The Benefit of Laparoscopic Partial Nephrectomy in High Body Mass Index Patients

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Objective: The aims of the present study were to evaluate the effect of body mass index on the surgical outcomes of open partial nephrectomy and laparoscopic partial nephrectomy, and to analyze whether higher body mass index patients may derive greater benefit from laparoscopic partial nephrectomy.

Methods: We reviewed 110 patients who underwent open partial nephrectomy and 47 patients who underwent laparoscopic partial nephrectomy at our institution. We analyzed the data to determine what kind of factor would be associated with prolonged operative time, increased estimated blood loss and prolonged ischemic time, and compared the result of open partial nephrectomy with that of laparoscopic partial nephrectomy.

Results: A statistically significant correlation was observed between body mass index and operative time or estimated blood loss in open partial nephrectomy. Multivariate analysis also demonstrated that body mass index was an independent predictor for prolonged operative time and higher estimated blood loss in open partial nephrectomy, but not in laparoscopic partial nephrectomy. In the normal body mass index group (body mass index ≤ 25.0 kg/m²), although mean operative time in the laparoscopic partial nephrectomy group was significantly longer than that in the open partial nephrectomy group, the difference was relatively small. In the high body mass index group (body mass index ≥ 25.0 kg/m²), the mean operative time of the two groups was not statistically different. The estimated blood loss of open partial nephrectomy was significantly higher than that of laparoscopic partial nephrectomy in both groups. In both operative procedures, tumor size was an independent predictor for prolonged ischemic time in multivariate analysis.

Conclusions: Body mass index was an independent predictor for prolonged operative time and higher estimated blood loss in open partial nephrectomy but not in laparoscopic partial nephrectomy. Laparoscopic partial nephrectomy was less influenced by body mass index and had a greater benefit, especially in high body mass index patients.

Key words: Urologic-Surg – endourology – laparoscopy – partial nephrectomy – renal cell carcinoma – body mass index

INTRODUCTION

The prevalence of obesity has increased dramatically, and obesity is now an important problem in many countries because obese patients are more likely to have multiple medical co-morbidities, including hypertension, diabetes and coronary artery disease. Obesity is also associated with a higher risk of developing renal cell carcinoma (RCC) (1). In several series, the prevalence of obesity in patients...
undergoing surgery for RCC has ranged from 29 to 42% (2–4). The widespread use of abdominal imaging has led to an increase in the detection rate for RCCs (5), and most RCCs are commonly diagnosed incidentally and at a smaller size. Therefore, nephron-sparing surgery, such as partial nephrectomy, has become an increasingly accepted option due to its potential advantages with respect to renal function (6).

Laparoscopic partial nephrectomy (LPN) for benign renal diseases was first reported by Winfield et al. (7) in 1993. Since then, LPN for small renal tumors has become widely accepted as the preferred surgical procedure and has oncologic outcomes similar to those of open partial nephrectomy (OPN) and decreased patient morbidity (8). However, it remains controversial as to whether or not LPN is suitable for obese patients.

Some studies have previously reported that LPN could be safely performed even in obese patients and with a rate of morbidity similar to that of non-obese patients (2–4), although it remained technically more challenging with increases in body mass index (BMI). However, these studies used different cut-off points for BMI and demonstrated the safety of LPN in obese patients by comparing with normal and low BMI patients. Studies that integrated BMI into a statistical analysis as one of the clinical parameters affecting surgical outcome have not been reported.

The aim of the present study was to evaluate the effect of BMI on surgical outcomes, including operative time (OT), estimated blood loss (EBL) and ischemic time during tumor resection in both OPN and LPN, and to analyze whether a higher BMI patient may derive greater benefit from LPN.

PATIENTS AND METHODS

We performed a retrospective analysis of data obtained from patients who had undergone OPN or LPN at our institution. The indication for OPN and LPN was clinical T1a RCC without lymph node and distant metastasis. Even in the cases of clinical T1a RCC in which the tumor was not exophytic or located close to the renal pelvis, partial nephrectomies were performed as much as possible. If the renal pelvis and calyx were opened during tumor resection, they were closed by suturing and repaired. A total of 110 OPNs were performed from May 2003 to July 2011, and 47 LPNs were performed from July 2005 to July 2011. All OPNs were performed via a retroperitoneal approach, whereas all LPNs were closed by suturing and repaired. A total of 110 OPNs and 47 LPNs were performed. In the OPN group, 67.3% of the patients were classified as having a healthy weight (BMI < 25.0 kg/m²), 29.1% as overweight (25.0 kg/m² < BMI < 29.9 kg/m²) and 3.6% as obese (BMI ≥ 30.0 kg/m²) according to the WHO classification. In the LPN group, 63.8 and 36.2% were classified as having a healthy weight and overweight, respectively.

