Renal Parenchymal Volumetric Expansion Assessed by CT Imaging After Laparoscopic Cyst Decortication

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Purpose: To delineate the expansion of the renal parenchyma using volumetric CT imaging before and after the laparoscopic cyst decortication procedure and to determine the possible associations between parenchymal expansion and laboratory parameters and cyst volume.

Materials and Methods: Thirty-five patients who underwent laparoscopic cyst decortication were included in this prospective study. Abdominal contrast-enhanced CT was performed in all patients in the preoperative and postoperative period. Semi-automatic volume quantification was undertaken offline, and renal parenchymal volumes before and after cyst decortication, as well as serum creatinine and estimated glomerular filtration rate (eGFR) were compared.

Results: The changes in serum creatinine and eGFR in the postoperative period were non-significant. The mean postoperative renal parenchymal volumes were higher compared to the preoperative measurements for both observations (P = .014 and .034 for the first and second measurements, respectively). There was no correlation between the volumetric change and the cyst volume (r = -0.18, P = .560).

Conclusion: In patients undergoing laparoscopic cyst decortication, post-operative parenchymal expansion can be detected using volumetric CT imaging to confirm the immediate benefits of the procedure.

Keywords: computed tomography; laparoscopic cyst decortication; renal cyst; renal parenchyma; laparoscopic surgery; volumetric evaluation

INTRODUCTION

Renal cysts are very common in the adult population with approximately 50% prevalence.[1] These cysts are rarely symptomatic and do not require treatment in most cases. Treatment strategies include percutaneous cyst aspiration with or without sclerosing agent application, and open or laparoscopic cyst decortication. However, laparoscopic cyst decortication, first described by Hulbert et al.[2] as an alternative option to open surgery, has gradually lost popularity and been replaced by new methods, such as laparoendoscopic single-site surgery and mini-laparoscopic cyst decortication that cause less pain in the postoperative period and less scarring.[3] The main target of cyst decortication is to relieve to pain caused by the cyst and maintain renal function which can be affected by the pressure of the cyst that eventually leads to renal atrophy.[4] Apart from laboratory tests, the functionality of the kidneys can be determined based on data derived from radiological studies. It has been reported that renal parenchymal thickness and related measurements, such as volumetric data calculated from CT imaging can estimate renal function.[5,6] Our hypothesis was that laparoscopic cyst decortication and relieving the pressure of the cyst would alter the function of the renal parenchyma and result in parenchymal expansion in the postoperative period. Thus, in this study, we aimed to delineate renal parenchymal expansion using volumetric CT imaging before and after the laparoscopic cyst decortication procedure. We also aimed to determine the possible associations between parenchymal expansion and laboratory parameters and cyst volume.

MATERIALS AND METHODS

This study received institutional approval from the Ethical Committee of Erzincan Binali Yildirim University Medical Faculty with the IRB number of 9059, and informed consent was obtained from all patients.

Patients

Between February 2017 and February 2018, 102 patients that presented to the outpatient clinic with symptomatic renal cysts were enrolled in our study. From this patient population, 35 patients were selected according to the inclusion criteria. After excluding seven patients based on the exclusion criteria, the final assessment included 28 patients (**Figure 1**).

Evaluation of renal functions

Renal function was evaluated with serum creatinine levels and eGFR. Serum creatinine levels below 1.4 mg/dL were accepted as normal. Creatinine clearance was calculated using the Cockcroft-Gault equation. For indi-

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Table 1. Preoperative and postoperative data with the corresponding p values.

	Preoperative Mean (Median)	95% CI for Mean (Median)	Postoperative Mean(Median)	95% CI for Mean (Median)	p value
Creatinine, mg/dL	0.879	0.758–0.972	0.860	0.803–0.918	0.535*
eGFR, mL/min	81.6	75.6–87.5	81.5	75.1–87.8	0.976*
Parenchymal volume, cm3 1st measurement	132.4	119.4–145.4	136.4	122.7–150.0	0.014*
Parenchymal volume, cm3 2nd measurement	132.5	119.3–145.7	136.8	122.6–151.1	0.034*
Median VAS score	6	5–6.25	1	0–2	< 0.001**

Abbreviations: eGFR, estimated glomerular filtration rate; VAS, visual analog scale
* *p* value for the paired t-test; ** *p* value for the Wilcoxon test

vidual comparisons, a >20% decrease in eGRF was considered to indicate deterioration of renal function. Biochemical tests were conducted preoperatively (one day before the surgery) and postoperatively (immediately after the surgery and at the third, ninth and 18th months.

