Original paper

Risk of postoperative urinary retention with early removal of the urinary catheter after surgery with epidural analgesia: A systematic review and meta-analysis

Teppei Miyakawa^{1,2)}, Hidetaka Kawamura^{1,2)}, Ryuya Yamamoto^{1,2)}, Katsuhiko Hashimoto^{1,3)}, Hiroshi Kobayashi^{1,2)}, Cong Yue^{1,4)}, Soshi Hori^{1,2)}, Takaki Hirano⁵⁾, Michitaka Honda^{1,2)}

¹⁾ Department of Minimally Invasive Surgical and Medical Oncology, Fukushima Medical University, Fukushima, Fukushima, Japan

²⁾ Department of Surgery, Southern Tohoku General Hospital, Southern Tohoku Research Institute for Neuroscience, Koriyama, Fukushima, Japan

³⁾ Department of Emergency and General Practice, Southern Tohoku General Hospital, Southern Tohoku Research Institute for Neuroscience, Koriyama, Fukushima, Japan

⁴⁾ Department of Thoracic Surgery, Southern Tohoku General Hospital, Southern Tohoku Research Institute for Neuroscience, Koriyama, Fukushima, Japan

⁵⁾ Department of Emergency and Anesthesiology, Ohta Nishinouchi Hospital, Koriyama, Fukushima, Japan

Abstract

Introduction: It is unclear whether the early removal of urinary catheters during epidural analgesia increases postoperative urinary retention. This systematic review and meta-analysis aimed to evaluate the risk of postoperative urinary retention by comparing early removal with late removal of urinary catheters after surgery with epidural analgesia.

Methods: We searched the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, World Health Organization International Clinical Trials Registry Platform, and Clinical Trials.gov for randomized controlled trials involving early versus late removal of urinary catheters after surgery with epidural analgesia. Primary outcomes were postoperative urinary retention and urinary tract infection, and we conducted a meta-analysis using a random-effects model to calculate the pooled estimates of risk differences. The Cochrane risk of bias tool and Grading of Recommendations, Assessment, Development, and Evaluation approach were used to assess the quality of individual studies and the overall body of evidence, respectively.

Results: Four studies involving 584 patients were included. The pooled risk difference of early versus late removal was 0.05 (95% confidence interval, -0.01–0.10; $I^2 = 59\%$) for postoperative urinary retention and -0.03 (95% confidence interval, -0.12–0.05; $I^2 = 89\%$) for urinary tract infection. We did not conduct a meta-analysis regarding length of stay.

Conclusions: Early urinary catheter removal may be associated with a 5% increased risk of postoperative urinary retention. We could not conclude whether this increased risk of postoperative urinary retention is clinically acceptable or not.

Keywords: epidural analgesia, postoperative urinary retention, urinary tract infection

(Received September 1, 2021; Accepted November 24, 2021)

Introduction

Early recovery programs after surgery are attracting attention because they improve recovery and reduce morbidity and length of hospital stay (LOS)¹⁾. In 2005, the enhanced recovery after surgery (ERAS) group provided proposals for early recovery in the perioperative management of elective colorectal surgery²⁾. Subsequently, the concept of ERAS was applied in various fields. Among the elements currently proposed, epidural analgesia is

recommended for postoperative pain control, and early removal of urinary catheters is recommended for the prevention of urinary tract infection (UTI)^{1,3)}.

Epidural analgesia using a low-dose local anesthetic minimizes the surgical stress response and provides sufficient postoperative analgesia. However, postoperative urinary retention (POUR) is a potential side effect^{1,3,4)}. Therefore, some institutions delay the removal of urinary catheters in patients with epidural analgesia. As a result, there may be a trade-off between the two elements of the ERAS program, epidural analgesia and early removal of urinary catheters. Several randomized controlled trials (RCTs) have examined whether it is feasible to remove urinary catheters during epidural analgesia⁵⁻⁸⁾. However, these trials were largely single-center studies with small

Corresponding author: Teppei Miyakawa, Department of Minimally Invasive Surgical and Medical Oncology, Fukushima Medical University, 7-115 Yatsuyamada, Koriyama, Fukushima 963-8563, Japan. Tel.: +81-24-934-5322, E-mail: tpsundaysilence@yahoo.co.jp

sample sizes, and the results remain inconclusive regarding whether early removal of urinary catheters during analgesia is acceptable.

