Transient acute kidney injury observed immediately after robot-assisted radical prostatectomy but not after open radical prostatectomy

AKIHIRO NAITO1, SATORU TAGUCHI1,2, MOTOFUMI SUZUKI1, TAKEKO KAWAI1, KANJI UCHIDA3, TETSUYA FUJIMURA4, HIROSHI FUKUHARA2 and HARUKI KUME1

1Department of Urology, Graduate School of Medicine, University of Tokyo, Bunkyo-ku, Tokyo 113-8655; 2Department of Urology, Kyorin University School of Medicine, Mitaka, Tokyo 181-8611; 3Department of Anesthesiology, Graduate School of Medicine, University of Tokyo, Bunkyo-ku, Tokyo 113-8655; 4Department of Urology, Jichi Medical University, Shimotsuke, Tochigi 329-0498, Japan

Received February 8, 2020; Accepted May 15, 2020

DOI: 10.3892/mco.2020.2087

Abstract. Acute kidney injury (AKI) is a serious postoperative complication that occurs following laparoscopic surgery. However, its association with robot-assisted radical prostatectomy (RARP), the gold standard surgery for prostate cancer, is controversial. The current cohort included 257 patients with prostate cancer who underwent either RARP (n=187) or open radical prostatectomy (ORP; n=70). Patient serum creatinine concentration was measured at the following six time points: Prior to surgery, on postoperative day 0 (immediately after surgery), on postoperative day 1, 3 months after surgery, 1 year after surgery and 2 years after surgery. AKI was diagnosed according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria. A total of 25 RARP and 0 ORP patients met the KDIGO criteria on postoperative day 0. On postoperative day 1, 3 RARP and 2 ORP patients met the criteria, suggesting that AKI after RARP was a transient phenomenon. At 1 and 2 years after surgery, 5 of 257 patients exhibited a significant increase in serum creatinine concentrations from baseline results. Clinicians should be aware of transient AKI occurring after RARP, rather than ORP, to ensure better perioperative management in patients undergoing radical prostatectomy.

Introduction

Robot-assisted radical prostatectomy (RARP) is currently the gold standard surgical procedure for localized prostate cancer (PC). Although RARP is reportedly associated with safer surgery and better oncological outcomes than conventional open radical prostatectomy (ORP) (1), RARP has risks of specific complications due to the use of carbon dioxide pneumoperitoneum and a steep Trendelenburg position (2,3). Acute kidney injury (AKI) is a serious postoperative complication especially after laparoscopic surgery; however, the link between RARP and AKI is controversial (2-6). A previous study reported that the postoperative serum creatinine (sCr) concentration increased in patients who underwent RARP but decreased in those who underwent ORP (2). To the contrary, another study reported that the incidence of AKI after RARP was significantly lower than that after ORP (5). Yet other studies reported that postoperative renal function was unaltered in patients who underwent RARP (3,6). Therefore, there is currently no consensus regarding the risk of AKI after RARP. Furthermore, long-term follow-up data on changes in renal function after RARP are also lacking. The present study aimed to compare the incidences of postoperative AKI between RARP and ORP, as well as long-term changes in postoperative renal function between them.

Patients and methods

Patients and surgical techniques. We retrospectively reviewed 257 patients with PC who underwent either RARP (n=187) or ORP (n=70) at our institution from 2011 to 2014. Since RARP started to be covered by Japanese public health insurance in 2012, most patients underwent ORP between 2011 and the first half of 2012, while majority of patients received RARP after the second half of 2012. We performed RARP using the peritoneal approach as previously described (1) and ORP using the conventional retroperitoneal approach, respectively. Patients who underwent RARP were placed in the Trendelenburg position at an angle of 25° from the horizontal plane. Lymph
Table I. Patient baseline characteristics.

| Variables                              | Total (257) | ORP (70)  | RARP (187) | P-value |
|----------------------------------------|-------------|-----------|------------|---------|
| Age, years, median (IQR)               | 67 (63-71)  | 67 (61-71)| 66 (63-70) | 0.898a  |
| BMI, kg/m², median (IQR)               | 24.0 (22.1-25.5) | 23.8 (21.6-25.8) | 24.1 (22.0-25.2) | 0.791a  |
| Initial PSA, ng/ml, median (IQR)       | 7.6 (5.8-10.9) | 8.1 (6.0-11.8) | 7.4 (5.5-10.6) | 0.131a  |
| Preoperative sCre, mg/dl, median (IQR)| 0.82 (0.73-0.95) | 0.81 (0.70-0.90) | 0.83 (0.73-0.96) | 0.154a  |
| Prostate volume, ml, median (IQR)      | 29.9 (22.4-40.3) | 32.0 (21.4-41.9) | 29.4 (22.5-40.0) | 0.581a  |
| Pathological T stage, n (%)            |             |           |            | 0.306b  |
| ≥pT2                                   | 198 (77.0)  | 57 (81.4) | 141 (75.4) |         |
| ≥pT3                                   | 59 (23.0)   | 13 (18.6) | 46 (24.6)  |         |
| Pathological N stage, n (%)            |             |           |            | 0.001b,c |
| pN0/x                                  | 253 (98.4)  | 66 (94.3) | 187 (100)  |         |
| pN1                                    | 4 (1.6)     | 4 (5.7)   | 0 (0)      |         |
| Pathological Gleason score, n (%)      |             |           |            | 0.081b   |
| ≤7                                     | 199 (77.4)  | 49 (70.0) | 150 (80.2) |         |
| ≥8                                     | 58 (22.6)   | 21 (30.0) | 37 (19.8)  |         |
| Surgical time, min, median (IQR)       | 231 (199-265) | 209 (190-243) | 237 (204-271) | 0.001a,c |
| Blood loss, ml, median (IQR)           | 450 (150-865) | 1075 (728-1753) | 300 (100-500) | <0.001a,c |
| Fluid infusion, ml, median (IQR)       | 2100 (1800-2750) | 2975 (2600-3713) | 2000 (1700-2350) | <0.001a,c |

