reported in published studies. Patients undergoing RC at large, urban, teaching hospitals were less likely to have secondary complications after surgery. Information was gathered regarding the hospital bed size (small, medium, or large), teaching status (teaching or nonteaching), and hospital location (urban or rural). The authors created a composite variable to specifically identify large bed size, urban, teaching hospitals. They categorized the hospitals by the average number of cystectomies performed per year into high (more than three per year), moderate (1.5–3 per year), and low (less than 1.5 per year) volume. Of the 1,057 hospitals, 329 were high-volume (4,451 cases), 354 were moderate-volume (1,450 cases), and 375 were low-volume (676 cases). Younger patients, women, and those undergoing RC at high-volume hospitals were less likely to have primary complications.

Primary complications are those directly attributable to the cystectomy, including digestive system complications, accidental punctures or lacerations, postoperative fistulas, hematomas complicating a procedure, seromas, and nonhealing surgical wounds. Secondary complications are defined as those that occur distant from the surgical field, in an organ system other than the urinary tract (such as cardiac, respiratory, urinary, vascular, and postoperative infectious complications) and that could occur with most types of surgery. In their study, Konety *et al.*[7] concluded that the overall morbidity and mortality rates associated with RC in a population-based sample were comparable to those reported from individual centers. Larger centers in urban locations might have lower secondary complication rates but only hospitals performing a

high volume of RCs were associated with fewer primary surgery-related complications.

In 2008, Shabsigh *et al.*[21] studied the early morbidity of RC and urinary diversion using the MSKCC modified Clavien system.[21] The investigators sought to define the type, incidence, and severity of early postoperative morbidities. All patients underwent RC and urinary diversion (any type) by high-volume fellowship-trained urologic oncologists. Of 1,142 patients, 735 (64%) experienced a complication within 90 days of surgery. Among these, 67% experienced a complication during hospital admission and 58% after discharge. Overall, the highest grade of complication reported was grade 0 in 36%, grade 1–2 in 51%, and grade 3–5 in 13% of the cohort. Gastrointestinal complications were most common (29%), followed by infectious complications (25%) and wound-related complications (15%). The 30-day mortality rate was 1.5%. The authors concluded that surgical morbidity after RC and urinary diversion is significant and, when strict reporting guidelines are incorporated, higher than previously published—being 67% in this study, compared to 28.4% reported previously.[7] Univariate analysis identified gender, prior pelvic radiotherapy, estimated blood loss, number of packed red blood cells or fibrin patches used, and American Society of Anesthesiologists (ASA) score as significant predictors of any grade complication. Using multivariate analysis, gender, ASA score and type of urinary diversion were significant predictors, while prior pelvic radiotherapy and age trended towards significance.

In 2010, Hautmann *et al.*[3] reported the 90-day complication rate of 1,000 neobladder operations in a large, contemporary, homogeneous series of patients who underwent RC at a tertiary academic referral center using a standard approach.[3] The authors performed RC on 1,540 patients, 1,259 of whom were candidates for a neobladder. Of these patients, 1,013 (66%) received a neobladder and form the cohort of this study. All complications within 90 days of surgery were defined, categorized and classified using an established 5 grade and 11 domain modification of the original Clavien system.[3] 587 patients (58%) experienced at least one complication within 90 days of surgery. Infectious complications were most common (24%), followed by genitourinary (17%), gastrointestinal (15%) and wound-related complications (9%). The 90-day mortality rate was 2.3%. Overall, 36% of patients reported minor complications (grade 1–2) and 22% experienced major complications (grade 3–5). On univariate analysis, the incidence and severity of 90-day complications correlated significantly with age, tumor stage, ASA score and preoperative comorbidity. Hautmann *et al.*[3] concluded that RC with neobladder construction represents a major surgery with potential relevant early complications, even in the most experienced hands. Overall, it seems the perioperative surgical morbidity following RC and urinary diversion is significant and, when strict reporting guidelines are incorporated, much higher than previously published.

Long-term complications

Reliable long-term data on any form of urinary diversion are lacking, because many series include a mixture of patients with short-term and long-term follow-up. Studies tend to focus on early complications owing to the high early mortality from underlying disease and patient comorbidities. At the time of RC, most patients are elderly (65–70 years), and 40–50% of patients die of bladder cancer within 2–3 years of surgery. A representative contemporary series had only 18 patients with more than 15 years' follow-up.[4] The authors report complications directly related to the ileal conduit in 66% of patients in the long-term. Almost 40% required surgical intervention. The fact that these complications occurred up to 20 years after surgery emphasizes the need for more long-term studies (>10-year follow-up) to determine the entire morbidity spectrum.[4]

To address important long-term issues, such as kidney function, problems related to the stoma and bowel, metabolic disorders, recurrent pyelonephritis or urinary tract infections and stone formation, Madersbacher *et al.*[4] reviewed the charts of all patients who underwent an ileal conduit diversion at their institution between 1971 and 1995, and who lived for a minimum of 5 years after surgery. The authors analyzed all conduit-related complications occurring more than 3 months after surgery in 131 long-term survivors. Median follow-up was 98 months. Overall, 192 conduit-related complications developed in 66% of patients. The most frequently occurring complications were related to kidney function or morphology (27%), stoma (24%), bowel (24%), symptomatic urinary tract infection including pyelonephritis (23%), conduit or ureteral anastomosis (14%) and urolithiasis (9%; Table 2). Complications developed in 45% of patients in the first 5 years. This percentage increased to 50%, 54% and 94% at 10, 15 and 20 years, respectively. At 20 years, 50% of patients had upper urinary tract changes and 38% had urolithiasis. This study demonstrates a high conduit-related complication rate in long-term ileal conduit diversion recipients and underlines the need for vigorous long-term follow-up of these patients.

