International Journal of Colorectal Disease (2019) 34:2011–2021
https://doi.org/10.1007/s00384-019-03404-0

REVIEW

Optimal timing of urinary catheter removal following pelvic colorectal surgery: a systematic review and meta-analysis

Yung Lee[1,2] · Tyler McKechnie[1,2] · Jeremy E. Springer[2] · Aristithes G. Doumouras[2,3] · Dennis Hong[2,3] · Cagla Eskicioglu[2,3,4]

Accepted: 11 September 2019 / Published online: 9 November 2019

Abstract

Purpose Acute urinary retention (AUR) is a common postoperative complication in colorectal surgery. In pelvic colorectal operations, the optimal duration for postoperative urinary catheter use is controversial. This systematic review and meta-analysis aims to compare early (POD 1), intermediate (POD 3), and late (POD 5) urinary catheter removal.

Methods Medline, EMBASE, CENTRAL, and PubMed databases were searched. Articles were eligible for inclusion if they compared patients with urinary catheter removal on POD 1 or earlier to patients with urinary catheter removal on POD 2 or later in major pelvic colorectal surgeries. The primary outcome was rate of postoperative AUR. The secondary outcome was rates of postoperative urinary tract infection (UTI).

Results From 691 relevant citations, five studies with 928 patients were included. Comparison of urinary catheter removal on POD 1 versus POD 3 demonstrated no significant difference in rate of urinary retention (RR 1.36, 95%CI 0.83–2.21, $P = 0.22$); however, compared to POD 5, rates of AUR were significantly higher (RR 2.58, 95%CI 1.51–4.40, $P = 0.0005$). Rates of UTI were not significantly different between POD 1 and POD 3 urinary catheter removal (RR 0.40, 95%CI 0.05–3.71, $P = 0.45$), but removal on POD 5 significantly increased risk of UTI compared to POD 1 (RR 0.50, 95%CI 0.31–0.81, $P = 0.005$).

Conclusion Risk of AUR can be minimized with late postoperative urinary catheter removal compared to early removal, but at the cost of increased risk of UTI. Patient-specific factors should be taken into consideration when deciding upon optimal duration of postoperative urinary catheterization.

Keywords Colorectal surgery · Pelvic surgery · Urinary catheter · Acute urinary retention · Urinary tract infections

Introduction

Acute urinary retention (AUR) is a common postoperative complication in colorectal surgery as it can occur in 4% to 22% of patients [1]. The underlying cause of AUR is multifactorial. Factors common to all colorectal procedures such as perioperative medications and stress-induced sympathetic stimulation have been cited as contributory factors [2]. In pelvic colorectal surgery, specifically, dissection of structures adjacent to pelvic parasympathetic nerves may lead to neuropraxia and temporary urinary dysfunction [3]. In addition, manipulation of the bladder intraoperatively can lead to edematous changes in the surrounding tissue, which may induce urinary dysfunction [3].

To mitigate the symptoms of AUR, urinary catheters are routinely placed perioperatively. Current American Society of Colon and Rectal Surgeons (ASCRS) guidelines recommend the routine use of urinary catheter into the postoperative period and reflect the heightened risk of AUR following pelvic colorectal surgery [4]. Guidelines recommend removal of the urinary catheter

Yung Lee and Tyler McKechnie are joint first authors, contributed equally

✉ Cagla Eskicioglu
eskicio@mcmaster.ca

1 Michael G. DeGroote School of Medicine, McMaster University, Hamilton, Ontario, Canada

2 Division of General Surgery, Department of Surgery, McMaster University, Hamilton, Ontario, Canada

3 Division of General Surgery, Department of Surgery, St. Joseph Healthcare, Hamilton, Ontario, Canada

4 Division of General Surgery Department of Surgery, St. Joseph's Healthcare, McMaster University, 50 Charlton Avenue East, Hamilton, Ontario L8N 4A6, Canada

24 h postoperatively in colonic or upper rectal resections and removal 48 h postoperatively in mid-to-lower rectal resections [4]. Despite these recommendations, the optimal duration for postoperative urinary catheter use remains controversial.

In pelvic colorectal operations in particular, removal of urinary catheter at postoperative day (POD) 1 has been compared to removal at POD 3 or to removal at POD 5 with conflicting results. Some studies have demonstrated increased rates of AUR with early urinary catheter removal on POD 1, while others have failed to demonstrate a significant difference [5–9]. Conversely, standard urinary catheter removal on POD 2 or later may increase the risk of symptomatic urinary tract infection (UTI) [5, 9]. However, there is a paucity of data comparing POD 1 and POD 2 urinary catheter removal [4]. As such, this systematic review and meta-analysis compares early urinary catheter removal on POD 1 with urinary catheter removal on POD 3 and POD 5 with the aim to evaluate the safety and efficacy of early urinary catheter removal.

Methods

Search strategy

The following databases covering the period from database inception through February 2019 were searched: Medline, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), and PubMed (Table 5). The search was designed and conducted by a medical research librarian with input from study investigators. Search terms included "colorectal surgery", "rectal cancer", "urinary catheter", and more (complete search strategy available in Appendix 1). The references of published studies and gray literature were searched manually to ensure that all relevant articles were included. Full texts were not discriminated by language. This systematic review and meta-analysis is reported in accordance with the Preferred Reporting items for Systematic Reviews and Meta-Analyses (PRISMA) [10].

Outcome assessed

The primary outcome was AUR postoperatively during index admission. Secondary outcomes included (1) symptomatic UTI, (2) asymptomatic UTI, and (3) postoperative complications.