Data were analyzed using *Mann-Whitney U and *Pearson's χ² tests. *Statistically significant data. ORP, open radical prostatectomy; RARP, robot-assisted radical prostatectomy; IQR, interquartile range; BMI, body mass index; PSA, prostate-specific antigen; sCre, serum creatinine.

Results

Patient characteristics and postoperative AKI. The patients' baseline characteristics are summarized in Table I. As shown in Fig. 1, 25 of 187 (13.4%) patients who underwent RARP met the KDIGO's AKI criteria on POD0, while none of the patients who underwent ORP met the criteria (Pearson's χ² test, P=0.001). On POD1, 3 of 187 (1.6%) patients who underwent RARP and 2 of 70 (2.9%) patients who underwent ORP met the criteria (P=0.517).

Long-term follow-up data of postoperative renal function. Three months after surgery, none of the 28 patients who met the KDIGO criteria on either POD0 or POD1 had a prolonged significant increase in sCre, whereas 2 of 257 (0.8%) patients (both in the RARP group) had a new increase in sCre from baseline. One year after surgery, 5 of 257 (1.9%) patients (4 in the RARP group and 1 in the ORP group) had a significant increase in sCre from baseline, whereas 5 (1.9%) patients (all in the RARP group) had a significant increase 2 years after surgery.
Correlations between clinicopathological variables and AKI on POD0. In the univariate analysis, the procedure type (ORP vs. RARP), initial PSA concentration (<7.55 vs. ≥7.55 ng/ml), preoperative sCre (<0.82 vs. ≥0.82 mg/dl), pathological T stage (pT2 vs. pT3), and surgical time (<231 vs. ≥231 min) were significantly associated with AKI.
on POD0 (Table II). The multivariate analysis incorporating these five variables showed that performance of RARP and a surgical time of ≥231 min were independent predictors of AKI on POD0. However, the odds ratio for the procedure type was not convergent because there was no event in the ORP group. Therefore, these results might be used for reference purposes only.

Discussion

In the present study, a large number of patients who underwent RARP met the KDIGO’s AKI criteria immediately after surgery (POD0), whereas patients who underwent ORP (control group) did not. Nevertheless, on POD1, only a few patients in both treatment groups met the criteria, suggesting that AKI after RARP was just a transient phenomenon. Furthermore, the long-term follow-up data demonstrated that only a few patients developed a decline in renal function after surgery regardless of the procedure type. Therefore, the transient AKI phenomenon immediately after RARP might have little clinical significance.

The association between RARP and AKI is controversial (2-6). One study showed results similar to ours in that the postoperative ScRe concentration increased in patients who underwent RARP but decreased in those who underwent ORP (2). However, another study showed a completely opposite result; i.e., the incidence of AKI after RARP was significantly lower than that after ORP (5). In yet other studies, postoperative renal function was unaltered in patients who underwent RARP (3,6). These inconsistencies might be attributable to the diagnostic time of AKI or the timing of blood sampling, given that fewer patients who underwent RARP than ORP in our study met the AKI criteria on POD1 (<24 h after surgery).

Impairment of renal function after laparoscopic surgery has been widely reported, and the common underlying mechanisms include increased intra-abdominal pressure and carbon dioxide pneumoperitoneum (4,5,10). Under conditions of pneumoperitoneum, direct compression of the intra-abdominal vessels and renal parenchyma can decrease cardiac output, renal blood flow, and urine output (10). These physiologic changes stimulate the renin-angiotensin system and further decrease renal blood flow, eventually resulting in impairment of renal function (4,5). Additionally, the steep Trendelenburg position required for RARP could be an additional cause of renal impairment, although the mechanism has not been well documented (2,3). Other possible mechanisms include pseudo-renal failure due to intraperitoneal urine leakage during prostatectomy; however, this may depend on the amount of leaked urine (11). We consider that in general, the amount of leaked urine during prostatectomy is not large enough to cause pseudo-renal failure and that the risk of pseudo-renal failure is likely similar between RARP and ORP (Note: No patient receiving ORP developed AKI immediately after surgery, although there should exist a certain amount of urine leakage). Finally, prerenal AKI can be suspected because of decreased fluid replacement during surgery; notably, however, fluid infusion was not associated with AKI on POD0 in the present study, even in the univariate analysis.