The aim of this systematic review was to examine the hypothesis that urinary catheters can be removed during epidural anesthesia without increasing POUR. If it is proven that early removal of the urinary catheter does not increase the risk of POUR, it will contribute to further development of the ERAS program and may lead to a reduced risk of UTI and reduced LOS, which will be of great benefit in clinical practice.

Methods

This systematic review and meta-analysis was registered in the PROSPERO database (registration number: CRD42020189736) and was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines⁹.

Inclusion criteria for studies in this review

Types of studies

We considered all RCTs, including cluster-randomized trials.

Types of participants

Adults aged ≥ 18 years who underwent surgery under epidural analgesia were included. We did not place restrictions on the type of surgery or the intervertebral level of epidural insertion. Women in labor under epidural analgesia were excluded.

Types of interventions

We defined patients who had urinary catheters removed within 48 h after surgery, regardless of ongoing epidural analgesia, as the early removal group. We defined patients who had catheters removed after epidural analgesia as the late removal group. Selected studies were those comparing the early removal and late removal groups. The dose of epidural anesthesia, presence or absence of opioids, and intervertebral level of epidural insertion followed the protocol of the selected studies and were not restricted.

Outcome measures

Primary outcomes were (i) POUR, (ii) UTI, and (iii) LOS. Secondary outcomes included urinary catheter-related complications, quality of life, and costs. POUR was defined as the inability to void adequately after catheter removal, requiring recatheterization with either intermittent or indwelling catheters. UTIs were defined according to the definitions used in the selected studies.

Search methods for identification of studies

Electronic searches

We searched the following bibliographic databases: MEDLINE (PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), and EMBASE (ProQuest). We conducted searches using controlled vocabulary and free-text terms. The search was adapted for each database search and is shown in Online Resource 1 (MEDLINE), Online Resource 2 (CENTRAL), and Online Resource 3 (EMBASE). There were no restrictions based on language, publication year, or publication status. The most recent date for this search was December 13, 2020.

Search of other resources

We searched ClinicalTrials.gov and the World Health Organization Clinical Trials Registry Platform for relevant ongoing trials.

Data collection and analysis

Selection of studies

Two authors (TM and HK) independently reviewed the titles and abstracts of the references retrieved from the searches and selected all potentially relevant studies. Full-text copies of these studies were obtained and reviewed independently by the same authors against the inclusion criteria of the present study. When disagreement occurred in the trial selection, it was discussed with another author (RY) until a consensus was reached.

Data extraction and management

Data were collected according to the aforementioned outcomes. Two authors (TM and HK) extracted the data independently for each study and compared them, resolving disagreements by discussion. We used Review Manager (RevMan; Computer program, Version 5.4, the Cochrane Collaboration, 2020). Data not suitable for inclusion in the meta-analysis are discussed in the Results section.

Assessment of risk of bias in the included studies

Two authors (TM and HK) independently assessed the methodological quality of the studies based on the quality checklist recommended by the Cochrane Handbook, version 6.1¹⁰. The risk of bias of the included studies was assessed using the following bias risk domains: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), and other potential threats to validity. For each of these risk do-

mains of bias, the studies were categorized as having low, unclear, or high risk of bias. Any discrepancies were resolved by discussion among all authors. The risk of bias was assessed using RevMan 5.4.

Measures of treatment effect

For dichotomous variables, we calculated the risk difference (RD) with a 95% confidence interval (CI). For continuous variables, the mean difference was estimated with a 95% CI. The threshold for significance was a *p*-value of < 0.05.

Unit of analysis issues

Regarding RCTs for this intervention, we would expect only a simple parallel design. All analyses were performed according to the intention-to-treat principle.

Dealing with missing data

To avoid missing unpublished studies, we searched clinical trial databases, as stated above. We compared the reported outcomes to published protocols or the Methods section of each article. If we found inconsistencies, this was reported in the selective outcome reporting section of the risk of bias table. The authors of the primary studies were contacted, and requests were made regarding any unpublished data. We used the available data for the analyses if no response was obtained from the authors.