Evaluation of the degree of pain

Pain was the only indication of operation in our study. There was no other renal disease or pathology (e.g., hypertension, urinary tract infection, hydronephrosis, and macroscopic hematuria) (**Figure 1**). The degree of pain was evaluated by the visual analog scale (VAS) preoperatively at the same time as imaging, and the VAS scores were recorded for each patient. A postoperative evaluation of pain was performed three months after the surgery for comparison.

Imaging Method and Volumetric Analysis

All patients were examined using a 16-row multi-detector computed tomography device (Somatom Emotion 16, Siemens Healthcare, Erlangen, Germany) one month before the surgery and at the postoperative third month. The abdominal CT imaging parameters were as follows: collimation 1 mm, tube current 150 mAs, FOV 300 mm, and matrix 512x512. All patients received an intravenous contrast administration at a dose of 1 mL/kg (Ultravist, Bayer Schering Pharma, Berlin, Germany). The infusion started 35 seconds before image acquisition to ensure that the kidneys were scanned during the late arterial phase. The data obtained from CT imaging were transferred to an offline workstation, and the parenchymal volume was calculated semi-automatically using dedicated software (3D Slicer v4.9.0 software, http://www.slicer.org). A single radiologist with ten years' of experience in abdominal radiology, who was blinded to patient information, processed the data. Volumetric analysis was performed through the segmentation of the selected kidney and labeling the cyst and renal parenchyma in each slice. The level tracing method, which allows highlighting similar densities in the pixels, was used to label the kidney and renal cyst. The renal pelvis, ureter, renal arteries, and veins were excluded from this evaluation. Other small cysts smaller than 1 cm in diameter were disregarded and included in the renal parenchyma. One week after the first measurement, the same radiologist reassessed the patients in mixed order for intra-observer variability.

Statistical Analysis

The sample size was calculated considering the requirements for pairwise comparisons. A minimum of

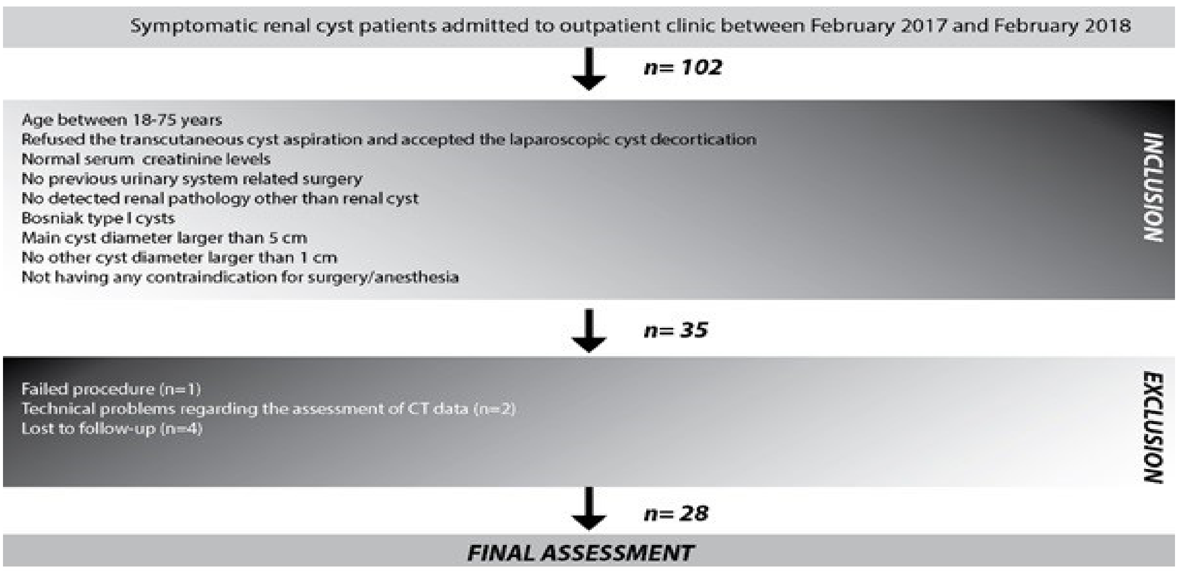

Figure 1. Inclusion and exclusion criteria.