Study selection and data extraction

Early removal was defined by urinary catheter removal less than 24 h after surgery or on POD 1. Intermediate removal was defined by urinary catheter removal on or following POD 3. Late removal was defined by urinary catheter removal on or following POD 5.

Articles were eligible for inclusion if they compared patients with early removal of urinary catheter to intermediate or late removal in major pelvic colorectal surgeries (i.e., low anterior resection, ultralow anterior resection, abdominoperineal resection, total proctocolectomy, ileal pouch anal anastomosis, proctectomy, rectopexy). Exclusion criteria was (1) studies with a population primarily composed of patients that underwent colon resections (e.g., right, transverse, and left hemicolectomy); (2) studies that included patients with preoperative urinary tract dysfunction (e.g., enterovesicular fistula, urinary tract malignancy, renal failure, severe benign prostatic hyperplasia); (3) studies with less than 10 patients; and (4) unpublished abstracts, poster presentations, opinions, case reports, reviews, letters to editors, and editorials. Two reviewers (YL and TM) independently evaluated the systematically searched titles and abstracts using a standardized, pilot-tested form. Discrepancies that occurred at the title and abstract stages were resolved with automatic inclusion. Discrepancies at the full-text stage were resolved by consensus between the two reviewers, and if disagreement persisted, a third reviewer (JS) was consulted. Two reviewers independently conducted data extraction onto a data collection manual designed a priori. Extracted data included study characteristics (e.g., author, year of publication, study design), patient characteristics (e.g., age, gender, type of surgery, indication for surgery, surgical approach), and outcomes.

Risk of bias assessment

Risk of bias for randomized controlled trials (RCT) was assessed using the Cochrane Risk of Bias Tool for RCTs [11]. The Cochrane Risk of Bias Tool analyzes RCTs according to randomization, allocation, blinding, outcome assessment, data collection, and outcome reporting. The included RCTs were scored as high risk, low risk, or unclear with respect to each category. Methodological quality assessment of included cohort studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS) [12]. The MINORS tool utilizes 12 evidence-based items to evaluate the methodological quality of the included studies. Each item is scored from 0 to 2. A score of 0 indicates lack of reporting, 1 indicates inadequate reporting, and 2 indicating adequate reporting. Two reviewers (YL and TM) assessed the studies according to these tools independently. Discrepancies were discussed among reviewers until consensus was reached.

Statistical analysis

All statistical analysis and meta-analysis were performed on STATA version 14 (StataCorp, College, TX) and Cochrane Review Manager 5.3 (London, United Kingdom). The threshold for statistical significance was set a priori at a p of <0.05. A pairwise meta-analysis was performed using a DerSimonian and Laird random effects model for all meta-analyzed outcomes. Pooled effect estimates were obtained by calculating the mean difference (MD) in outcomes for continuous variables and risk ratios (RR) for dichotomous variables along with their respective 95% confidence intervals (CI) to confirm the effect size estimation. In addition, mean and standard deviation (SD) was estimated for studies and studies that only reported median and interquartile range using the estimation method described by Wan et al. [13]. For studies that did not report standard deviation or interquartile range, we contacted the authors for missing data. Funnel plot for assessing publication bias was not used as this review contained less than 10 studies [14]. A leave-one-out sensitivity analysis was performed by iteratively removing one study at a time to ensure that a single study was not driving the significance or insignificance of the pooled estimates. Assessment of heterogeneity was completed using the inconsistency (I^2) statistic. We considered I^2 higher than 50% to represent considerable heterogeneity [15]. For outcomes that were reported in less than three studies, a systematic narrative summary was provided.

Results

Study characteristics

Table 1 presents the detailed characteristics of studies included in this review. Among 691 potentially eligible studies, 5 studies with 928 patients were included (Fig. 1). Three studies were RCTs [5, 6, 9], and two studies [7, 8] were retrospective cohort studies. Median age of included patients was 57.4 years with 43.3% patients being female. The most common indications for pelvic colorectal surgery were malignancy (80%), inflammatory bowel disease (14.0%), and rectal prolapse (1.8%). The most commonly performed procedures were low anterior resection (69.1%), ileal pouch anal anastomosis (12.6%), abdominoperineal resection (5.2%), and rectopexy (1.9%).

In total, 233 patients had their urinary catheter removed on POD 1 (early), 326 patients on POD 3 (intermediate), and 205 patients on POD 5 (late). Four studies compared urinary catheter removal on POD 1 to POD 3 [6, 7, 9], and three studies compared POD 1 to POD 5 [5, 6, 8]. There were no studies comparing POD 3 to POD 5. Thus, meta-analysis was done separately for studies comparing early removal versus intermediate removal and early removal versus late removal across all outcomes of interest. A study by Lee et al. compared urinary catheter removal on POD 1–2 to urinary catheter removal on POD 3–4 and POD 5 or more [8]. Therefore, this study was included in the meta-analysis comparing early removal to intermediate removal and early removal to late removal.

Urinary retention

All included studies reported AUR as an outcome. AUR was defined according to two variables: residual urine volume and time to first void. Residual urine volumes used to define AUR among the included studies ranged from 250 to 1200 mL. A prolonged time to first void was defined as 6 h by Lee et al. and 8 h in the remainder of the studies. When comparing early urinary catheter removal to intermediate urinary catheter removal, there was no significant difference in rate of AUR (RR 1.36, 95%CI 0.83–2.21, $P=0.22$) (Fig. 2). However, patients who had late urinary catheter removal had significant lower rates of AUR compared to early removal (RR 2.58, 95%CI 1.51–4.40, $P=0.0005$) (Fig. 2). Heterogeneity was very low across both analyses ($I^2=0\%$).