In a similar study, Shimko *et al.*[5] evaluated long-term surgical complications and clinical outcomes in 1,057 patients who underwent RC with conduit urinary diversion using ileum or colon at the Mayo clinic from 1980 to 1998 with complete follow-up information. Median follow-up after surgery for the entire cohort was 6.3 years (range 0.1–29.1 years). For those alive at last evaluation, follow-up was 15.5 years (range 0.3–29.1 years). 97 patients had at least 20 years of follow-up. 643 patients (60.8%) reported 1,453 complications, directly attributable to the urinary diversion performed. Bowel complications were the most common, occurring in 20.3% of patients, followed by renal complications (20.2%), infectious complications (16.5%), stomal complications (15.4%), and urolithiasis (15.3%). The least common were metabolic abnormalities (12.8%) and complications of the conduit excluding the stoma (11.5%; Table 2). Advanced age at cystectomy, high

Table 2 | Diversion-specific long-term complications

Study	*n*	Median follow-up (years)	Reoperation rate (%)	Complications *n* (%)						
				Bowel	UTI	Stoma	Anastomosis	Urolithiasis	Renal function	Total
Conduit										
Bern[4]	131	8.1	40	32 (24.0)	30 (23.0)	32 (24.0)	18 (14.0)	12 (9.0)	35 (27.0)	87 (66.0)
Mayo[5]	1,057	6.3	6	215 (20.3)	174 (16.5)	163 (15.2)	122 (11.5)	162 (15.3)	213 (20.2)	643 (61.0)
Neobladder										
Ulm[22]	923	6.0	NR	31 (3.4)	46 (5.0)	NR	102 (11.5)	3 (0.2)	NR	376 (40.8)

Abbreviations: NR, not reported; UTI, urinary tract infection.

Eastern Cooperative Oncology Group performance status and recent surgery were significantly associated with a higher incidence of complications. The authors concluded that conduit diversion is associated with a high overall complication rate, but a low reoperation rate. The recent increase in complications might be attributable to more aggressive treatment of urothelial carcinoma as well as improved availability of health records of recent patients. Long-term follow-up of these patients is necessary to closely monitor for potential complications from the urinary diversion that can occur decades later.

Patients with comorbidities are often recommended for conduit diversion because it is associated with a shorter operative time than neobladder construction. Thus, making unbiased comparisons between different types of reconstruction is difficult.[19,29,30] The high complication rates reported in the aforementioned studies further suggest that conduit diversion is not the low-risk, low-complication procedure it was once thought to be, and potential complications do not necessarily support one type of urinary reconstruction over another.

Functional complications

Renal function

The most concerning issue following urinary diversion is upper urinary tract changes, which are found consistently in long-term studies.[31–35] Absorption of urinary constituents through the bowel mucosa causes an increase in acid load. The larger the bowel surface and the greater the contact time with urine the greater the acid load will be, thus continent reconstruction has greater potential to cause a problem than conduit diversion. In the context of normal renal function most patients with a neobladder or a continent cutaneous reservoir are able to compensate for an increased acid load, provided the reservoir is emptied to completion at regular intervals. In the context of renal impairment, a patient's ability to handle the increased acid load is reduced, which can lead to metabolic acidosis.

Many studies that report renal function after urinary diversion are small and of limited follow-up. Moreover, reporting retrospectively on serum creatinine with or without ultrasonography or intravenous pyelography is not useful because not only does serum creatinine remain within normal limits until there is a 50% reduction in glomerular filtration rate (GFR), but also the presence of upper tract dilatation does not necessarily equate to a reduction in renal function. Rinnab *et al.*[36] studied the resorptive and excretory capacity of the ileal neobladder. They found that mild metabolic acidosis caused by proton reabsorption is common after such surgery, and long-term pharmacological correction is often necessary. To assess the effect of the neobladder on retention values, serum creatinine and urea were analyzed before and after removal of the transurethral catheter. 15 patients (50%) showed resorption of creatinine and urea, eight (27%) excreted creatinine into the neobladder and resorbed urea from it at the same time, and three (10%) demonstrated creatinine resorption and urea excretion. Interestingly, four patients (13%) excreted both creatinine and urea into the neobladder.

Ideally, serial isotopic GFR should be measured for an accurate assessment of renal function. Chromium-51 labeled ethylenediamine tetraacetic acid (^{51}Cr-EDTA) is often used for this purpose, because it is freely filtered through the glomeruli and minimally reabsorbed from the intestinal mucosa. Kristjansson *et al.*[37] report ^{51}Cr-EDTA isotopic GFR after 10 years of follow-up in patients who were randomized to receive either an ileal or colonic conduit as well as a refluxing or nonrefluxing ureteroileal anastomosis.[37] A drop in GFR of >25% was reported in 34% of the cohort—40% in the colonic group and 28% in the ileal group. No difference in GFR reduction was noted between refluxing and nonrefluxing ureteroileal anastomoses, although renal scarring and bacteriuria were more common in patients with a refluxing anastomosis. Ureteroileal strictures developed up to 14 years after surgery in eight patients. In these patients, ureteric reimplantation improved renal function in six of seven renal units, and balloon dilation improved renal function in one of five renal units.