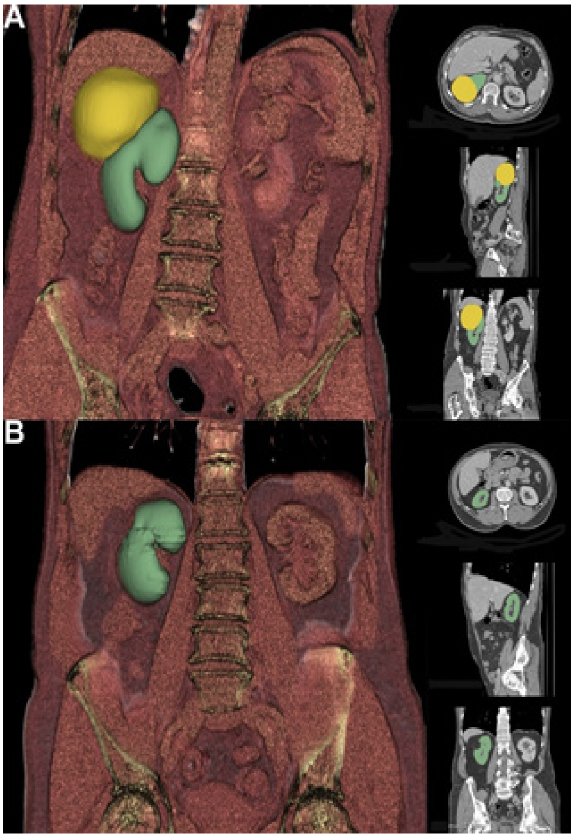

Figure 2. A three-dimensional volume-rendered image showing the labeled kidney and renal cyst in preoperative **(A)** and postoperative **(B)** periods.

14 pairs were needed for the 95% confidence interval (CI), and the power was 0.80 at the significance level of 0.05. The summary statistics of all patients were obtained as mean and standard deviation values. The distribution of normality was assessed using the D'Agostino-Pearson test. The continuous variables with normal distribution belonging to the same patient group were compared using the paired t-test. The Wilcoxon test was used for the non-normally distributed data. Intra-observer variability was assessed with the intra-class correlation coefficient (ICC). A two-tailed p value of < 0.05 was considered statistically significant. All statistical analyses were performed using MedCalc statistical software version 14 (Ostend, Belgium).

RESULTS

The mean age of the study population was 62.7 ± 7.8 years. Sixteen of the 28 patients were female (57.1%). The preoperative and postoperative data regarding the creatinine level, eGFR, renal volume, and median VAS scores were summarized in **Table 1**. The mean postoperative renal parenchymal volume was higher compared to preoperative measurements (**Table 1**). ICC showed very good agreement between the two measurements (ICC: 0.89, 95% CI: 0.88–0.90). The mean cyst volume was 143.9 cm3, and the range of cyst diameter was 6.1–13.2 cm. There was no correlation between the volumetric change and cyst volume (r = -0.18, P = .560). Laparoscopic decortication procedures were successfully performed in all cases except for one patient (3.5%) who was found to have a residual cyst after the surgery. None of the patients required blood transfusion during or after the operation. There were no signs of malignancy in the pathological specimens. All patients were asymptomatic after a mean follow-up of 18 months, and their biochemical test results were within the normal range.