In conclusion, this retrospective single-center study revealed transient AKI immediately after RARP, but not after ORP. However, this finding might be of little clinical significance given the long-term follow-up data of postoperative renal function. Nevertheless, this transient AKI phenomenon immediately after RARP should be recognized to provide better perioperative management of patients undergoing radical prostatectomy.

Acknowledgments

Not applicable.

Funding

No funding was received.

Availability of data and materials

The datasets used and/or analyzed are available from the corresponding author on reasonable request.

Authors’ contributions

AN and ST conceived and designed the present study, analyzed and interpreted the data, and drafted the manuscript. MS analyzed and approved the final manuscript. HK supervised the study, acquired patient pre-operative data, drafted the manuscript and were involved in revising it critically for important intellectual content. HF and HK supervised the study, acquired patient pre-operative data, drafted the manuscript and were involved in revising it critically for important intellectual content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The present study was approved by the Internal Institutional Review Board of Graduate School of Medicine and Faculty of Medicine, University of Tokyo (approval no. 3124). Written informed consent was obtained from each patient prior to surgery. Patients were given the opportunity to decline participation in the study through the opt-out form on our website.

Patient consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

References

1. Fujimura T, Fukuhara H, Taguchi S, Yamada Y, Sugihara T, Nakagawa T, Niimi A, Kume H, Igawa Y and Homma Y: Robot-assisted radical prostatectomy significantly reduced biochemical recurrence compared to retro pubic radical prostatectomy. BMC Cancer 17: 454, 2017.
2. D’Alonzo RC, Gan TJ, Moul JW, Albala DM, Polascik TJ, Robertson CN, Sun L, Dahm P and Habib AS: A retrospective comparison of anesthetic management of robot-assisted laparoscopic radical prostatectomy versus radical retropubic prostatectomy. J Clin Anesth 21: 322-328, 2009.
3. Saito J, Noguchi S, Matsumoto A, Jinushi K, Kasai T, Kudo T, Sawada M, Kimura F, Kushikata T and Hirota K: Impact of robot-assisted laparoscopic prostatectomy on the management of general anesthesia: Efficacy of blood withdrawal during a steep Trendelenburg position. J Anesth 29: 487-491, 2015.

4. Li JR, Cheng CL, Weng WC, Hung SW and Yang CR: Acute renal failure after prolonged pneumoperitoneum in robot-assisted prostatectomy: A rare complication report. J Robot Surg 1: 313-314, 2008.

5. Joo EY, Moon YJ, Yoon SH, Chin JH, Hwang JH and Kim YK: Comparison of acute kidney injury after robot-assisted laparoscopic radical prostatectomy versus retropubic radical prostatectomy: A propensity score matching analysis. Medicine (Baltimore) 95: e2650, 2016.

6. Ahn JH, Lim CH, Chung HJ, Choi SU, Youn SZ and Lim HJ: Postoperative renal function in patients is unaltered after robotic-assisted radical prostatectomy. Korean J Anesthesiol 60: 192-197, 2011.

7. Naito S, Kuroiwa K, Kinukawa N, Goto K, Kogaw H, Ogawa O, Murai M and Shiraishi T; Clinicopathological Research Group For Localized Prostate Cancer Investigators: Validation of Partin tables and development of a preoperative nomogram for Japanese patients with clinically localized prostate cancer using 2005 International Society of Urological Pathology consensus on Gleason grading: Data from the clinicopathological research group for localized prostate cancer. J Urol 180: 904-909, 2008.

8. Kellum JA, Lameire N, Aspelin P, Barsoum RS, Burdmann EA, Goldstein SL, Herzog CA, Ioannidis M, Kribben A, Levey AS, et al: Kidney disease: Improving global outcomes (KDIGO) acute kidney injury work group. KDIGO clinical practice guideline for acute kidney injury. Kidney Int (Suppl 2): 1-138, 2012.

9. Doi K, Nishida O, Shigematsu T, Sadahirov T, Itami N, Iseki K, Yuzawa Y, Okada H, Koya D, Kiyomoto H, et al: Japanese clinical practice guideline for acute kidney injury 2016 committee: The Japanese clinical practice guideline for acute kidney injury 2016. Clin Exp Nephrol 22: 985-1045, 2018.

10. Wever KE, Bruinjes MH, Warlé MC and Hooijmans CR: Renal perfusion and function during pneumoperitoneum: A systematic review and meta-analysis of animal studies. PLoS One 11: e0163419, 2016.

11. Kruger PS and Whiteside RS: Pseudo-renal failure following the delayed diagnosis of bladder perforation after diagnostic laparoscopy. Anaesth Intensive Care 31: 211-213, 2003.