More recently, Samuel *et al.*[38] used serial isotopic GFR to report follow-up of >4 years in 178 patients who had an ileal conduit with a freely refluxing ureteroileal anastomosis.[39] GFR worsened by >5% (mean 31%) in 29% of patients at a mean of 8.2 years. In 33 patients there was no identifiable obstruction as a cause for deteriorating GFR. Following continent cutaneous diversion, Kristjansson *et al.*[37] reported a decrease in renal function (using ^{51}Cr-EDTA isotopic GFR) of >25% in 28% of 18 patients 11 years after construction of a cecal reservoir.[37] The high incidence of upper tract changes is in contrast

to the low incidence following orthotopic bladder substitution using a tubular isoperistaltic ileal segment similar to an ileal conduit but connected to an orthotopic low pressure reservoir.[39] Upper urinary tracts were preserved in 95% of patients who underwent the latter.[39] In the few cases where upper urinary tract changes were observed postoperatively, they were invariably associated with pre-existing pathology or *de novo* obstruction.[39] The usually sterile urine in the bladder substitute (in contrast to ileal conduit) might have contributed to these favorable results.[39]

Minervini *et al.*[40] reported on the follow-up of 110 patients who underwent ileal orthotopic reconstruction.[40] Serum creatinine was measured with CT or ultrasonography, followed by technetium diethylene triamine pentaacetic acid renography if upper tract dilatation was detected. Of 206 ureterorenal units, seven (3.4%) developed ureteroileal strictures after a mean follow-up of 65 months. Five ureters were reimplanted open and maintained stable renal function thereafter. In the remaining two units renal function was poor and they were managed conservatively resulting in further deterioration. 13 additional ureterorenal units (in 10 patients) were found to be dilated on imaging without obstruction on renography. In seven of these patients, the function of both kidneys did not change during a further mean follow-up of 44 months. The remaining three patients had bilateral nonobstructive upper tract dilatation and showed a decline in renal function thought to be secondary to associated infection.

Urinary diversion into bowel segments is not inherently damaging to the kidneys. In general, renal function after diversion into continent detubularized reservoirs compares favorably with ileal conduit diversion, although the literature is insufficient to recommend one form of diversion over another. There remains a long-term risk of renal deterioration, which is often asymptomatic and therefore close follow-up is necessary for all patients who have undergone urinary diversion, in order to identify correctable causes early. Those with pre-existing renal pathology before surgery seem to be at greatest risk of postoperative renal deterioration.

Metabolic consequences

Mills and Studer[41] outlined many potential metabolic complications following continent urinary diversion, of which both surgeons who perform the procedures and urologists who subsequently manage these patients should be aware. Metabolic complications (such as hypovolemic renal salt wasting and acidosis) can be minimized by careful patient selection, use of an appropriate bowel segment, and meticulous follow-up. Good renal function, regular voiding to completion, sterile urine and normal blood gas analysis are particularly important in preventing metabolic dysfunction. Clear differences exist between ileum and colon with regard to metabolic consequences but this is only one consideration when planning continent diversion.

The rather theoretical differences between small and large bowel are underlined by clinical experience. Hyperchloremic acidosis is most prevalent following ureterosigmoidostomy, where urine might come into contact with the whole colonic mucosa. The frequency and severity of metabolic complications after ureterosigmoidostomy were major stimuli for the development of alternative procedures. Comparative studies of ileal and colonic pouches are limited as the absorptive surface areas are difficult to calculate. However, chloride absorption and bicarbonate excretion are more pronounced in the colon, and there is evidence to suggest that inherent chloride absorption is maintained when in contact with urine. Therefore, it might be preferable to use ileum rather than colon for bladder reconstruction to reduce the risk of hyperchloremic acidosis, particularly in the presence of renal impairment.

Whichever segment of bowel is used, regular voiding and drainage to completion are important.[41] No clear advantage has yet been demonstrated for one bowel segment over another. Some doubt remains about the long-term consequences, particularly with regard to bone metabolism and secondary neoplasms. Many metabolic effects might be subtle and only manifest after a long time. Provided these caveats are rigorously respected, continent urinary diversion is an inherently safe procedure after cystectomy with regard to metabolic function.

Ureteroenteric stenosis

Shimko *et al.*[5] evaluated the medium-term surgical complications of a large group of patients treated with conduit diversion. 11.5% of patients reported structural complications at a median of 1.5 years, which the authors defined as complications of the conduit itself, not the stoma (Table 2).[5] Of these patients, 10.0% experienced anastomotic strictures at a median of 1.1 years. Most of these patients were treated with antegrade stent placement but 14.2% required open ureteroileal anastomosis revision.

Voiding with an orthotopic bladder substitute cannot produce reflux, a finding that has been confirmed on scintigraphy.[42] The long-term upper tract outcomes of this particular type of diversion are excellent—as few as 2.7% of patients have been reported to develop a ureteroileal stricture if a direct end-to-side anastomosis is used.[43,44] The use of temporary stents for ureteroileal anastomosis after orthotopic bladder substitution has been shown to improve outcomes.[45] Up to half of patients who develop a short ureteroileal stricture can be successfully managed endourologically.[44] These data are consistent with the outcome of two randomized surgical trials that assessed the effects of different afferent mechanisms—the use of an antireflux nipple valve was associated with a worse outcome than a dynamic isoperistaltic afferent tubular ileal segment. In the long term, the upper tracts are well-preserved.[46]

Urinary retention

Voiding dysfunction after orthotopic neobladder construction can be divided into failure to empty the bladder and failure to store urine (Table 3). Failure to

Table 3 | Continence and retention in females after orthotopic diversion

Study	*n*	Mean follow-up (months)	Continence (%)		Self-catheterization (%)
			Daytime	Night-time	
Hautmann (1996–2006)[48,58,61]	116	60	83	83	50
Granberg (2008)[91]	59	29	90	57	35
Nesrallah (2005)[92]	29	37	97	86	10
Ali-el-Dein (2008)[93]	192	51	92	72	16
Stenzl (2001)[94]	83	26	82	72	11
Stein (2002)[49]	81	78	78	NR	33
Stein (2007)[52]*	56	103	87	66	61

*Anonymous validated questionnaire. Abbreviation: NR, not reported.

store urine can occur during the daytime, night-time or both. For patients who experience voiding dysfunction, the orthotopic neobladder fails to improve quality of life compared to an ileal conduit. A comparison of the severity and prevalence of voiding dysfunction in many surgical series is confounded by variability in end points, definitions, length of follow-up, patient age, patient sex, and surgical technique. Moreover, lower urinary tract symptoms, incontinence, and retention have been rarely assessed with validated outcome instruments or voiding diaries.[47]

