Original Research

Associating the learning curve and tumor anatomical complexity with the margins, ischemia, and complications rate after robot-assisted partial nephrectomy

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HIGHLIGHTS

- The MIC system was found to be an easy and reproducible tool to standardize the evaluation of the early outcomes of RAPN.
- The MIC rate increased with surgical experience and decreased with tumor anatomical complexity.
- We confirmed that RAPN was less technically challenging with a less steep learning curve than LPN.

ARTICLE INFO

ABSTRACT

Objectives: In this paper, we report the robot-assisted partial nephrectomy (RAPN) outcomes of our institution by using the margins, ischemia, and complications (MIC) system, which was recently proposed to standardize the evaluation of partial nephrectomy outcomes and observe the effect of learning curve and tumor anatomical complexity on the results.

Patients and methods: We conducted a retrospective analysis of our prospectively maintained database of 144 patients treated with RAPN by one surgeon from May 2013 to May 2014. The MIC system was defined as a combination of negative surgical margins, warm ischemia time<20 min and no major complications. We stratified the patients by quartiles of distribution called RAPN eras 1, 2, 3, and 4 and RENAL score risk group categories. We determined the MIC rate in our study population. The MIC rates in each era and the RENAL score risk group were compared to assess the effect of the learning curve and tumor anatomical complexity on outcomes.

Results: A total of 144 patients were included in this study. The overall MIC rate was 62.5% (90/144), and the MIC was commonly higher in recent eras (38.9%, 55.6%, 72.2%, and 83.3%, p = 0.001). The MIC rate progressively decreased along the RENAL score risk group categories (low, moderate, and high complexity, p = 0.002). When the RAPN eras and RENAL score risk group categories considered simultaneously, we determined that the previous eras showed a lower MIC rate, regardless of the RENAL score risk group categories. However, no significant difference was observed (p = 0.590).

Conclusions: The MIC system was found to be an appropriate, easy and reproducible tool to standardize the evaluation of the early outcomes of RAPN in patients. The MIC rate increased with surgical experience and decreased with tumor anatomical complexity.

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1. Introduction

Partial nephrectomy (PN) is the gold standard in managing renal tumors smaller than 7 cm, which achieves the same oncological outcomes and a lower risk of chronic kidney disease compared with radical nephrectomy (RN) [1,2]. An increasing number of minimally

invasive surgeries are developed and applied in urology because these methods are less invasive and result in the faster recovery of patients. The evolution of PN progressed from open PN (OPN), laparoscopic PN (LPN), and robot-assisted PN (RAPN) [3]. However, laparoscopic suturing is technically and ergonomically difficult, which limits its extensive use [3]. More recently, robotic surgery was developed to enhance the performance of surgeons during surgical procedures [4]. In urology, because of wider degrees of freedom, tremor control, and magnified vision of robotic surgery, RAPN was proven to be a promising procedure that has been extensively applied. Thus, employing an appropriate approach to standardize the evaluation of RAPN outcomes in patients is necessary. Buffi et al. [5] presented a new margins, ischemia, and complications (MIC) binary system in 2012 to standardize the evaluation of PN outcomes. According to the new MIC binary system, the goal of PN is reached when (1) the surgical margins are negative, (2) warm ischemia time (WIT) is < 20 min, and (3) no major complications occur (grades 3–4 according to the Clavien–Dindo classification) [5]. Buffi et al. [5] also supported the use of the MIC system in different series to define the potential role of the system after PN accurately. To contribute to this field, in this study, we analyzed our RAPN results and evaluated the effect of learning curve and tumor anatomical complexity on the results by adopting the MIC system.

2. Patients and methods

The Institutional Review Board of the Chinese People's Liberation Army General Hospital reviewed and approved the study. Data were collected from the prospectively maintained database. A total of 144 patients treated with RAPN by one surgeon from May 2013 to May 2014 in our institution without any missing information for analysis were included in the study. The surgeon was an experienced laparoscopic surgeon and had already performed more than 1000 cases of laparoscopic partial nephrectomy prior to this series. RAPN procedures were performed transperitoneally. Patients with cold ischemia, multiple or bilateral tumors, solitary kidney, and metastatic disease were excluded. For the analysis, we stratified the patients by quartiles of distribution called RAPN eras 1, 2, 3, and 4, to assess the effect of learning curve on the outcomes. The RENAL nephrometry scoring system was used to evaluate the ability to determine tumor complexity from preoperative images. The following are the RENAL score risk group categories: scores 4 to 6 indicate low complexity; scores 7 to 9 denote moderate complexity; and scores 10 to 12 indicate high complexity [6].