The patient characteristics and operative data are shown in Table 1. No significant differences in sex, age, BMI, tumor side (left or right), tumor location (upper, middle or lower pole) or tumor size between the two groups were found. The OT and ischemic times of the LPN group were significantly longer than those of the OPN group (P = 0.026 and 0.001, respectively). The mean EBL of the OPN and LPN groups was 217.0 and 25.9 ml, respectively, and the difference between the two groups was significant (P < 0.001).

The mean preoperative estimated glomerular filtration rate (eGFR) in the OPN and LPN groups was 68.0 and 67.1 ml/min/1.73 m², respectively. The mean eGFR for the 3 postoperative months (POM) in the OPN and LPN groups was 63.8 and 62.4 ml/min/1.73 m², respectively. These values deteriorated to 4.2 and 4.7 ml/min/1.73 m² from the preoperative eGFR, and the difference between the two groups was not significant (P = 0.811).

In the OPN group, the correlation between BMI and OT was significant in Spearman’s rank correlation test (P < 0.001, R = 0.455; Fig. 1A), and multivariate logistic regression analysis demonstrated that BMI was an independent predictor for a prolonged OT (P = 0.012, odds ratio = 1.183; Table 2). In the LPN group, the correlation between BMI and OT was not significant (P = 0.567; Fig. 1B). The correlation between tumor size and OT was significant in Spearman’s rank correlation test (P = 0.015), and multivariate analysis also demonstrated that tumor size was an independent predictor for a prolonged OT (P = 0.029, odds ratio = 3.630; Table 2).

Similarly, the correlation between BMI and EBL was found to be significant in the OPN group (P < 0.001, R =
Fig. 1C), and multivariate analysis revealed that BMI was an independent predictor for higher EBL ($P < 0.001$, odds ratio $= 1.325$; Table 3). However, in the LPN group, the correlation between BMI and EBL was not significant ($P = 0.167$; Fig. 1D).

Next, we analyzed the OT and EBL in both the normal (BMI $< 25.0 \text{ kg/m}^2$) and high (BMI $\geq 25.0 \text{ kg/m}^2$) BMI groups (Fig. 2A and B). In the normal BMI group, LPN required a longer OT than OPN ($P = 0.002$), whereas there was no significant difference between OPN and LPN in the high BMI group ($P = 0.997$). The EBL of LPN was significantly lower than that of OPN in both groups.

Multivariate analysis demonstrated that tumor size was an independent predictor for prolonged ischemic time during tumor resection in both OPN and LPN ($P = 0.003$, odds ratio $= 2.136$ and $P = 0.043$, odds ratio $= 2.934$, respectively).

In the OPN group, the pathological diagnosis was clear cell carcinoma in 82 cases, papillary RCC in 12 cases, chromophobe RCC in 9 cases, angiomyolipoma in 5 cases and oncocytoma in 2 cases. Among the RCC cases, the stage distribution was pT1a in 98 cases, pT1b in 2 cases and pT3a in 3 cases. In the LPN group, the pathological diagnosis was clear cell carcinoma in 38 cases, papillary RCC in 5 cases, angiomyolipoma in 3 cases and cystic nephroma in 1 case. In the RCC cases, the stage distribution was pT1a in 42 cases and pT3a in 1 case. Surgical margins were negative in all OPN and LPN cases. Intraoperative bleeding that required blood transfusion occurred in one (0.9%) patient in the OPN