Symptomatic UTI

The definition of symptomatic UTI was consistent across studies, which was defined by diagnosis based on clinical symptoms and positive urine culture. Compared to early removal, intermediate urinary catheter removal was not significantly different in rate of symptomatic UTIs (RR 0.40, 95%CI 0.05–3.71, $P=0.45$, $I^2=0\%$) (Fig. 3). Conversely, patients with late urinary catheter removal had significantly higher rates of UTI compared to early removal (RR 0.50, 95% CI 0.31–0.81, $P=0.005$, $I^2=0\%$) (Fig. 3).

Table 2 shows the detailed description of postoperative complications reported by each included study. Outcomes such as surgical site infections, asymptomatic UTI, and overall complication rates could not be meta-analyzed due to lack of studies reporting these outcomes. Rate of asymptomatic UTI was reported by one study, which failed to demonstrate a significant difference between early, intermediate, and late urinary catheter removal ($P=0.30$) [6].

Table 1 Study characteristics of included studies

Study	Time points	*N*	Age (years)	% female	Type of surgery	Indication for surgery	Surgical approach	Tumor location	Pre-op radiation	Stoma creation
Benoist, 1999	1 day	64	55 (18)	48.4	CA anastomosis *n* = 14 (22%) CR anastomosis *n* = 27 (42%) IPAA *n* = 12 (19%) IR anastomosis *n* = 1 (1%) APR *n* = 10 (16%)	Carcinoma *n* = 44 (69%) IBD *n* = 8 (13%) FAP *n* = 6 (9%) Others *n* = 6 (9%)	Open (100%)	High (30%) Middle (23%) Low (48%)	57%	56%
	5 days	62	56 (17)	53.2	CA anastomosis *n* = 7 (11%) CR anastomosis *n* = 27 (43%) IPAA *n* = 12 (19%) IR anastomosis *n* = 0 (0%) APR *n* = 16 (27%)	Carcinoma *n* = 39 (63%) IBD *n* = 16 (26%) FAP *n* = 2 (3%) Other *n* = 5 (8%)	Open (100%)		41%	57%
Zmora, 2010	1 day	41	57.4	44	Anterior resection *n* = 10 (24%) LAR *n* = 10 (24%) Proctectomy with anal anastomosis *n* = 11 (27%) APR *n* = 3 (7%) Rectopexy *n* = 6 (15%), Other *n* = 1 (2.5%)	Carcinoma *n* = 30 (73%) Rectal prolapse *n* = 6 (15%) Diverticular disease *n* = 1 (2.5%) IBD *n* = 1 (2.5%) Other *n* = 3 (7%)	Retention: Open (6.8%) Lap (2.5%) Converted (0.8%) No retention: Open (53.4%) Lap (28.0%)	–	–	Retention: 5.1% No retention: 42.4%
	3 days	38	54.6	40	Anterior resection *n* = 8 (21%) LAR *n* = 8 (21%) Proctectomy with anal anastomosis *n* = 14 (36%) APR *n* = 3 (8%), Rectopexy *n* = 4 (11%) Other *n* = 4 (10%)	Carcinoma *n* = 26 (68%) Rectal prolapse *n* = 4 (11%) Diverticular disease *n* = 2 (5%) IBD *n* = 2 (5%) Other *n* = 4 (11%)	Converted (8.5%)	–	–	
	5 days	39	54.2	44	Anterior resection *n* = 8 (21%) LAR *n* = 9 (23%) Proctectomy with anal anastomosis *n* = 14 (36%) APR *n* = 2 (5%), Rectopexy *n* = 2 (5%) Other *n* = 4 (10%)	Carcinoma *n* = 31 (79%) Rectal prolapse *n* = 2 (5%) IBD *n* = 4 (11%) Other *n* = 2 (5%)		–	–	
Lee, 2015	1, 2 days	51	60 (21–94)	34.4	LAR *n* = 202 (57.4%) Ultralow anterior resection *n* = 96 (27.3)	Malignancy (100%)	Open (35.8%) Lap (64.2%)	High (21.3%) Middle (42.6%) Low (36.1%)	31.5%	–
	3, 4 days	198			Intersphincteric resection *n* = 33 (9.4%) APR *n* = 14 (4%)					
	5 or more	104			Hartmann's operation *n* = 7 (2.0%)					
Yoo, 2015	1 day	104	64.5 (36–82)	53.8	LAR *n* = 87 (83.7%) CA anastomosis *n* = 17 (16.3%)	Malignancy (100%)	Open/converted (4.8%) Lap (95.2%)	Mean = 7 cm from anal verge (1–15)	70.2%	–
	2 or more	85	66 (27–87)	54.1	LAR *n* = 65 (76.5%) CA anastomosis *n* = 20 (23.5%)	Malignancy (100%)	Open/converted (4.7%)	Mean = 7 cm from anal verge (1–15)	64.7%	–

Table 1 (continued)

Study	Time points	*N*	Age (years)	% female	Type of surgery	Indication for surgery	Surgical approach	Tumor location	Pre-op radiation	Stoma creation
							Lap (95.3%)			
Patel, 2018	1 day	71	43 (31.5–5-6.5)	44	IPAA *n* = 52 (73.2%) LAR *n* = 12 (16.9%) Rectopexy *n* = 3 (4.2%) Other *n* = 4 (5.6%)	IBD *n* = 55 (77.5%) Cancer *n* = 11 (15.5%) Prolapse *n* = 3 (4.2%) Other *n* = 2 (2.8%)	Open (11.3%) Lap (88.7%)		7%	87.3%
	3 days	71	44 (29–60)	48	IPAA *n* = 41 (57.7%) LAR *n* = 14 (19.7%) Rectopexy *n* = 3 (4.2%) Other *n* = 13 (18.3%)	IBD *n* = 48 (67.6%) Cancer *n* = 19 (26.8%) Prolapse *n* = 2 (2.8%) Other *n* = 2 (2.8%)	Open (12.7%) Lap (87.3%)		7%	85.9%