Urinary retention is much more common in women than men after orthotopic reconstruction. Retention might occur early, but often presents after years of good neobladder function and emptying.[1] In the Ulm series of 116 women, the rate of retention increased steadily over time to approximately 50% at 5 years.[48] The etiology of urinary retention in women has been debated, but most authors believe it is due to a mechanical kink in the urethra–reservoir anastomosis. Lateral straining cystogram reveals the full pouch falls posteriorly during the Valsalva maneuver in some patients.[49–54] Other suggested etiologies include autonomic denervation of the urethral remnant and disordered re-innervation resulting in the inability to relax the urethral sphincter.[48,55–57]

Since the first report of urinary retention after orthotopic bladder substitution in 1996,[58] a number of studies have demonstrated modifications to the surgical technique that improve outcomes.[49,50,52,54,59] However, all of these studies were consecutive case series and because the complication might appear late, such reports could be biased by shorter follow-up in the most-recently treated patients (Table 3). Nevertheless, attempting to fill the posterior pelvis and re-establish anterior and superior fixation of the new bladder seems warranted. At the University of Southern California a sacrocolpopexy with mesh and omental transposition laid between the bladder and vagina has been routinely performed,[52] and Ali-el-Dein[50] has described anchoring of the vaginal apex to the preserved round ligaments and also used an omental flap. However, others believe these maneuvers are unnecessary,[60] and recent results suggest that they do not prevent retention.

Studer[60] has proposed that location of the urethral opening in the pouch is an important variable. A recent study from the group in Ulm suggested that patients in whom the bladder neck itself is preserved (for example, in those with nonurothelial tumors) are at a higher risk of urinary retention than those in whom the urethra is divided just below the bladder neck.[61] Preservation of the uterus and its supporting ligaments when possible might be an effective way to prevent retention, although this has not been evaluated in a prospective or randomized trial.[62] Urinary retention is treated with intermittent catheterization; alpha-blockers are not effective.[50] Transurethral resection of a urethral fold and open reduction of the pouch size with anterior fixation to the abdominal wall have also been described.[50,62]

Clearly, every women undergoing neobladder reconstruction should be advised that intermittent catheterization might be required for adequate emptying and must be willing and able to learn how to perform this. Many women who are dry but require self-catheterization seem quite happy with the diversion in spite of this.[63]

A consecutive series of 655 men who received an ileal neobladder following RC revealed that 11.5% experienced at least one episode of failure to empty the neobladder that required some form of therapy during follow-up (median 36.5 months).[64] Failure was due to dysfunctional voiding in 3.5% of patients and mechanical obstruction (including benign strictures of the neovesicourethral anastomosis or the anterior urethra, neoplastic obstruction by local tumor recurrence or a nonurological malignancy and obstruction by mucosal valves or a foreign body) in 8%. In 38 of 52 patients with mechanical obstruction of the neobladder, outlet emptying was fully restored after an endourological procedure. Long-term catheterization was necessary in the remaining 14 men, and in all patients with dysfunctional voiding.

Some recommendations for the construction of an ileal reservoir in both sexes can be made, based on various studies in the literature. In order to avoid dysfunctional voiding, the size of the reservoir does not seem to be as important as is often suggested. Previous observations suggested an increased risk of developing a floppy bag with increased residual urine and the need

for lifelong intermittent self-catheterization if a longer ileal segment was used.[65] However, analysis of contemporary literature reveals rates of dysfunctional voiding of 0–20%[66–71] and 9.0–21.2%[67,69,72,73] for a 40–50 cm and 60 cm ileal segment, respectively. Therefore, we believe it is more important to instruct the patient to empty the neobladder on a regular basis to avoid the development of a floppy bag, which is independent of the initial size of the reservoir. With this regimen the catheterization rate for dysfunctional voiding in our male patients is 3.5%.[64] On the other hand, the advantages of neobladders made from a longer ileal segment include more-favorable pressure characteristics that result in prolonged micturition intervals, particularly at night, and better postoperative urinary continence.[74] Box 2 summarizes the main reasons for the failure of neobladder emptying in both sexes.

Box 2 | Causes of neobladder emptying failure

- Angulation of the urethra
- Elongation of the neobladder neck
- Position of neobladder neck—not at the lowest portion of pouch
- Lack of funnelling of neobladder neck during abdominal straining
- Preserved but dysfunctional native bladder neck
- Denervated proximal urethra
- Inadequate pelvic floor relaxation during voiding
- Neobladder too large (floppy bag)
- Ineffective Valsalva straining

Oncologic complications

Pelvic recurrence of transitional cell carcinoma after RC is relatively infrequent but when it does develop, the prognosis is poor. In contemporary series the pelvic recurrence rate ranges from 4% to 18%[75–82] depending on the pathological stage of the bladder malignancy. The role of orthotopic bladder replacement in patients undergoing cystectomy for locally advanced or node positive bladder cancer is unclear. In these patients, there is a risk that local recurrence might cause mechanical or functional interference with the reservoir.

Retrospective assessment of a large series of patients with locally advanced transitional cell cancer of the bladder who underwent ileal neobladder construction revealed local recurrence in 43 of the 357 patients.[83] Median survival was 17 months and median time to recurrence was 10 months. Of the patients with local recurrence, 36 had locally advanced cancer on the final pathological evaluation (stage pT3a or higher, or node positive). A total of 17 patients had concomitant distant metastasis. Three of the 43 patients were alive at 36, 48 and 147 months. Deaths were due to disease ($n = 36$), chemotherapy-related complications ($n = 3$) and other causes ($n = 1$). Of the 43 patients, 40 maintained good neobladder function. Local recurrence interfered with upper urinary tract function in 24 cases, the neobladder in 10 patients and the intestinal tract in seven patients. The neobladder was removed owing to development of a neovesical intestinal fistula in one patient.