| Table 1. Patient characteristics and operative data |
|---------------------------------|-----------------|----------------|
|                                | OPN             | LPN             |
| No. of patients                | 110             | 47              |
| Sex                            |                 |                 |
| Male                           | 94              | 35              |
| Female                         | 16              | 12              |
| Age (years)                    | 59.1 $\pm$ 12.3 | 55.9 $\pm$ 12.2 |
| BMI (kg/m$^2$)                 | 23.7 $\pm$ 3.3  | 24.0 $\pm$ 3.7  |
| Tumor side                     |                 |                 |
| Left                           | 55              | 27              |
| Right                          | 55              | 20              |
| Tumor location                 |                 |                 |
| Upper pole                     | 36              | 16              |
| Middle pole                    | 40              | 14              |
| Lower pole                     | 34              | 17              |
| Tumor size (cm)                | 2.4 $\pm$ 0.9   | 2.2 $\pm$ 0.7   |
| Operative time (min)           | 159.4 $\pm$ 42.7| 175.2 $\pm$ 33.1|
| Ischemic time (min)            | 23.2 $\pm$ 7.2  | 28.0 $\pm$ 8.4  |
| EBL (ml)                       | 217.0 $\pm$ 224.3| 25.9 $\pm$ 58.5 |
| Blood transfusion              | 1               | 1               |

OPN, open partial nephrectomy; LPN, laparoscopic partial nephrectomy; BMI, body mass index; EBL, estimated blood loss.

Figure 1. (A) Scatter plot showing the relationship between body mass index (BMI) and operative time in open partial nephrectomy (OPN). (B) Scatter plot showing the relationship between BMI and operative time in laparoscopic partial nephrectomy (LPN). (C) Scatter plot showing the relationship between BMI and estimated blood loss (EBL) in OPN. (D) Scatter plot showing the relationship between BMI and EBL in LPN.
All LPN procedures were performed without blood transfusion and open conversion. Postoperative bleeding from a tumor resected site occurred in one patient (0.9%) in the OPN group and in two patients (4.3%) in the LPN group, and blood transfusion was required in one LPN case (2.1%). In the OPN group, one patient (0.9%) had a postoperative pseudoaneurysm, one (0.9%) a pulmonary embolism and two (1.8%) a wound infection. The differences in the incidences of intraoperative and postoperative complications between the two groups were not significant ($P = 0.705$ and $0.660$, respectively). The hospital stay of the patients in the LPN group was significantly shorter than that of the OPN group (6.6 vs. 11.5 postoperative days, $P < 0.001$).

In the OPN group, lung metastasis was observed in two patients (1.8%) at 40.3 and 39.3 POM, while it was observed in one patient (2.1%) at 46.7 POM after LPN. Other cases were recurrence and metastasis free for a mean of 41.8 and 25.4 months in the OPN and LPN groups, respectively.

**DISCUSSION**

The prevalence of obesity has increased dramatically in the USA in the last 2 decades from ~15% in 1980 to 30% in 2000 (9), and obesity has also become a major social and health issue in Japan. Obese patients are predisposed to the development of various diseases including diabetes mellitus, hypertension, coronary heart disease, airway obstruction and certain types of malignant tumors including RCC (10). Therefore, obese patients are potentially at risk for poor outcomes following a wide variety of surgical procedures (11). In the urologic field, several studies have reported that obesity is a risk factor for complications of laparoscopic surgery; therefore, obesity has been considered a relative contraindication for laparoscopic surgery (12,13). We previously evaluated the effect of BMI on OT and EBL in laparoscopic radical nephrectomy (LRN) and open radical nephrectomy (ORN) (14). We found that the OT for ORN was almost the same as that for LRN in the high BMI group (BMI $\geq 25$ kg/m$^2$); however, the EBL for ORN was significantly higher than that for LRN, and we concluded that the LRN is safer than ORN, especially for high BMI patients.

The widespread use of abdominal imaging has led to an increase in the detection rate of RCCs (5), and most RCCs are now commonly diagnosed incidentally and at a smaller size. Therefore, nephron-sparing surgery has become an accepted procedure because it has potential advantages with respect to renal function. LPN for small renal tumors has become accepted as a preferred surgical procedure with an oncologic outcome similar to that of OPN and decreased patient morbidity (8). However, LPN is still technically challenging because of the difficulty associated with intracorporeal suturing of renal parenchyma during a short ischemic time, and it is still controversial as to whether LPN is suitable or not for obese patients.