Sensitivity analysis

A study by Patel et al. was the only study included in this review with a patient population primary composed of IBD [9]. Moreover, this study provided alpha-antagonist (1 mg oral prazosin) 6 h before catheter removal to the patients in the POD 1 group. Sensitivity by removing this study from the meta-analysis did not impact the significance across all outcomes. Furthermore, leave-one-out sensitivity analysis did not influence the statistical significance or insignificance of pooled estimates across all outcomes.

Risk of bias

Three of the included studies were RCTs and were analyzed according to the Cochrane Risk of Bias Tool (Table 3). According to the Cochrane Risk of Bias tool, the included studies were at high risk of bias due to the unblinded nature of the trials. Otherwise, the RCTs were at low risk of bias from sequence generation, allocation concealment, data loss, and selective reporting.

Two of the included studies were observational and were analyzed using the MINORS tool (Table 4). Lee et al. scored 17 points and Yoo et al. scored 16 points, out of 24 points [12]. The scoring distribution was similar between the two studies, with both studies reporting appropriate study end points, adequate statistics, and appropriate control groups and follow-up periods. However, there was an absence of prospective study size calculation, unblinded study end point assessment, and lack of contemporary groups.

Discussion

This systematic review and meta-analysis demonstrates that early urinary catheter removal may be safe following major pelvic colorectal operations. Specifically, there was no significant difference in rates of AUR between early (POD 1) and intermediate (POD 3) urinary catheter removal (RR 1.36, 95%CI 0.83–2.21, $P = 0.22$). Yet, a significant increase in rates of AUR was found with early urinary catheter removal as compared to late (POD 5) removal (RR 2.58, 95%CI 1.51–4.40, $P = 0.0005$). Conversely, rates of symptomatic UTIs were significantly increased with late urinary catheter removal compared to early removal (RR 0.50, 95%CI 0.31–0.81, $P = 0.005$), while there was no difference between early and intermediate removal (RR 0.40, 95%CI 0.05–3.71, $P = 0.45$).

Not surprisingly, rates of AUR and UTI demonstrate an inverse relationship. AUR is mitigated with the use

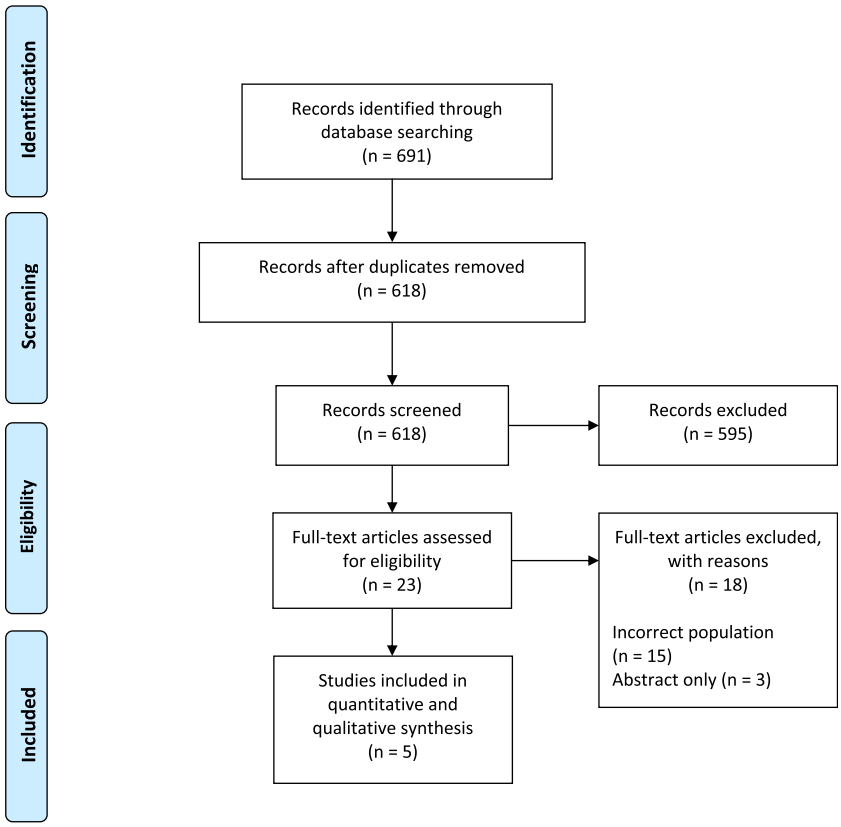

Fig. 1 PRISMA Diagram—transparent reporting of systematic reviews and meta-analysis flow diagram outlining the search strategy results from initial search to included studies

of urinary catheter; a foreign body acting as a nidus for infection [16]. In the present study, absolute rates of AUR decreased by 6.5% in the late removal group compared to the early removal group. Conversely, absolute rates of UTI increased by 9.7% in the late removal group compared to the early removal group. Therefore, the increased absolute risk of UTI is 1.5 times that of the decreased absolute risk of AUR with late urinary catheter removal. Furthermore, UTIs are associated with increased length of stay in hospital and increased mortality [17]. The estimated annual economic burden of UTIs in the USA is 450 million USD [16]. While AUR also increases length of stay, its impact on mortality and healthcare costs is much less substantial [18]. Given the changes in absolute risk and the relative morbidity and cost of AUR and UTI, it is likely reasonable that at least one attempt to discontinue the catheter should be made prior to POD 5.