With regards to mechanical interference of local recurrence with the neobladder, the location of recurrence seems to be more important than size of recurrent tumor. Recurrence in the true pelvis, away from the ileourethral or ureteroileal anastomosis, might grow to a large diameter without interfering with the urinary tract. By contrast, a small recurrence within the soft tissue of the pelvis near the neobladder outlet can obstruct the outlet and cause significant morbidity.

The local recurrence rate after orthotopic urinary reconstruction is 12%. Survival after diagnosis of local recurrence is limited despite advances in multimodal therapy. However, most patients can anticipate normal neobladder function even in the presence of recurrent disease. Thus, creating orthotopic diversion after RC in patients with locally advanced bladder cancer, including macroscopically or microscopically positive lymph nodes, is safe.[83]

Conclusions

RC and subsequent urinary diversion has been assessed the most difficult surgical procedure in the field of urology.[1] They are also the most difficult laparoscopic and robotic procedures to perform. The surgical morbidity following RC is significant and, when strict reporting guidelines are used, much higher than previously published. Accurate reporting of postoperative complications is essential for patient counseling, combined-modality treatment planning, clinical trial design, assessment of surgical success and for perioperative patient education.

In the long run, a conduit must be expected to develop complications in at least 60% of patients and almost 40% will require surgical reintervention. These complications can occur up to 20 years after surgery, emphasizing the need for more long-term studies to determine the full morbidity spectrum. This must be considered particularly in regard to newer forms of urinary diversion. One might even raise the provocative question of whether the time honored gold standard of urinary diversion, the conduit is really golden, safe and simple.

Urinary diversion using segments of bowel is not inherently damaging to the kidneys. In general, renal function after construction of continent detubularized reservoirs compares favorably with ileal conduit diversion, although the literature is insufficient to recommend one form over another. There remains a long-term risk of renal deterioration, which is often asymptomatic, and thus close follow-up is necessary for all patients who have undergone urinary diversion in order to identify correctable causes early. Those with pre-existing renal pathology before surgery seem to be at greatest risk of postoperative renal deterioration. Serum creatinine is an imprecise measure of renal function; isotopic GFR measurement can detect renal function deterioration most accurately and at an early stage. Early intervention for physical obstruction often results in a sustained improvement in renal function.

Of paramount importance is the active postoperative management and regular long-term follow-up of patients with an orthotopic bladder substitute. The key issues[84,85] are achieving a capacity of 400–500 ml, residual-free voiding of sterile urine and the treatment of any outlet obstruction. Evidence suggests an association between volume and outcome in cystectomy procedures for invasive bladder cancer.[86–90] The challenge of optimum care for elderly patients with comorbidities is best mastered at a high-volume hospital by high-volume surgeons. This applies more so to the urinary diversion because although RC and urinary diversion are two steps of one operation, almost 75% of all complications stem from the diversion.[3,22]

Review criteria

There are no randomized trials in the field of urinary diversion, comparing ileal conduit to orthotopic reconstruction or to continent cutaneous diversion. There are a few trials that examine specific aspects of urinary diversion, such as the type of ureteroileal anastomosis. Therefore, this Review is based on expert opinion, delivered without formal analysis. The expert opinion emerged from the recent joint International Consultation on Urological Disease (ICUD)-European Association of Urology (EAU) consultation on bladder cancer and was based on almost 16,000 diversion procedures performed in three continents.