Several studies have examined the safety of laparoscopy for obese patients and the findings suggested that obesity should not be regarded as a contraindication for laparoscopy (2–4). Anast et al. (4) compared 12 obese (BMI $\geq 30$ kg/m$^2$)
and 32 non-obese patients (BMI < 30 kg/m²) undergoing LPNs and reported that the obese patients had significantly longer OT and greater EBL than non-obese patients, although there were no differences in any other paraoperative data. Gong et al. (3) compared 85 patients undergoing LPN with BMI cut-offs of greater or less than 30, 35 and 40 kg/m² and reported that the greatest BMI range was associated with a significantly increased rate of intraoperative complications; there were no statistically significant differences in any other paraoperative data. Meanwhile, Colombo et al. (2) compared 140 obese (BMI ≥ 30 kg/m²) and 238 non-obese patients (BMI < 30 kg/m²) undergoing LPNs and reported that there were no significant differences in paraoperative data in both groups. No uniform results concerning LPN for obese patients were obtained; therefore, whether or not LPN is suitable for obese patients remains controversial. Additionally, whether BMI has a significant impact on paraoperative outcome compared with any other factors has not been examined. In the present study, we evaluated the impact of BMI as one of the clinical parameters with which to analyze the effect on intraoperative and postoperative outcomes in OPN and LPN.

In the present study, BMI was significantly correlated with OT and EBL in OPN; however, no such correlation was demonstrated in LPN. Additionally, multivariate analysis also showed that BMI was an independent predictor for a prolonged OT and higher EBL in OPN; however, it was not a predictor in LPN. As shown in Fig. 2A, in the normal BMI group, although the mean OT was significantly longer in the LPN group than in the OPN group, the difference was relatively small. Meanwhile, in the high BMI group, the mean OT of the two groups was almost the same. In addition, the EBL of OPN was significantly higher than that of LPN in both the normal and high BMI groups (Fig. 2B). As shown in Fig. 2C, in the LPN group, the OT of normal BMI patients was not statistically different from that of high BMI patients (P = 0.283). Similarly, the EBL of normal BMI patients was not statistically different from that of high BMI patients (P = 0.508; Fig. 2D). These results demonstrated that LPN is less influenced by BMI, and it is thought that LPN is a suitable procedure for not only normal BMI patients, but also high BMI patients.

The advantage of a partial nephrectomy is the preservation of renal function. At many institutions, cooling of renal parenchyma by slush ice is performed during ischemia in OPN, while warm ischemia without cooling is performed in LPN. Therefore, we hypothesized that the damage to renal function in LPN was more severe than that in OPN. Adamy et al. (15) compared renal function at 2 and 6 POM after 805 OPNs and 182 LPNs, and concluded that the difference in
the surgical approach had only a small effect on renal function. A similar result was obtained in the present study. The ischemic time in LPN was significantly longer than that in OPN; however, the eGFR reduction from preoperation to 3 POM was similar. The difference in the surgical procedure did not reduce renal function.

There are several limitations in the present study. First, although the LPNs were performed by only two highly experienced laparoscopic surgeons, the OPNs were performed by many different surgeons. As described above, LPN is a technically difficult procedure because an advanced laparoscopic technique such as intracorporeal suturing is required, and it was reported that the intraoperative ischemic time is generally longer during LPN than OPN (16), and LPN has a higher complication rate compared with OPN (17,18). Thus, OPN continues to be a standard procedure for small localized renal masses, while LPN is established as an option for only experienced surgeons at high-volume centers in both American Urological Association and European Association of Urology guidelines (17,18). Therefore, LPN will be performed by experts only for the time being. Meanwhile, although the OPNs were performed by many surgeons, all surgeons received similar training for laparotomies, including a partial nephrectomy, and have gained adequate experience. Therefore, it is thought that the likelihood of a difference in surgical outcome due to the different surgeons was relatively small. For these reasons, we believe that the conclusion of the present study is universally applicable. Secondly, a few patients in the present study were classified as obese (BMI ≥ 30 kg/m²) according to the WHO classification. Therefore, whether or not the present conclusion is applicable to the group including many obese patients is still not clear and needs to be determined in future studies. However, the aim of the present study was not to compare the surgical outcomes between obese and non-obese patients as in previously reported studies. The aim was to evaluate what kind of factor is associated with surgical outcomes of partial nephrectomy, and BMI was used in the form of a continuous variable as one of the clinical parameters. As a result of multiple logistic regression analysis, it was found that BMI was an independent predictor for a prolonged OT and higher EBL in OPN, but not in LPN. Therefore, we concluded that LPN was less influenced by BMI and had a greater benefit, especially in high BMI patients.

Conflict of interest statement
None declared.

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