The 2017 ASCRS guidelines on Enhanced Recovery After Surgery (ERAS) recommend, based on moderate quality evidence (grade 1B), that urinary catheter be removed on POD 2 following major pelvic colorectal surgery [4]. Due to the lack of studies comparing urinary catheter removal on POD 2 to earlier removal, this review cannot directly conclude whether removal before, on, or following POD 2 is most effective at reducing rates of AUR and UTIs. However, as this review did not demonstrate any significant difference in AUR with early urinary catheter removal compared to intermediate removal, it may be reasonable to predict that rates of AUR would be similar between urinary catheter removal on POD 1 and POD 2. Furthermore, it is unlikely that rates of symptomatic UTI would be significantly different between POD 1 and POD 2 given the similar rates between POD 1 and POD 3.

Irrespective of guideline recommendations, there are a number of patient factors to consideration when determining optimal timing of urinary catheter removal. These factors include older age, male gender, history of benign prostatic hyperplasia, and the use of epidural anesthesia [19–21]. Epidural anesthesia, in particular, is a risk factor that has been studied extensively [19]. Conflicting evidence currently exists as to whether urinary catheter can be safely removed while an epidural catheter remains in situ [22, 23]. Studies including the use of epidural catheterization were excluded from the present review, as they failed to compare urinary catheter postoperative removal dates, but rather compared urinary catheter removal prior to epidural discontinuation and following epidural discontinuation [22, 23].

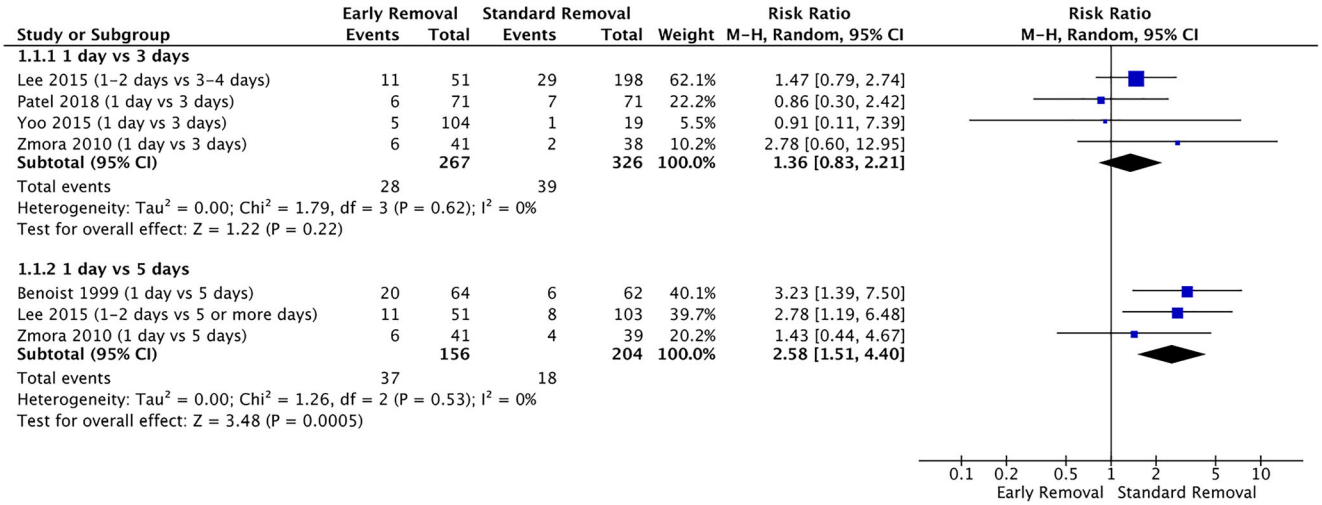

Fig. 2 Random effects meta-analysis forest plot comparing rate of acute urinary retention at different postoperative days of removing urinary catheter after pelvic colorectal surgery

Thus, the findings of this review are not applicable to patients with an epidural anesthesia for colorectal surgery.

In addition to patient factors, there are surgical factors to consider. The risk of AUR in pelvic colorectal surgery is linked to intraoperative factors unique to pelvic dissection. Pelvic splanchnic nerves and the hypogastric plexus are at risk of iatrogenic injury with pelvic dissection [7]. The risk of iatrogenic nerve injury increases as the extent of pelvic dissection increases [24]. Thus, operations such as abdominoperineal resection and total proctocolectomy are associated with increased rates of AUR compared to other colorectal operations [25–28]. Moreover, operations performed for malignancy increase the extent of mesorectal dissection and thus increase the risk of postoperative AUR [9]. However, non-pelvic surgeries such as orthopedic, thoracic, and general surgery operations are also associated with increased risk of postoperative AUR [29–31]. The risk of AUR following orthopedic surgery ranges from 2.3 to 8.8%, and urinary catheter removal generally occurs on POD 1 [26]. Postoperative AUR rates following inguinal herniorrhaphy range from 8.9 to 22% and many of these operations are performed on an outpatient basis without urinary catheterization [30, 31]. Furthermore, colectomies are routinely performed with POD 0 or POD 1 removal of urinary catheter, with relatively low rates of AUR [32, 33]. While this demonstrates that early urinary catheter removal is safe in the other surgical populations, it also highlights surgical factors beyond pelvic nerve injury that increase the risk of AUR that need to be considered when deciding the most appropriate POD for urinary catheter removal. In particular, factors that may increase the risk of postoperative AUR include operative time, administration of large volume of intraoperative fluid, and laparoscopy

