学 位 論 文 の 要 旨

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学 位 論 文 名　Impact of Early Unclamping Technique on Perioperative and Postoperative Outcomes in Robot-assisted Laparoscopic Partial Nephrectomy: a Propensity Score-matched Analysis From a Single Center

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論 文 内 容 の 要 旨

INTRODUCTION

In the current era of robotic surgery, robot-assisted laparoscopic partial nephrectomy (RAPN) is a standard treatment option for patients with localized renal cell carcinoma (RCC). The early unclamping technique (EUC), reported by Baumert et al. (Eur Urol. 2007;52(4):1164–9), is an innovative approach that significantly reduces warm ischemia time (WIT) in laparoscopic partial nephrectomy compared with the standard unclamping technique (SUC) (EUC vs. SUC: 14 min vs. 27 min, $p < 0.01$). However, studies comparing EUC and SUC in terms of renal function changes after RAPN are limited, purely retrospective, and have yielded inconsistent conclusions. Therefore, in this study, we conducted a comparative analysis of perioperative and postoperative outcomes by using propensity score-matching (PSM) to adjust for differences in patient backgrounds, with a particular focus on changes in renal function, between EUC and SUC in patients with small renal tumors who underwent RAPN.

MATERIALS AND METHODS

The study protocol was approved by the Research Ethics Committee of Shimane University. We retrospectively analyzed 117 patients who underwent RAPN at Shimane University Hospital between 2013 and 2023, with a minimum follow-up of 12 months. RAPN was performed using a standard surgical technique with the da Vinci S or Xi surgical system. Partial nephrectomy was performed after total clamping of the renal artery. SUC was defined as the release of renal artery clamping following the completion of renal reconstruction. EUC was defined as the release of renal artery clamping after achieving sufficient hemostasis of the tumor bed with barbed suture and/or soft coagulation before repairing the renal parenchymal defect.

To balance preoperative patient characteristics, we conducted one-to-one PSM between SUC and EUC groups in localized RCC patients who underwent RAPN to minimize selection bias and potential confounding. PSM analysis with multivariable logistic regression included the following covariates: age, sex, BMI, diabetes mellitus, hypertension, ASA-PS, tumor size, R.E.N.A.L. score, and preoperative eGFR. PSM was performed using a caliper width of 0.2, and balance between matched groups was assessed using standardized mean differences (SMDs). Univariable and multivariable logistic regression analyses were conducted to identify factors associated with postoperative renal function changes at 12 months after RAPN.

RESULTS AND DISCUSSION

According to our inclusion criteria, 104 patients were included in the full cohort, which consisted of 73 patients in the SUC group and 31 patients in the EUC group. After matching, 31 patients were included in each group. No patients in either group developed tumor recurrence during follow-up period. There were no significant differences in patient characteristics between the two groups, and all variables used for PSM had SMDs less than 0.2. The EUC group had a significantly shorter WIT (19 vs. 28 min; $p < 0.001$). Although estimated blood loss was higher in the EUC group (50 vs. 0 mL; $p < 0.001$), no significant difference was observed in postoperative hemoglobin decline. The EUC group showed significantly smaller eGFR declines at 6 months (-4.2% vs. -15%; $p = 0.005$) and at 12 months (-5.3% vs. -14%; $p < 0.001$). There was no significant difference in the incidence of overall or major postoperative complications (Clavien- Dindo classification ≥ 3) between the two groups. Although two cases of symptomatic renal artery pseudoaneurysm were observed in the SUC group in the full cohort, there were no cases of symptomatic renal artery pseudoaneurysm in the PSM cohort.

Multivariable analysis revealed that smaller tumor size (< 25 mm) (OR: 6.81, 95% CI: 1.67–27.9, $p = 0.008$), lower R.E.N.A.L. score (< 7) (OR: 5.06, 95% CI: 1.19–21.5, $p = 0.028$), and EUC (OR: 11.8, 95% CI: 2.57–54.5, $p = 0.002$) were independent predictors of renal function preservation, defined as a renal function decline of less than 10%.

We found several key findings in this study. First, the EUC group showed significantly better renal function compared to the SUC group at both POM6 and POM12. Second, EBL was significantly higher in the EUC group than in the SUC group, although there was no significant difference in postoperative hemoglobin level changes between the two groups. Third, there was no significant difference in the incidence of overall or major complications between the two groups.

Few studies have evaluated renal function changes after RAPN. Previous studies (Peyronnet et al. (BJU Int. 2014;114(5):741–7), Kondo et al. (Int J Urol. 2015;22(12):1096–102), Motoyama et al. (J Robot Surg. 2020;14(1):47–53), Song et al. (BMC Urol. 2022;22(1):81)) reported no significant differences in postoperative renal function between EUC and SUC. A

recent meta-analysis suggested that EUC was associated with better renal function preservation after RAPN (Eur Urol Focus. 2019;5(4):619–35.), but many studies had follow-up periods of less than one year and the results remain inconsistent. In our study, although limited in sample size, EUC was identified as a factor potentially associated with renal function preservation at one year after RAPN, based on PSM and multivariable analysis.

In our study, smaller tumor size (<25 mm) and lower R.E.N.A.L. score (<7) were associated with better renal function preservation at 12 months after RAPN. Wu et al. (Eur Urol Oncol. 2019;2(1):97–103) reported that larger tumors and higher tumor complexity were associated with reduced preserved renal parenchymal volume, which negatively affects postoperative renal function. A large-scale study by Razdan et al. (Urology. 2023;173:92–7) showed that lower tumor complexity (R.E.N.A.L. score) was associated with less renal function decline. These findings are consistent with our results and suggest that smaller tumor size and lower R.E.N.A.L. score, similar to EUC, may contribute to postoperative renal function preservation.

EBL was higher in the EUC group than in the SUC group (50 vs. 0 mL, $p < 0.001$). Previous reports have shown inconsistent results: while Peyronnet et al. (BJU Int. 2014;114(5):741–7) reported higher EBL in the EUC group, other studies found no significant difference between the two groups (BMC Urol. 2022;22(1):81, J Robot Surg. 2020;14(1):47–53, Int J Urol. 2015;22(12):1096–102). In our study, the absolute EBL was relatively low in both groups, and postoperative hemoglobin changes did not differ. Therefore, EUC does not appear to increase the risk of clinically significant intraoperative bleeding.

In our study, there was no significant difference in overall or major perioperative complications between the EUC and SUC groups, which is consistent with previous reports. Additionally, two studies have shown a lower incidence of renal artery pseudoaneurysm in the EUC group (J Robot Surg. 2020;14(1):47–53, Int J Urol. 2015;22(12):1096–102). In our study, contrast-enhanced CT was not routinely performed in the early postoperative period, so asymptomatic pseudoaneurysms may have been missed; however, symptomatic pseudoaneurysms were observed only in the SUC group. These findings suggest that EUC may help reduce the incidence of renal artery pseudoaneurysm.

CONCLUSION

We found that EUC was associated with better preservation of renal function after RAPN without increasing the incidence of overall or major perioperative complications. Although we believe that EUC is a feasible technique during RAPN, further well-designed studies with longer follow-up periods are needed to clarify the association between EUC and renal function changes.