1. Montie, J. E. in *Textbook of Operative Urology* (ed. Marshall, F. F.) 396–407 (Saunders, Philadelphia, 1996).
2. Hautmann, R. E. *et al.* in *Bladder Cancer* (eds Soloway, M., Abrams, P. & Khoury, S.) in press (Health Publication Ltd, Paris, 2011).
3. Hautmann, R. E., de Petriconi R. C. & Volkmer, B. G. Lessons learned from 1,000 neobladders: the 90-day complication rate. *J. Urol.* **184**, 990–994 (2010).
4. Madersbacher, S. *et al.* Long-term outcome of ileal conduit diversion. *J. Urol.* **169**, 985–990 (2003).
5. Shimko, M. S. *et al*. Long-term complications of conduit urinary diversion. *J. Urol.* **185**, 562–567 (2011).
6. Froehner, M., Brausi, M. A., Herr, H. W., Muto, G. & Studer, U. E. Complications following radical cystectomy for bladder cancer in the elderly. *Eur. Urol.* **56**, 443–454 (2009).
7. Konety. B. R., Allareddy, V. & Herr, H. Complications after radical cystectomy: analysis of population-based data. *Urology* **68**, 58–64 (2006).
8. Chang, S. S., Cookson, M. S., Baumgartner, R. G., Wells, N. & Smith, J. A. Jr. Analysis of early complications after radical cystectomy: results of a collaborative care pathway. *J. Urol.* **167**, 2012–2016 (2002).
9. Cookson, M. S., Chang, S. S., Wells, N., Parekh, D. J. & Smith, J. A. Jr. Complications of radical cystectomy for nonmuscle invasive disease: comparison with muscle invasive disease. *J. Urol.* **169**, 101–104 (2003).
10. Frazier, H. A., Robertson, J. E. & Paulson, D. F. Complications of radical cystectomy and urinary diversion: a retrospective review of 675 cases in 2 decades. *J. Urol.* **148**, 1401–1405 (1992).
11. Ghoneim, M. A., el-Mekresh, M. M., el-Baz, M. A., el-Attar, I. A. & Ashamallah, A. Radical cystectomy for carcinoma of the bladder: critical evaluation of the results in 1,026 cases. *J. Urol.* **158**, 393–399 (1997).
12. Hollenbeck, B. K. *et al.* Identifying risk factors for potentially avoidable complications following radical cystectomy. *J. Urol.* **174**, 1231–1237 (2005).
13. Joniau, S. *et al.* Clinical experience with the N-shaped ileal neobladder: assessment of complications, voiding patterns, and quality of life in our series of 58 patients. *Eur. Urol.* **47**, 666–673 (2005).
14. Meller, A. E., Nesrallah, L. J., Dall'Oglio, M. F. & Srougi, M. Complications in radical cystectomy performed at a teaching hospital. *Int. Braz. J. Urol.* **28**, 522–525 (2002).
15. Meyer, J. P. *et al*. A three-centre experience of orthotopic neobladder reconstruction after radical cystectomy: initial results. *BJU Int.* **94**, 1317–1321 (2004).
16. Quek, M. L. *et al.* A critical analysis of perioperative mortality from radical cystectomy. *J. Urol.* **175**, 886–890 (2006).
17. Breau, R. H. *et al*. Reporting of harm in randomized controlled trials published in the urological literature. *J. Urol.* **183**, 1693–1697 (2010).
18. Hautmann, R. E. *et al.* Urinary diversion. *Urology* **69** (Suppl. 1), 17–49 (2007).
19. Gore, J. L. & Litwin, M. S. Quality of care in bladder cancer: trends in urinary diversion following radical cystectomy. *World J. Urol.* **27**, 45–50 (2009).
20. Donat, S. M. Standards for surgical complication reporting in urologic oncology: time for a change. *Urology* **69**, 221–225 (2007).
21. Shabsigh, A. *et al.* Defining early morbidity of radical cystectomy for patients with bladder cancer using a standardized reporting methodology. *Eur. Urol.* **55**, 164–174 (2009).
22. Hautmann, R. E., de Petriconi R. C. & Volkmer, B. G. Lessons learned from 1,000 neobladders: the 90-day complication rate. *J. Urol.* **184**, 990–994 (2010).
23. Morgan, M., Smith, N., Thomas, K. & Murphy, D. G. Is Clavien the new standard for reporting urological complications? *BJU Int.* **104**, 434–436 (2009).
24. Dindo, D., Demartines, N. & Clavien, P. A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann. Surg.* **240**, 205–213 (2004).
25. Stolzenburg, J. U. *et al*. Categorisation of complications of endoscopic extraperitoneal and laparoscopic transperitoneal radical prostatectomy. *World J. Urol*. **24**, 88–93 (2006).
26. Constantinides, C. A. *et al*. Short- and long-term complications of open radical prostatectomy according to the Clavien classification system. *BJU Int.* **103**, 336–340 (2009).
27. Murphy, D. G., Kerger, M., Crowe, H., Peters, J. S. & Costello, A. J. Operative details and oncological and functional outcome of robotic-assisted laparoscopic radical prostatectomy: 400 cases with a minimum of 12 months follow-up. *Eur. Urol.* **55**, 1358–1366 (2009).
28. Hayn, M. H., Hellenthal, N. J., Hussain, A., Stegemann, A. P. & Guro, K. A. Defining morbidity of robot-assisted radical cystectomy using a standardized reporting methodology. *Eur. Urol.* **59**, 213–218 (2011).
29. Gore, J. L. *et al.* Urinary diversion and morbidity after radical cystectomy for bladder cancer. *Cancer* **116**, 331–339 (2010).
30. Lawrentschuk, N. *et al.* Prevention and management of complications following radical cystectomy for bladder cancer. *Eur. Urol.* **57**, 983–1001 (2010).
31. Williams, O., Vereb, M. J. & Libertino, J. A. Noncontient urinary diversion. *Urol. Clin. North Am.* **24**, 735–744 (1997).
32. Pernet, F. P. P. M. & Jonas, U. Ileal conduit urinary diversion: Early and late results of 132 cases in a 25-year period. *World J. Urol.* **3**, 140–144 (1985).
33. Killeen, K. P. & Libertino, J. A. Management of bowel and urinary tract complications after urinary diversion. *Urol. Clin. North Am.* **15**, 183–194 (1988).
34. Neal, D. E. Complications of ileal conduit diversion in adults with cancer followed up for at least five years. *Br. Med. J.* **290**, 1695–1697 (1985).
35. Singh, G., Wilkinson, J. M. & Thomas, D. G. Supravesical diversion for incontinence: a long-term follow-up. *Br. J. Urol.* **79**, 348–353 (1997).
36. Rinnab, L., Straub, M., Hautmann, R. E. & Braendle, E. Postoperative resorptive and excretory capacity of the ileal neobladder. *BJU Int.* **95**, 1289–1292 (2005).
37. Kristjánsson, A., Wallin, L. & Månsson W. Renal function up to 16 years after conduit (refluxing or anti-reflux anastomosis) or continent urinary diversion. 1. Glomerular filtration rate and patency of uretero-intestinal anastomosis. *Br. J. Urol.* **7**, 539–545 (1995).
38. Samuel, J. D., Bhatt, R. I., Montague, R. J., Clarke, N. W. & Ramani, V. A. The natural history of postoperative renal function in patients undergoing ileal conduit diversion for cancer measured using serial isotopic glomerular filtration rate and 99m technetium-mercaptoacetyltriglycine renography. *J. Urol.* **176**, 2518–2522 (2006).
39. Thoeny, H. C., Sonnenschein, M. J., Madersbacher, S., Vock, P. & Studer, U. E. Is ileal orthotopic bladder substitution with an afferent tubular segment detrimental to the upper urinary tract in the long term? *J. Urol.* **168**, 2030–2034 (2002).
40. Minervini, R. *et al*. Effects on renal function of obstructive and nonobstructive and dilatation of the upper urinary tract in ileal neobladders with refluxing ureteroenteric anastomoses. *Eur. J. Surg. Oncol.* **36**, 287–291 (2010).
41. Mills, R. D. & Studer, U. E. Metabolic consequences of continent urinary diversion. *J. Urol.* **161**, 1057–1066 (1999).
42. Waidelich, R., Rink, F., Kriegmair, M., Tatsch, K. & Schmeller, N. A study of reflux in patients with an ileal orthotopic bladder. *Br. J. Urol.* **81**, 241–246 (1998).
43. Nesbit, R. M. Ureterosigmoid anastomosis by direct elliptical connection; a preliminary report. *J. Urol.* **61**, 728–734 (1949).