Assessment of heterogeneity

We used Cochran's *Q* test to assess heterogeneity and the *I*² statistic to estimate the degree of heterogeneity. Statistical heterogeneity among the trials was evaluated using the significance level of the chi-square test set at 0.10. We considered an *I*² between 0% and 40% as probably not important, between 30% and 60% as representing moderate heterogeneity, between 50% and 90% as substantial heterogeneity, and between 75% and 100% as considerable heterogeneity¹⁰.

Assessment of reporting biases

If more than 10 studies were included, we planned to generate a funnel plot to assess the potential for publication bias for our primary outcome.

Data synthesis

We performed a meta-analysis based on the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions using RevMan 5.4. Continuous variables were analyzed using the mean differences with 95% CIs. For dichotomous variables, we used the RDs with 95% CIs. Forest plots were constructed using the Mantel-Haenszel method with random effects to combine the outcomes.

Subgroup analysis and investigation of heterogeneity

To examine clinical heterogeneity, the following prespecified subgroup analyses of the primary outcomes were planned: (i) sex (male vs. female), (ii) age (age: ≥ 65 years vs. age < 65 years), (iii) type of surgery, (iv) intervertebral level of epidural insertion, (v) use/non-use of opioid, and (vi) existence/absence of benign prostatic hypertrophy (BPH).

Sensitivity analysis

Sensitivity analyses were performed to assess the robustness of the results. We estimated outcome measures after excluding the below-mentioned influential factors to check whether the results changed. We conducted the following sensitivity analyses: (i) changing between fixed-effects or random-effects methods and (ii) excluding studies with a small sample size (*n* < 100). If the results remained consistent after the sensitivity analyses, they were considered robust. If the results changed after the sensitivity analyses, they had low stability and may need to be interpreted with caution.

Summary of findings table

The main results of our review are summarized in Table 1, which includes an overall grading of the evidence related to each of the main outcomes using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach¹¹.

Results

Results of the search

Figure 1 shows an overview of the literature search performed for this systematic review and meta-analysis according to the PRISMA statement. Our searches of the CENTRAL, MEDLINE, and EMBASE databases, plus other resources, identified 724 results. After exclusion of duplicates, we screened 569 references, and finally, four RCTs that comprised a total of 584 patients were included in the analysis⁵⁻⁸.

Included studies and risk of bias in the included studies

The study characteristics are summarized in Table 2. Figure 2 shows the results of the assessment of the risk of bias in the included studies according to the Cochrane Handbook¹⁰. Four RCTs were included; all four studies demonstrated adequate random sequence generation and two studies had properly concealed allocations^{7,8}. Owing to the nature of the interventions, it was impossible to completely blind assessors and participants in the RCTs. We detected attrition bias in one study because there was more loss of follow-up in the intervention group⁷. Comparing the described protocols and methods to the reported results, we did not detect evidence of reporting bias in two studies^{7,8}. However, two studies had an

Table 1 Summary of findings. Early removal of urinary catheter versus late removal

Patient or population: patients who underwent surgery under epidural analgesia

Intervention: Early removal of urinary catheter (within 48 hours after surgery regardless of ongoing epidural analgesia)

Comparison: Late removal of urinary catheter (after epidural analgesia)

Outcomes	Study event rates (%)		Anticipated absolute effects ^a		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Late removal	Early removal	Risk with late removal	Risk difference with early removal (95% CI)	RR (95% CI)			
POUR	8/298 (2.7%)	26/286 (9.1%)	27 per 1000	50 more per 1000 (from 10 fewer to 100 more)	See comment	584 (4 RCTs)	⊕⊕⊕⊕ VERY LOW ^{b,c,d} due to risk of bias, inconsistency, and imprecision	No participants developed POUR in one RCT (Chia 2009). RR was not estimable in this RCT
UTI	16/298 (5.4%)	3/286 (1.0%)	54 per 1000	30 fewer per 1000 (from 120 fewer to 50 more)	See comment	584 (4 RCTs)	⊕⊕⊕⊕ VERY LOW ^{b,e,f} due to risk of bias, inconsistency, and imprecision	No participants developed UTI in one RCT (Chia 2009). RR was not estimable in this RCT
LOS	See comment	See comment	See comment	See comment	See comment	215 (one RCT)	⊕⊕⊕⊕ LOW ^{b,g} due to risk of bias	9 days (range: 5–11 days) in late removal group and 7 days (range: 6–14 days) in early removal group, respectively

^a The risk in the intervention group (and its 95% CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

^b Risk of bias: Both participants and outcome assessors were not blinded.