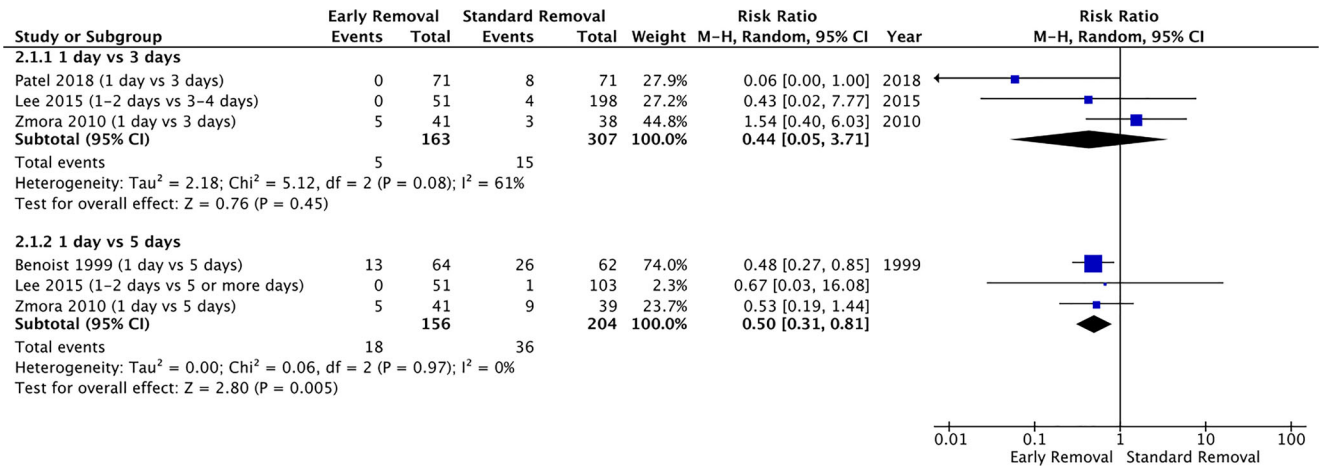

Fig. 3 Random effects meta-analysis forest plot comparing rate of symptomatic urinary tract infection at different postoperative days of removing urinary catheter after pelvic colorectal surgery

Table 2 Outcomes of early versus standard removal of urinary catheters

Study	Time points	*N*	*N* (%) urinary retention	*N* (%) symptomatic UTI	*N* (%) asymptomatic UTI	*N* (%) SSI	*N* (%) overall complications	Description of complications
Benoist, 1999	1 day	64	20 (31%)	13 (20%)	–	7 (11%)	17 (26%)	Wound infection *n* = 7 (11%) Pelvic abscess *n* = 1 (1%) Perineal sepsis *n* = 9 (9%) Pulmonary or cardiac complications *n* = 4 (6%) Long term urinary complications *n* = 10 (16%)
	5 days	62	6 (10%)	26 (42%)	–	8 (13%)	21 (34%)	Wound infection *n* = 8 (13%) Pelvic abscess *n* = 1 (2%) Perineal sepsis *n* = 8 (13%) Pulmonary or cardiac complications *n* = 5 (8%) Long term urinary complications *n* = 9 (15%)
Zmora, 2010	1 day	41	6 (14.6%)	5 (12%)	5 (12%)	11 (27%)	14 (34%)	Anastomotic leak *n* = 3 (7%) Pulmonary complications *n* = 2 (5%)
	3 days	38	2 (5.3%)	3 (8%)	7 (18%)	10 (26%)	16 (42%)	Anastomotic leak *n* = 2 (5%) Pulmonary complications *n* = 3 (8%)
	5 days	39	4 (10.5%)	9 (23%)	10 (26%)	15 (38%)	21 (53%)	Anastomotic leak *n* = 6 (15%) Pulmonary complications *n* = 3 (8%)
Lee, 2015	1, 2 days	51	11 (21.6%)	0 (0%)	–	–	–	–
	3, 4 days	198	29 (14.6%)	4 (2.0%)	–	–	–	–
	5 or more	104	8 (7.8%)	1 (0.97%)	–	–	–	–
Yoo, 2015	1 day	104	5 (4.8%)	–	–	–	–	–
	3 days	19	1 (5.3%)	–	–	–	–	–
Patel, 2018	1 day	71	6 (8.5%)	0 (0%)	–	–	–	–
	3 days	71	7 (9.9%)	8 (11.3%)	–	–	–	–

Table 3 Cochrane Risk of Bias Tool for included randomized controlled trials

Author, year	Selection bias		Performance bias	Detection bias	Attrition bias	Reporting bias	Other bias
	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	
Benoist, 1999	+	−	−	−	+	+	+
Zmora, 2010	+	+	−	−	+	+	−
Patel, 2018	+	?	−	−	+	+	+

"+" low risk, "−" high risk, "?" unclear

[3, 19]. Therefore, the findings of this review should be applied within the context of known surgical risk factors for AUR.