44. Studer, U. E. *et al.* Twenty years experience with an ileal orthotopic low pressure bladder substitute—lessons to be learned. *J. Urol.* **176**, 161–166 (2006).
45. Mattei, A., Birkhaeuser, F. D., Baermann, C., Warncke, S. H. & Studer U. E. To stent or not to stent perioperatively the ureteroileal anastomosis of ileal orthotopic bladder substitutes and ileal conduits? Results of a prospective randomized trial. *J. Urol.* **179**, 582–586 (2008).
46. Perimenis, P., Burkhard, F. C., Kessler, T. M., Gramann, T. & Studer, U. E. Ileal orthotopic bladder substitute combined with an afferent tubular segment: long-term upper urinary tract changes and voiding pattern. *Eur. Urol.* **46**, 604–609 (2004).
47. Steers, W. D. Voiding dysfunction in the orthotopic neobladder. *World J. Urol.* **18**, 330–337 (2000).
48. Hautmann, R. E., Volkmer, B. G., Schumacher, M. C., Gschwend, J. E. & Studer, U. E. Long-term results of standard procedures in urology: the ileal neobladder. *World J. Urol.* **24**, 305–314 (2006).
49. Stein, J. P., Ginsberg, D. A. & Skinner, D. G. Indications and technique of the orthotopic neobladder in women. *Urol. Clin. North Am.* **29**, 725–734 (2002).
50. Ali-El-Dein, B., Gomha, M. & Ghoneim, M. A. Critical evaluation of the problem of chronic urinary retention after orthotopic bladder substitution in women. *J. Urol.* **168**, 587–592 (2002).
51. Hautmann, R. E. Urinary diversion: ileal conduit to neobladder. *J. Urol.* **169**, 834–842 (2003).
52. Stein, J. P., Penson, D. F., Wu, S. D. & Skinner, D. Pathological guidelines for orthotopic urinary diversion in women with bladder cancer: a review of the literature. *J. Urol.* **178**, 756–760 (2007).
53. Lee, K. S., Montie, J. E., Dunn, R. L. & Lee, C. T. Hautmann and Studer orthotopic neobladders: a contemporary experience. *J. Urol.* **169**, 2188–2191 (2003).
54. Nagele, U. *et al*. Radical cystectomy and orthotopic bladder replacement in females. *Eur. Urol.* **50**, 249–257 (2006).
55. Borirakchanyavat, S., Aboseif, S. R., Carroll, P. R., Tanagho, E. A. & Lue, T. F. Continence mechanism of the isolated female urethra: an anatomical study of the intrapelvic somatic nerves. *J. Urol.* **158**, 822–826 (1997).
56. Hugonnet, C. L., Danuser, H., Springer, J. P. & Studer, U. E. Decreased sensitivity in the membranous urethra after orthotopic ileal bladder substitute. *J. Urol.* **161**, 418–421 (1999).
57. Kessler, T. M., Studer, U. E. & Burkhard, F. C. Increased proximal urethral sensory threshold after radical pelvic surgery in women. *Neurourol. Urodyn.* **26**, 208–212 (2007).
58. Hautmann, R. E., Paiss, T. & de Petriconi, R. The ileal neobladder in women: 9 years of experience with 18 patients. *J. Urol.* **155**, 76–81 (1996).
59. Stenzl, A. *et al*. Rationale and technique of nerve sparing radical cystectomy before an orthotopic neobladder procedure in women. *J. Urol.* **154**, 2044–2049 (1995).
60. Studer, U. E. *et al.* Twenty years experience with an ileal orthotopic low pressure bladder substitute—lessons to be learned. *J. Urol.* **176**, 161–166 (2006).
61. Hautmann, R. E., de Petriconi, R., Kleinschmidt, K., Gottfried, H. W. & Gschwend J. E. Orthotopic ileal neobladder in females: impact of the urethral resection line on functional results. *Int. Urogynecol. J. Pelvic Floor Dysfunct.* **11**, 224–229 (2000).
62. Bhatta Dhar, N., Kessler, T. M., Mills, R. D., Burkhard, F. & Studer, U. E. Nerve-sparing radical cystectomy and orthotopic bladder replacement in female patients. *Eur. Urol.* **52**, 1006–1014 (2007).
63. Stein, J. P., Penson, D. F., Wu, S. D. & Skinner, D. Pathological guidelines for orthotopic urinary diversion in women with bladder cancer: a review of the literature. *J. Urol.* **178**, 756–760 (2007).
64. Simon, J. *et al*. neobladder emptying failure in males: incidence, etiology and therapeutic options. *J. Urol.* **176**, 1468–1472 (2006).
65. Burkhard, F. C. & Studer, U. E. Orthotopic bladder substitution. *Curr. Opin. Urol.* **10**, 343–349 (2000).
66. Abol-Enein, H. & Ghoneim, M. A. Functional results of orthotopic ileal neobladder with serous-lined extramural ureteral reimplantation: experience with 450 patients. *J. Urol.* **165**, 1427–1432 (2001).
67. Parekh, D. J., Gilbert, W. B. & Smith, J. A. Jr. Functional lower urinary tract voiding outcomes after cystectomy and orthotopic neobladder. *J. Urol.* **163**, 56–58 (2000).
68. Porru, D. *et al.* Urodynamic analysis of voiding dysfunction in orthotopic ileal neobladder. *World J. Urol.* **17**, 285–289 (1999).
69. Nesrallah, L. J., Srougi, M. & Dall'Oglio, M. F. Orthotopic ileal neobladder: the influence of reservoir volume and configuration on urinary continence and emptying properties. *BJU Int.* **93**, 375–378 (2004).