^c Inconsistency: Serious unexplained inconsistency [$I^2 = 59\%$, $\text{Chi}^2 = 7.37$, (df = 3), $P = 0.06$]

^d Imprecision: The 95% confidence interval includes no effect, and upper bound of 100 more per 1000 is questionable clinical importance.

^e Inconsistency: Serious unexplained inconsistency [$I^2 = 89\%$, $\text{Chi}^2 = 27.66$, (df = 3), $P < 0.001$]

^f Imprecision: The 95% confidence interval is wide and includes no effect.

^g Length of hospital stay depends on postoperative protocols. CI: confidence interval; RR: risk ratio; POUR: postoperative urinary retention; UTI: urinary tract infection; LOS: length of stay

GRADE: Grading of Recommendations, Assessment, Development, and Evaluation; RCT: randomized controlled trial

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate and may change the estimate

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate

Very low quality: We are very uncertain about the estimate

Figure 1 Flow chart of the literature search according to the PRISMA statement.
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Table 2 Study characteristics

Author	Publication Year Setting Methods	Intervention	Outcomes and definitions	Number of patients	Sex Male/ Female	Type of surgery (patients)	Epidural analgesia (days and composition)
Chia et al.	2009 Single center Parallel design	Early removal on the first postoperative day	POUR: inability to urinate 6 h after catheter removal, managed by in-out catheterization	38	20/18	Thoracotomy (78)	3 days 0.08% bupivacaine 0.04 mg/mL morphine 7 µg/mL neostigmine
		Late removal after epidural removed	UTI: Catheter-related infection, details unknown	40	19/21		
Zaoter et al.	2009 Single center Parallel design	Early removal on the first postoperative day	POUR: inability to void with urine volume > 600 ml as measured by bladder scanning, managed by in-out catheterization	105	54/51	Thoracic (49) Abdominal (56)	Thoracic: 5days Abdominal: 3days 0.1% bupivacaine 3 µg/mL fentanyl
		Late removal after epidural removed	UTI: positive urine culture with symptoms LOS: days	110	68/42	Thoracic (56) Abdominal (54)	
Coyle et al.	2015 Single center Parallel design	Early removal at 48 hours postoperatively	POUR: inability to pass urine and requiring re-insertion of urethral catheter, with a residual of 400 mL	22	20/2	Colon (10) Rectal (10) Total colectomy (1)	Details unknown
		Late removal within 12 hours after epidural removed	UTI: positive urine culture	22	10/12	Colon (6) Rectal (13) Total colectomy (2)	
Allen et al.	2016 Single center Parallel design	Early removal within 48 hours	POUR: Urinary catheter reinserted: inability to void with estimated volume > 500 mL, managed by in-out catheterization. The urinary catheter was reinserted in an in-out manner; catheterization was needed three consecutive times	121	68/53	Thoracic surgery (247)	At least 2days 0.075% bupivacaine 5 µg/mL fentanyl
		Late removal after epidural removed	UTI: Symptomatic UTI	126	73/53		

POUR: postoperative urinary retention; UTI: urinary tract infection; LOS: length of stay

Figure 2 Risk of bias summary

Review of author judgments about the risk for each bias item in all included trials.

unclear risk of bias for reporting bias because the protocols were not published^{5,6}. We identified other potential sources of bias in one study because there was a considerable baseline imbalance for sex⁷.

Effects of interventions

Pooled estimates were calculated for two primary outcomes: POUR and UTI. The outcome of LOS was only available for one study. There were no studies that measured the secondary outcomes.