This review has several limitations. First, there was heterogeneity in the timing of urinary catheter removal across studies. Nonetheless, separate analyses of POD 1 versus POD 3 and POD 1 versus POD 5 allowed for pooling of similar study designs. Second, the majority of the studies did not distinguish between cancer and non-cancer patients. Yet, more than 80% of the operations in the included studies were performed for malignancy, thus likely ensuring fairly uniform extents of mesorectal dissection. Additionally, complications associated with IBD and diverticular disease, such as enterovesicular fistula, were controlled for in the included studies through exclusion of patients with known urinary tract abnormalities. Third, definitions of AUR across studies were variable. While the residual urine volume used to define AUR was heterogenous, ranging from 250 to 1200 mL, the time to void following catheter removal used to define AUR was homogenous [6, 7, 9, 21]. Lastly, one of the included studies included the use of an oral alpha-blocker in their early catheter removal group [9]. However, sensitivity analysis removing this study from overall pooled effect estimates did not influence the overall significance of the findings.

In summary, the findings of this review demonstrate that early postoperative urinary catheter removal following pelvic colorectal operations may be as safe as intermediate removal but carries increased risk of AUR when compared to late removal. Additionally, early urinary catheter removal is proportionate in risk for symptomatic UTI with intermediate urinary catheter removal, while it decreases the risk of symptomatic UTI compared to late removal. As such, due to the higher morbidity and cost associated with UTI, it is likely reasonable, given the individual patient and surgical risk factors, that at least one attempt to remove the urinary catheter prior to POD 5 should be made. Interestingly, ASCRS recommends urinary catheter removal on POD 2 following major pelvic colorectal operations. Thus, the existing literature does not uniformly address the safety of early urinary catheter removal compared to ASCRS' recommendations. As such, large studies comparing POD 1 and POD 2 should be conducted to further evaluate the safety and efficacy of early urinary catheter removal following major pelvic colorectal surgery. In the interim, there is currently a paucity of data to support that routine removal of urinary catheter on POD 1. Although the lack of significant difference between early and intermediate groups in the present study suggests that there is no reason to believe that removal of urinary catheter on POD 1 would be more harmful than removal on POD 2. Nonetheless, urinary catheter removal following major pelvic colorectal surgery should be performed in compliance with ASCRS guidelines, while also taking into consideration important patient and surgical factors.

Table 4 Methodological Index for Non-Randomized Studies (MINORS)

Study	MINORS criteria												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Lee, 2015	1	2	2	2	1	2	2	0	2	0	1	2	17
Yoo, 2015	2	2	0	2	0	2	2	0	2	0	2	2	16

Assessment criteria: 1 = clearly stated aim, 2 = inclusion of consecutive patients, 3 = prospective collection of data, 4 = end points appropriate to the aims of the study, 5 = unbiased assessment of the study end point, 6 = follow-up period appropriate to the aim of the study, 7 = loss to follow-up less than 5%, 8 = prospective calculation of the study size, 9 = adequate control group, 10 = contemporary groups, 11 = baseline equivalence of groups, 12 = adequate statistics. MINORs tool score: 0 = not reported, 1 = reported but not adequate, 2 = reported and adequate

Author's contributions Study concept and design–E, H, M, L.
Acquisition of data–M, L.
Analysis and interpretation of data–all authors.
Drafting of manuscript–D, S, M, L.

Critical revision of the manuscript for intellectual content–all authors. Final approval of version to be published–all authors.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interests.

Appendix

Table 5 Complete search strategy (Medline database example)

OVID Medline Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Feb 2019
1. exp. catheterization/
2. catheters.mp.
3. catheter.mp.
4. tube.mp.
5. tubes.mp.
6. exp. bladder/
7. urinary.mp.
8. foley.mp.
9. urinary-bladder.mp.
10. urine.mp.
11. transurethral.mp.
12. indwelling.mp.
13. urethral.mp.
14. exp. Surgery/
15. surgeries.mp.
16. operation.mp.
17. operations.mp.
18. procedure.mp.
19. procedures.mp.
20. resections.mp.
21. resection.mp
22. excision.mp.
23. excisions.mp.
24. anastomosis.mp.
25. anastomoses.mp.
26. Rectal.mp.
27. Colorectal.mp.
28. Pelvic.mp.
29. Coloanal.mp.
30. Anal.mp.
31. or/1–5
32. or/6–13
33. or/14–25
34. or/26–30
35. 31 AND 32 AND 33 AND 34