Demographic, preoperative, intraoperative, and postoperative data were recorded. Surgery-related complications (either intraoperative or postoperative) were also analyzed by applying the Clavien–Dindo classification and the European Association of Urology guidelines panel assessment and recommendations [7,8]. We calculated the estimated glomerular filtration rate according to the Modification of Diet in Renal Disease equation [9] to evaluate renal functional outcome preoperatively and postoperatively. Learning curve (RAPN eras) and tumor anatomical complexity (RENAL score risk group categories) were analyzed to assess the effect on the MIC rate. All tumor specimens were extracted undamaged for pathological evaluation based on the 2009 version of the TNM classification. When cancer cells are present at the inked parenchymal margin, the result is regarded as positive surgical margins (PSMs) [10]. The patients with PSMs were followed up with thoraco–abdominal computed tomography scan every 6 months during the first year after treatment and every 12 months thereafter.

For the statistical analysis, the Mann–Whitney *U* test was used to compare the means of the continuous variables. The means of more than two group categorical variables were compared by employing the Kruskal–Wallis ANOVA. Pearson's chi-square test was adopted to compare the categorical variables. The simultaneous interaction effects of multiple categorical variables on the dependent variable were analyzed by using the factorial ANOVA. The SPSS 20.0 statistical software package (SPSS Inc., Chicago) was utilized for the statistical analysis. All the significance levels were set at the two-sided p < 0.05.

3. Results

A total of 144 patients who underwent RAPN were analyzed in study. Based on the quartiles of distribution, patients #1–36 were defined as RAPN era 1 (May 2013 to October 2013), patients #37–72 were defined as RAPN era 2 (October 2013 to January 2014), patients #73–108 were defined as RAPN era 3 (January 2014 to March 2014), and patients #109–144 were defined as RAPN era 4 (March 2014 to May 2014). The baseline demographic and tumor characteristics are shown in Table 1. No statistically significant differences were observed in age, sex, BMI, ASA score, CCI, tumor size, and tumor side from RAPN era 1 to RAPN era 4. The RENAL score progressively increased from RAPN era 1 to RAPN era 4 (p < 0.001). The perioperative data and renal functional outcomes are presented in Table 2. No statistically significant differences were observed in the EBL, operative time, complications, major complications (Clavien–Dindo grades 3–4), PSM, and hospital stay from RAPN era 1 to RAPN era 4. No differences were also observed in renal functional outcomes either preoperatively or postoperatively. WIT progressively decreased from RAPN era 1 to RAPN era 4 (p = 0.007). The pathologic characteristics are listed in Table 3. No statistically significant differences were observed in the final pathology or pathological stage from RAPN era 1 to RAPN era 4. At a median follow up of 20 months (range, 16–28 months), no patients developed a local recurrence.

The overall MIC rate was 62.5% (90/144 patients). The MIC was commonly higher in recent eras (p = 0.001, Fig. 1): 38.9% (14/36 patients), 55.6% (20/36 patients), 72.2% (26/36 patients), and 83.3% (30/36 patients) in RAPN eras 1, 2, 3, and 4, respectively. The MIC rate progressively decreased along the RENAL score risk group categories (p = 0.002, Fig. 1). When the RAPN eras and RENAL score risk group categories considered simultaneously, a lower MIC rate was observed in the previous eras, regardless of RENAL score risk group categories. However, no significant difference was observed between the variables (p = 0.590, Fig. 1). When we analyzed the MIC components separately, the PSM rate was particularly low (1.4% overall) and similar in different eras (p = 0.567, Fig. 2) and risk group categories (p = 0.237, Fig. 2). When we considered the RAPN eras and RENAL score risk group categories simultaneously, no statistically significant differences were observed between the variables (p = 0.712, Fig. 2). WIT decreased significantly from RAPN era 1 to RAPN era 4 (p = 0.007, Fig. 2) and increased significantly from RENAL score risk group categories 1 to 3 (p < 0.001, Fig. 2). When the RAPN eras and RENAL score risk group categories are considered simultaneously, a shorter WIT was observed in recent eras, regardless of RENAL score risk group categories. However, no significant difference was observed between the two variables (p = 0.663, Fig. 2). The major complication rate was particularly low (3.5% overall) and similar in different eras (p = 0.268, Fig. 2). The major complication rate increased from RENAL score risk group categories 1 to 3 (p = 0.093, Fig. 2). However, the increase was nonsignificant. When we analyzed the RAPN eras and RENAL score risk group categories simultaneously, no statistically significant differences were observed (p = 0.306, Fig. 2).