POUR

POUR outcomes were available in four studies. Figure 3 presents the results of the pooled analysis for POUR. Although not significant, early removal of urinary catheters tended to increase the risk of POUR, relative to that with late removal (RD: 0.05, 95% CI: -0.01–0.10; $P = 0.10$). The statistical heterogeneity was significant ($I^2 = 59\%$, $\chi^2 = 7.37$, $df = 3$, $P = 0.06$).

UTI

UTI outcomes were available from four studies. Figure 4 presents the results of the pooled analysis of UTI. Although not significant, early removal of urinary catheters tended to reduce the risk of UTI, relative to that with late removal (RD: -0.03, 95% CI: -0.12–0.05; $P = 0.40$). The statistical heterogeneity was significant ($I^2 = 89\%$, $\chi^2 = 27.66$, $df = 3$, $P < 0.001$).

LOS

One study reported LOS as an outcome⁶. The median LOS (range) was 7 (5–11) days in the early removal group and 9 (6–14) days in the late removal group ($P = 0.02$). The LOS was longer in patients who contracted a UTI

(mean [standard deviation], 19 [14 days]) than in those who did not contract a UTI (mean [standard deviation], 10 [7 days]) ($P < 0.0001$).

Subgroup analysis

We performed a subgroup analysis of POUR and UTI because these outcomes showed an $I^2 > 50\%$. We conducted a pre-specified planned subgroup analysis for sex because the underlying mechanisms may differ between men and women. In addition, we consider that it is clinically important to estimate the effects on POUR for men because the male population is known to be at high risk for POUR due to the presence of the prostate gland¹¹. We could not perform the other planned subgroup analyses for age, type of surgery, and intervertebral level of epidural insertion, because the studies did not present separate data for these subgroups. One study⁷ did not describe the composition of epidural anesthesia, and the other three studies^{5,6,8} used opioids. Thus, we could not perform the subgroup analysis for use/non-use opioid. Also, no data were described for BPH in any of the studies, so subgroup analysis for existence/absence of BPH could not be performed.

The subgroup analysis showed the pooled effect of early versus late removal on POUR (Figure 5) and UTI (Figure 6) for men and women separately. Although not significant, with a wide confidence interval, early removal of urinary catheters tended to increase the risk of POUR, relative to that with late removal (RD: 0.05, 95% CI: -0.08–0.19; $P = 0.45$). The test for subgroup differences indicated that there were no statistically significant

Figure 3 Forest plot for POUR
Four studies were included. POUR: postoperative urinary retention

Figure 4 Forest plot for UTI
Four studies were included. UTI: urinary tract infection

Figure 5 Subgroup analysis of sex for POUR
POUR: postoperative urinary retention

Figure 6 Subgroup analysis of sex for UTI
UTI: urinary tract infection

subgroup effects (POUR, $P = 0.60$; UTI, $P = 0.38$). There was also substantial heterogeneity for the male subgroup (POUR: $I^2 = 66\%$, $\chi^2 = 5.93$, $df = 2$, $P = 0.05$, and UTI: $I^2 = 73\%$, $\chi^2 = 11.13$, $df = 3$, $P = 0.01$, respectively).

Sensitivity analysis

Figure 7 shows the sensitivity analysis for POUR. In these sensitivity analyses, the direction and magnitude of the effects were similar to those in the original analysis.

Figure 8 shows the sensitivity analysis for UTI. Although the widths of the CIs differed, the direction and magnitude of the effects were similar to those in the original analysis.

Discussion

This study has three important findings. First, early removal of the urinary catheter may increase the risk of POUR by approximately 5%, relative to the risk with late removal. This trend was consistent with the subgroup analysis of men. Secondly, early urinary catheter removal tended to reduce the risk of UTI. However, there was no significant difference between the early and late removal groups. Thirdly, the LOS may be shortened by early removal.

In this review, we followed a pre-specified protocol

Figure 7 Sensitivity analysis for POUR
(a) Using fixed-effect methods, (b) Excluding studies with a small sample size ($n < 100$), POUR: postoperative urinary retention

Figure 8 Sensitivity analysis for UTI
(a) Using fixed-effects methods, (b) Excluding studies with a small sample size ($n < 100$), UTI: urinary tract infection

and conducted a systematic search of electronic databases and trial registries without any language restrictions. Therefore, we believe that we have missed no important RCTs or ongoing clinical studies. In addition, this study was conducted by a team of experts in gastrointestinal surgery, thoracic surgery, anesthesiology, and an experienced medical librarian. The quality of evidence for each outcome was evaluated according to the GRADE system and crosschecked by several authors. There has been no

systematic review of research questions similar to this review. This review will be helpful to clinicians involved in the perioperative management of patients.