References

1. Kin C, Rhoads KF, Jalali M, Shelton AA, Welton ML (2013) Predictors of postoperative urinary retention after colorectal surgery. Dis Colon Rectum 56(6):738–746
2. Slors FJ, van Zuijlen PP, van Dijk GJ (2000) Sexual and bladder dysfunction after total mesorectal excision for benign diseases. Scand J Gastroenterol Suppl (232):48–51
3. Kang S-B, Park JW, Jeong S-Y, Nam BH, Choi HS, Kim D-W, Lim SB, Lee TG, Kim DY, Kim JS, Chang HJ, Lee HS, Kim SY, Jung KH, Hong YS, Kim JH, Sohn DK, Kim DH, Oh JH (2010) Open versus laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): short-term outcomes of an open-label randomised controlled trial. Lancet Oncol 11(7): 637–645
4. Carmichael JC, Keller DS, Baldini G, Bordeianou L, Weiss E, Lee L, Boutros M, McClane J, Feldman LS, Steele SR (2017) Clinical practice guidelines for enhanced recovery after Colon and Rectal surgery from the American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons. Dis Colon Rectum 60:761–784
5. Benoist S, Panis Y, Denet C, Mauvais F, Mariani P, Valleur P (1999) Optimal duration of urinary drainage after rectal resection: a randomized controlled trial. Surgery. 125(2):135–141
6. Zmora O, Madbouly K, Tulchinsky H, Hussein A, Khaikin M (2010) Urinary bladder catheter drainage following pelvic surgery - is it necessary for that long? Dis Colon Rectum 53(3):321–326
7. Yoo BE, Kye BH, Kim HJ, Kim G, Kim JG, Cho HM (2015) Early removal of the urinary catheter after total or tumor-specific mesorectal excision for rectal cancer is safe. Dis Colon Rectum 58(7):686–691
8. Lee SY, Kang SB, Kim DW, Oh HK, Ihn MH (2015) Risk factors and preventive measures for acute urinary retention after rectal cancer surgery. World J Surg 39(1):275–282
9. Patel DN, Felder SI, Luu M, Daskivich TJ, Zaghiyan NK, Fleshner P (2018) Early urinary catheter removal following pelvic colorectal surgery. Dis Colon Rectum 61(10):1180–1186
10. Moher D, Liberati ATJ, AD. The PRISMA Group (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 151(4):264–269
11. Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD et al (2011) The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. Br Med J 343:d5928
12. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J (2003) Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 73(9):712–716
13. Wan X, Wang W, Liu J, Tong T (2014) Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 14(1):135
14. Lau J (2006) The case of the misleading funnel plot. BMJ. 333(7568):597–600
15. Higgins JPT, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ Br Med J 327(7414):557–560
16. Klevens RM, Edwards JR, Richards CL, Horan TC, Gaynes RP, Pollock DA et al (2007) Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep 122: 160–166
17. Adams TD, Davidson LE, Litwin SE, Kim J, Kolotkin RL, Nanjee MN, Gutierrez JM, Frogley SJ, Ibele AR, Brinton EA, Hopkins PN, McKinlay R, Simper SC, Hunt SC (2017) Weight and metabolic outcomes 12 years after gastric bypass. N Engl J Med 377(12): 1143–1155

18. Kang CY, Chaudhry OO, Halabi WJ, Nguyen V, Carmichael JC, Mills S et al Risk factors for postoperative urinary tract infection and urinary retention in patients undergoing surgery for colorectal Cancer
19. Agrawal K, Majhi S, Garg R (2019) Post-operative urinary retention: review of literature. World J Anesthesiol 8(1):1–12
20. Zelmanovich A, Fromer DL (2018) Urinary retention after orthopedic surgery: identification of risk factors and management. J Clin Exp Orthop 04(01)
21. Lee KS, Lim KH, Kim SJ, Choi HJ, Noh DH, Lee HW, Cho MC (2011) Predictors of successful trial without catheter for postoperative urinary retention following non-urological surgery. Int Neurourol J 15(3):158–165
22. Coyle D, Joyce KM, Garvin JT, Regan M, McAnena OJ, Neary PM et al (2015) Early post-operative removal of urethral catheter in patients undergoing colorectal surgery with epidural analgesia - a prospective pilot clinical study. Int J Surg 16(Part A):94–98
23. Stubbs BM, Badcock KJM, Hyams C, Rizal FE, Warren S, Francis D (2013) A prospective study of early removal of the urethral catheter after colorectal surgery in patients having epidural analgesia as part of the enhanced recovery after surgery programme. Color Dis 15(6):733–736
24. Heald RJ, Moran BJ, Brown G, Daniels IR (2004) Optimal total mesorectal excision for rectal cancer is by dissection in front of Denonvilliers' fascia. Br J Surg 91(1):121–123
25. Meddings J, Skolarus TA, Fowler KE, Bernstein SJ, Dimick JB, Mann JD, Saint S (2019) Michigan appropriate perioperative (MAP) criteria for urinary catheter use in common general and orthopaedic surgeries: results obtained using the RAND/UCLA appropriateness method. BMJ Qual Saf 28(1):56–66
26. Zhao Y, Hou X, Zhao Y, Feng Y, Zhang B, Zhao K (2017) Risk factors of postoperative urinary retention after rectal cancer surgery. Zhonghua Wei Chang Wai Ke Za Zhi 20(3):295–299
27. Chaudhri S, Maruthachalam K, Kaiser A, Robson W, Pickard RS, Horgan AF (2006) Successful voiding after trial without catheter is not synonymous with recovery of bladder function after colorectal surgery. Dis Colon Rectum 49(7):1066–1070
28. Tekkis PP, Cornish JA, Remzi FH, Tilney HS, Strong SA, Church JM, Lavery IC, Fazio VW (2009) Measuring sexual and urinary outcomes in women after rectal cancer excision. Dis Colon Rectum 52(1):46–54
29. Kim KW, Lee J-I, Kim JS, Lee Y-J, Choi W-J, Jung H, Park KY, Park CH, Son KH (2015) Risk factors for urinary retention following minor thoracic surgery. Interact Cardiovasc Thorac Surg 20(4): 486–492
30. Patel JA, Kaufman AS, Howard RS, Rodriguez CJ, Jessie EM (2015) Risk factors for urinary retention after laparoscopic inguinal hernia repairs. Surg Endosc 29(11):3140–3145
31. Blair AB, Dwarakanath A, Mehta A, Liang H, Hui X, Wyman C, Ouanes JPP, Nguyen HT (2017) Postoperative urinary retention after inguinal hernia repair: a single institution experience. Hernia. 21(6):895–900
32. Alyami M, Lundberg P, Passot G, Glehen O, Cotte E (2016) Laparoscopic colonic resection without urinary drainage: is it "feasible"? J Gastrointest Surg 20(7):1388–1392
33. Varadhan KK, Neal KR, Dejong CHC, Fearon KCH, Ljungqvist O, Lobo DN (2010) The enhanced recovery after surgery (ERAS) pathway for patients undergoing major elective open colorectal surgery: a meta-analysis of randomized controlled trials. Clin Nutr 29: 434–440