70. Shaaban, A. A., Mosbah, A., El-Bahnassawy, M. S., Madbouly, K. & Ghoneim, M. A. The urethral Kock pouch: long-term functional and oncological results in men. *BJU Int.* **92**, 429–435 (2003).
71. Stein, J. P., Dunn, M. D., Quek, M. L., Miranda, G. & Skinner, D. G. The orthotopic T pouch ileal neobladder: experience with 209 patients. *J. Urol.* **172**, 584–587 (2004).
72. Carrion, R. *et al.* A multi-institutional study of orthotopic neobladders: functional results in men and women. *BJU Int.* **93**, 803–806 (2004).
73. Kulkarni, J. N., Pramesh, C. S., Rathi, S. & Pantvaidya, G. H. Long-term results of orthotopic neobladder reconstruction after radical cystectomy. *BJU Int.* **91**. 485–488 (2003).
74. Studer, U. E. & Zingg, E. J. Ileal orthotopic bladder substitutes. What we have learned from 12 years' experience with 200 patients. *Urol. Clin. North Am.* **24**, 781–793 (1997).
75. Brendler, C. B., Steinberg, G. D., Marshall, F. F., Mostwin, J. L. & Walsh, P. C. Local recurrence and survival following nerve-sparing radical cystoprostatectomy. *J. Urol.* **144**, 1137–1140 (1990).
76. Cole, C. J. *et al*. Local control of muscle-invasive bladder cancer: preoperative radiotherapy and cystectomy versus cystectomy alone. *Int. J. Radiat. Oncol. Biol. Phys.* **32**, 331–340 (1995).
77. Greven, K. M., Spera, J. A., Solin, L. J., Morgan, T. & Hanks, G. E. Local recurrence after cystectomy alone for bladder carcinoma. *Cancer* **69**, 2767–2770 (1992).
78. Herr, H. W. Preoperative irradiation with and without chemotherapy as adjunct to radical cystectomy. *Urology* **25**, 127–134 (1985).
79. Montie, J. E., Straffon, R. A. & Stewart, B. H. Radical cystectomy without radiation therapy for carcinoma of the bladder. *J. Urol.* **131**, 477–482 (1984).
80. Skinner, D. G. & Lieskovsky G. Contemporary cystectomy with pelvic node dissection compared to preoperative radiation therapy plus cystectomy in management of invasive bladder cancer. *J. Urol.* **131**, 1069–1072 (1984).
81. Skinner, D. G., Tift, J. P. & Kaufmann, J. J. High dose, short course preoperative radiation therapy and immediate single stage radical cystectomy with pelvic node dissection in the management of bladder cancer. *J. Urol.* **127**, 671–674 (1982).
82. Westney, O. L. *et al*. Presentation, methods of diagnosis and therapy for pelvic recurrence following radical cystectomy for transitional cell carcinoma of the bladder. *J. Urol.* **159**, 792–795 (1998).
83. Hautmann, R. E. & Simon, J. Ileal neobladder and local recurrence of bladder cancer: patterns of failure and impact on function in men. *J. Urol.* **162**, 1963–1966 (1999).
84. Thurairaja, R., Burkhard, F. C. & Studer, U. E. The orthotopic neobladder. *BJU Int.* **102**, 1307–1313 (2008).
85. Varol, C. & Studer, U. E. Managing patients after an ileal orthotopic bladder substitution. *BJU Int.* **93**, 266–270 (2004).
86. Elting, L. S. *et al.* Correlation between annual volume of cystectomy, professional staffing, and outcomes: a statewide, population-based study. *Cancer* **104**, 975–984 (2005).
87. Birkmeyer, J. D. *et al.* Hospital volume and surgical mortality in the United States. *N. Engl. J. Med.* **346**, 1128–1137 (2002).
88. Birkmeyer, J. D. *et al*. Surgeon volume and operative mortality in the United States. *N. Engl. J. Med.* **349**, 2117–2127 (2003).
89. Birkmeyer, J. D., Sun, Y., Wong, S. L. & Stukel, T. A. Hospital volume and late survival after cancer surgery. *Ann. Surg.* **245**, 777–783 (2007).
90. Hollenbeck, B. K., Wei, Y. & Birkmeyer, J. D. Volume, process of care, and operative mortality for cystectomy for bladder cancer. *Urology* **69**, 871–875 (2007).
91. Granberg, C. F. *et al.* Functional and oncological outcomes after orthotopic neobladder reconstruction in women. *BJU Int.* **102**, 1551–1555 (2008).
92. Nesrallah, L. J., Almeida, F. G., Dall'Oglio, M. F., Nesrallah, A. J. & Srougi, M. Experience with the orthotopic ileal neobladder in women: a mid-term follow-up. *BJU Int.* **95**, 1045–1047 (2005).
93. Ali-el-Dein, B. *et al*. Surgical complications following radical cystectomy and orthotopic neobladders in women. *J. Urol.* **180**, 206–210 (2008).
94. Stenzl, A. *et al*. Urethra-sparing cystectomy and orthotopic urinary diversion in women with malignant pelvic tumors. *Cancer* **92**, 1864–1871 (2001).

Author contributions

R. E. Hautmann, S. H. Hautmann and O. Hautmann contributed equally to the researching of data, discussion of content and reviewing of this manuscript before submission. R. E. Hautmann wrote the article.