The review suggests that early removal of urinary catheters may increase the risk of POUR. However, considering the magnitude of the effect, the 95% CI of the RD includes zero, and the upper bound of 10% is of questionable clinical importance. Epidural analgesia is considered to increase the risk of POUR by blocking the

transmission of afferent and efferent nervous impulses that innervate the bladder¹²⁾. In the context of catheter removal, it is biologically plausible that the early removal of urinary catheters during epidural analgesia increases POUR. Contrastingly, it is better to remove the urinary catheter as early as possible because early removal has several potential benefits, such as reducing the risk of UTI, LOS, and the discomfort associated with catheters, as well as increasing mobility^{3, 13, 14)}. Therefore, whether it is feasible to remove urinary catheters during epidural anesthesia depends on whether the increased risk of POUR is clinically acceptable. In this study, the upper bound of the 95% CI in the original analysis was 10%, and the sensitivity analysis showed a similar magnitude of effect. We could not conclude whether 10% of increased risk of POUR without obtaining apparent benefit such as reducing the risk of UTI is clinically acceptable or not. In the future, a study with a non-inferiority design would be more appropriate to examine the hypothesis that urinary catheters can be removed during epidural anesthesia.

Male sex is known to be a risk factor for POUR due to male-specific pathologies, such as BPH^{12, 15)}. The subgroup analysis of men subjects also suggested that the risk of POUR increased with early removal, as in the original analysis. However, the evidence is very uncertain because of the imprecision of the estimate with wide CIs. Thus, further studies are needed to examine whether early removal of urinary catheters is acceptable in men.

This review suggests that early urinary catheter removal may reduce the risk of UTI. Nevertheless, the evidence is very uncertain because of the imprecision of the estimate with wide CIs and unexplained heterogeneity. Previous evidence has shown that the incidence of UTI increases with the duration of indwelling urinary catheters^{14, 16)}. Herein, visual inspection of the forest plot of each study suggested that early removal of urinary catheters had the advantage of reducing the risk of UTI. However, the pooled estimates did not show a significant difference between the early and late removal groups. Insufficient detection power due to the small number of events may be involved. Moreover, contamination due to reinsertion of catheters for POUR and increased post-void residual urine volume due to epidural analgesia may be associated with an increased risk of UTI¹⁷⁾.

Early removal of the urinary catheter may reduce LOS. Only one study measured LOS as an outcome and suggested that the increased incidence of UTI due to late removal of the urinary catheter may increase LOS⁶⁾. However, this review showed that there was no significant difference in UTI between the early and late removal groups. Furthermore, LOS may be affected by other factors, such as the postoperative course, type of surgery, or the institution. Therefore, further studies that measure LOS as an outcome will be needed to examine whether

early removal of the urinary catheter during epidural analgesia contributes to shortening LOS.

This study has several limitations. First, there remained unexplained heterogeneity in the analysis of POUR and UTI. We performed one of the pre-specified planned subgroup analyses for sex to explore the causes of heterogeneity. However, we could not identify the causes of heterogeneity completely because substantial heterogeneity remained after the subgroup analysis. There are several possible causes of clinical heterogeneity, including differences in the type of surgery (thoracic, abdominal, or rectum), definitions of the outcomes, anesthetic concentrations used, presence or absence of opioid use, and the quality of the studies. Hence, the generalizability of the results of this study should be interpreted with caution. Secondly, there were no studies that measured other relevant outcomes such as quality of life, degree of mobility, and cost, which could be potential benefits when considering the effectiveness of early removal. Thirdly, there was possible low statistical power due to the small number of included studies and the small sample size. In light of these limitations, we are currently conducting a non-inferiority RCT to examine whether early removal of the urinary catheter is acceptable during epidural analgesia (registration number: UMIN000040468).