DISCUSSION

In this study, we showed that the renal parenchyma had a volumetric expansion without altering its functionality after laparoscopic decortication surgery. Based on the data acquired at the third month after surgery, the volume of the renal parenchyma increased compared to the preoperative measurement while the creatinine and eGFR levels did not change. Volumetric increment was independent of the renal cyst volume since we found no correlation between the amount of volumetric expansion and cyst volume. Renal cysts are common in the adult population with an estimated prevalence of 50%.[1] This rate ranges from 20% to 50% when applied to the general population.[7,8] Furthermore, the prevalence of these cysts tends to increase with aging.[9] The etiology of the development of simple renal cysts is not clear, and its association with genetics is unknown.[10] Renal cysts are often overdiagnosed with the frequent use of imaging modalities.[11] Although they usually do not require any intervention due to their benign and clinically silent nature, they can cause lumbar and abdominal pain, hypertension, infection, urinary obstruction, and hematuria in symptomatic patients.[12,13] In a recent systematic review, the most common symptom and indication for intervention was pain.[11] Medical treatment aims to reduce the effects of symptoms whereas surgery is indicated when cyst-related pain, infection, and obstruction develop. Medical therapy consists of anti-inflammatory agents mainly used to relieve pain. If medical treatment is inefficient, surgical options for the decompression of the cystic mass by either percutaneous aspiration or open surgery are considered.[14] Percutaneous aspiration of a simple renal cyst is the first choice of intervention and consists of transcutaneous needle placement with or without sclerosing agent application. Although this technique is simple and requires no anesthesia, it has a high recurrence rate.[15] It was reported that over half of the patients that underwent percutaneous aspiration of cysts had reaccumulation of the cystic fluid.[16] Hulbert et al. were the first to describe laparoscopic cyst decortication as an alternative method to conventional surgery.[2] The effectiveness of this technique compared to classical aspiration with sclerotherapy was investigated by Okeke et al., who reported results in favor of laparoscopic cyst deroofing.[17] The pressure applied by the cyst and its effect on the adjacent parenchyma is less discussed in the literature. In a previous study on cyst pressure, it was reported that intra-cystic pressure could reach 31 cm of water.[18] We considered that increased intra-cystic pressure compressed the neighboring parenchyma based on the fact that liquids transmit pressure evenly in all directions. This pressure is thought to be followed by blood supply deficiency. This mechanism is well known to eventually lead to renal atrophy. Some studies associated the compression applied by a cyst with renal arterial compression. Several authors suggested that this kind of pressure led to subsequent ischemia and ultimate activation of the renin-angiotensin, system which results in hypertension in patients. Furthermore, by relieving the pressure of the cyst by needle puncture or surgical decortication, it was shown that blood pressure returned to the normal range.[19,20] Another study conducted with cases of symptomatic autosomal dominant polycystic kidney disease showed that relieving the pressure of the cystic mass also reduced renal capsule tension and parenchymal compression, thereby eliminating symptoms.[21] In another study, Yu et al. performed laparoscopic cyst decortication for patients with autosomal dominant polycystic kidney disease who had renal volumes between 500-1500 cc and found that reducing the pressure on the renal parenchyma increased renal blood supply, improved renal function, and delayed disease progression.[22] To the best of our knowledge, there is no study in the literature that shows the recovery of the parenchymal volume after laparoscopic surgery in simple renal cysts. As summarized above, some authors associated the decompression of the cyst with functional or clinical outcomes. In our study, we revealed the effect of the elimination of this pressure on the volume of the parenchyma. CT imaging with three-dimensional (3D) volume rendering has been proven to be a useful imaging technique that allows the delineation of the detailed renal anatomy and adjacent structures, which is important for surgical planning.[6] Furthermore, 3D images have been used to assess the split renal function, and it has been shown that volumetric calculation can be used for the follow-up of the alteration of renal function over time.[23,24] The volumetric data derived from cross-sectional imaging were reported to be more closely associated with eGFR.[25] In this study, we used the data obtained from multi-detector computed CT imaging for the calculation of renal parenchymal volumes and compared them with the postoperative data. We showed that kidneys tended to expand after the operation without alteration of eGFR. This volumetric expansion occurred most likely due to the relieving of the cystic pressure. We utilized a 3D volumetric evaluation that is more suitable for the assessment of the success of laparoscopic cyst decortication in the absence of evident atrophy (i.e., eGFR was within the normal range). This study has certain limitations. First, our study population was relatively small. Our results should be confirmed by studies conducted with a larger patient population. Second, we evaluated the patients' renal function only by measuring their eGFR and serum creatinine levels. Renal scintigraphy could have provided more reliable information regarding the function of a single kidney. Finally, our mean follow-up duration was 18 months, was relatively short. The effectiveness of the volumetric parenchymal evaluation should be tested over a longer follow-up. Lastly, we chose to perform CT for volumetric imaging. Although this technique has better spatial resolution compared to other cross-sectional imaging methods, the use of radiation and contrast agent places a burden on the excretion system and involves risk of complications.

CONCLUSIONS

Laparoscopic cyst decortication is an effective and less invasive treatment option compared to conventional surgery for symptomatic renal cysts. It has excellent long-term results. The postoperative volumetric changes seen in CT imaging can confirm the immediate benefits of the procedure, and volumetric parenchymal evaluation is a reliable method for a long-term follow-up.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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