Conclusion

This systematic review suggested that early removal of the urinary catheter during epidural analgesia may increase the risk of POUR by ~5%. We could not conclude whether ~5% of increased risk of POUR without obtaining apparent benefit such as reducing the risk of UTI is clinically acceptable or not. The non-inferiority approach using a clinically valid non-inferiority margin may be a more appropriate study design to examine the hypothesis that urinary catheters can be removed during epidural analgesia.

Acknowledgments:

The authors would like to thank Mr. Takaaki Suzuki (Nara Medical University) for contributing to the peer review of the search strategies.

Conflict of interest: The authors have no conflict of interest to disclose.

Source of funding: This study was not supported by external funding.

References

- 1) Feldheiser A, Aziz O, Baldini G, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 2: consensus statement for anaesthesia practice. *Acta Anaesthesiol Scand*. 2016;60(3):289-334.
- 2) Fearon KC, Ljungqvist O, Von Meyenfeldt M, et al. Enhanced recovery after surgery: a consensus review of clinical care for pa-

- tients undergoing colonic resection. *Clin Nutr.* 2005;24(3):466-77.
- 3) Gustafsson UO, Scott MJ, Hubner M, et al. Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations: 2018. *World J Surg.* 2019;43(3):659-95.
 - 4) Pöpping DM, Elia N, Van Aken HK, et al. Impact of epidural analgesia on mortality and morbidity after surgery: systematic review and meta-analysis of randomized controlled trials. *Ann Surg.* 2014;259(6):1056-67.
 - 5) Chia YY, Wei RJ, Chang HC, et al. Optimal duration of urinary catheterization after thoracotomy in patients under postoperative patient-controlled epidural analgesia. *Acta Anaesthesiol Taiwan.* 2009;47(4):173-9.
 - 6) Zaouter C, Kaneva P, Carli F. Less urinary tract infection by earlier removal of bladder catheter in surgical patients receiving thoracic epidural analgesia. *Reg Anesth Pain Med.* 2009;34(6):542-8.
 - 7) Coyle D, Joyce KM, Garvin JT, et al. Early post-operative removal of urethral catheter in patients undergoing colorectal surgery with epidural analgesia - a prospective pilot clinical study. *Int J Surg.* 2015;16:94-8.
 - 8) Allen MS, Blackmon SH, Nichols III FC, et al. Optimal timing of urinary catheter removal after thoracic operations: a randomized controlled study. *Ann Thorac Surg.* 2016;102(3):925-30.
 - 9) Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol.* 2009;62(10):e1-34.
 - 10) Higgins JPT, Thomas J, Chandler J, et al., editors. *Cochrane Handbook for Systematic Reviews of Interventions* version 6.1. Cochrane. 2020 Sep. [cited 2021 February 18]. Available from: www.training.cochrane.org/handbook
 - 11) Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol.* 2011;64(4):383-94.
 - 12) Baldini G, Bagry H, Aprikian A, et al. Postoperative urinary retention: anesthetic and perioperative considerations. *Anesthesiology.* 2009;110(5):1139-57.
 - 13) Castelo M, Sue - Chue - Lam C, Kishibe T, Acuna S, Baxter N. Early urinary catheter removal after rectal surgery: systematic review and meta - analysis. *BJS Open.* 2020;4(4):545-53.
 - 14) Okrainec A, Aarts MA, Conn LG, et al. Compliance with urinary catheter removal guidelines leads to improved outcome in enhanced recovery after surgery patients. *J Gastrointest Surg.* 2017;21(8):1309-17.
 - 15) Grass F, Sliker J, Frauche P, et al. Postoperative urinary retention in colorectal surgery within an enhanced recovery pathway. *J Surg Res.* 2017;207:70-6.
 - 16) Wald HL, Ma A, Bratzler DW, et al. Indwelling urinary catheter use in the postoperative period: analysis of the national surgical infection prevention project data. *Arch Surg.* 2008;143(6):551-7.
 - 17) Zaouter C, Wuethrich P, Miccoli M, et al. Early removal of urinary catheter leads to greater post-void residuals in patients with thoracic epidural. *Acta Anaesthesiol Scand.* 2012;56(8):1020-5.