Comparison of Standard Absorbable Sutures with Self-Retaining Sutures in Retroperitoneoscopic Partial Nephrectomy: A Retrospective Study of 68 Patients

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Purpose: Although laparoscopic partial nephrectomy (LPN) has been increasingly adopted in the treatment of small localized renal tumor, technical changes remain nowadays. The current study aimed to evaluate the safety and efficacy of the novel QUILL™ Self-Retaining System (SRS) for renorrhaphy during LPN.

Materials and Methods: Sixty-eight patients with kidney neoplasm that accepted LPN at the Peking Union Medical College Hospital from July 2010 to March 2013 were retrospectively analyzed. Thirty-five patients who received renal sutures with QUILL™ SRS constituted group 1. The control group (group 2) composed of 33 patients who received standard absorbable Vicryl sutures by the same surgeon. Renorrhaphy was performed in both groups using two layers, with a closure of the deep vessels and collecting system, followed by a running closure of the renal capsule. The demographic and perioperative parameters [gender, laterality of the tumor, body mass index (BMI), tumor size, standardized nephrometry scoring system (R.E.N.A.L. Nephrometry Score)], estimated blood loss and warm ischemic time (WIT)) were compared between the groups. Risk factors of WIT and blood loss were analyzed using logistic regression analysis.

Results: Renorrhaphy was successfully completed in both groups. The baseline data of two groups did not differ significantly. Logistic regression analysis showed WIT decreased when the QUILL™ SRS was used (21.8 ± 3.5 min vs. 25.6 ± 4.0 min; $\beta = -4.109$, $P < .001$). Suture methods were an independent predictor of WIT rather than blood loss (115.7 ± 57.9 mL vs. 137.9 ± 68.5 mL; $P = .329$).

Conclusion: QUILL™ SRS can be effectively and safely used for renorrhaphy during LPN with the potential advantage of shortening WIT.

Keywords: suture techniques; laparoscopy; kidney neoplasms; nephrectomy; methods; feasibility studies; sutures; treatment outcome.

INTRODUCTION

Laparoscopic partial nephrectomy (LPN) is effective in tumor control and renal function preservation.[1-3] LPN achieves comparable effects on T1a-stage kidney neoplasms to open partial nephrectomy.[4,5] LPN results in satisfactory effects on T1b-stage kidney neoplasms.[2] Laparoscopic surgery has been adopted by an increasing number of urologists over traditional open surgery due to the following advantages: minimal invasiveness, more aesthetic wounds, less severe postoperative pain and faster recovery.[6] However, LPN remains technically challenging. During LPN, intraoperative warm ischemia of the affected kidney is often necessary. This treatment benefits the visualization of the tumor extent as well as complete tumor resection. In addition, it facilitates the closure of the parenchyma. However, ischemia reperfusion can lead to damage to renal function, and the severity of the damage is positively associated with warm ischemia time (WIT); to better preserve renal function, WIT should be shortened as much as possible.[7,8] Renal suturing and knotting are the most time-consuming and challenging steps during LPN. Simplifying these complex procedures can reduce WIT and better preserve renal function. Continuing innovation has led to the reduction of the WIT through various technical modifications, such as sliding clip renorrhaphy, early hilar unclamping and unclamped partial nephrectomy.[9-11]

The QUILL™ self-retaining suture (QUILL™ SRS) (Angiotech, Vancouver, Canada) is a barbed suture material (**Figure 1**). The barbs change direction mid-suture, prevent slippage through tissue, and eliminate the need to maintain continuous tension while suturing and tying knots. QUILL™ SRS is used primarily for wound closure during plastic surgery procedures. Its potential application in urological surgery was assessed in an animal model of vesicourethral and ureteropelvic anastomoses and found to be a reliable knotless method of performing watertight anastomoses.[12,13] Although the applicability of the self-retaining barbed suture V-Loc™ 180 for the renal collecting system and parenchyma sutures in LPN has been reported,[14,15] to the best of our knowledge stud-

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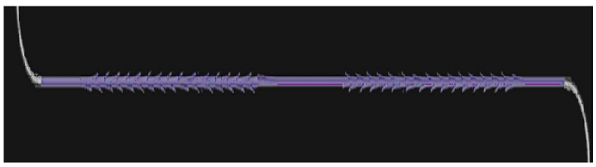

Figure 1. QUILL™ Self-Retaining System.

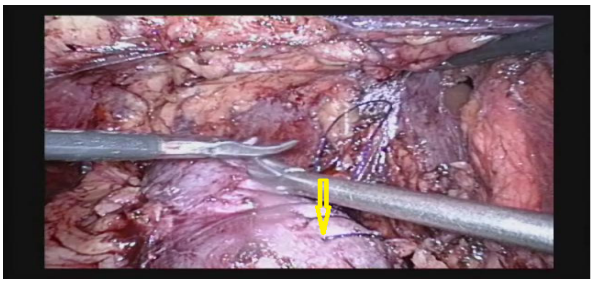

Figure 2. Photograph of a QUILL™ Self-Retaining System used during an operation.

ies on the safety and efficacy of QUILL™ SRS have not been found in literature. Here, we evaluated the safety of QUILL™ SRS for use in renal suturing in LPN. Furthermore, we compared it with a standard suture for effectiveness on renal WIT.

MATERIALS AND METHODS

Study Subjects

From July 2010 to March 2013, sixty-eight patients with kidney neoplasm who received LPN at the Peking Union Medical College Hospital were retrospectively analyzed. Thirty-five of them subjected to renal sutures with QUILL™ SRS between February 2012 and March 2013 constituted group 1. The remaining 33 of them subjected to standard absorbable Vicryl (Vicryl™, Ethicon, Johnson & Johnson, Somerville, NJ, USA) sutures by the same surgeon between July 2010 and December 2011 comprised group 2. Group 1 included 22 males and 13 females. The patients' ages ranged from 42 to 75 years with a median age of 58.1 ± 8.1 years. Group 2 included 21 males and 12 females. The patients' ages ranged from 38 to 72 years (median, 57.4 ± 8.7 years).

The inclusion criteria included single tumor with a clinical stage between cT1a and cT1b. The exclusion criteria included abnormalities in platelet or clotting time before operation, recurrent renal tumor, other simultaneous surgery and a history of surgery in the same operative region. For each patient, body mass index (BMI), tumor size, laterality, WIT, estimated blood loss during surgery, and postoperative complications were recorded. The standardized nephrometry scoring system (R.E.N.A.L. Nephrometry Score) was used to evaluate the complexity of the surgery.[16]

The R.E.N.A.L. Nephrometry Score consists of (R)adius (tumor size as maximal diameter), (E)xophytic/endophytic properties of the tumor, (N)earness of tumor deepest portion to the collecting system or sinus, (A)nterior (a)/posterior (p) descriptor and the (L)ocation relative to the polar line. WIT was calculated from the obstruction of the renal artery with the bulldog clip to the loosening of the clip. The final data were then compared between the groups. All the operations were performed by the same surgeon. The surgeon was experienced in retroperitoneoscopic surgery, who had performed LPN for hundreds of patients before this study.

This study was conducted in accordance with the Declaration of Helsinki and with the approval of the institutional ethics committee of Peking Union Medical College Hospital. Informed consent was obtained from all participants.

Surgical Techniques

The subjects in both groups underwent operations through

Table 1. Baseline data and perioperative outcomes of patients in the study groups.

Patient Characteristics	QUILLTM SRS Group (n = 35)	Absorbable Suture Group (n = 33)	*P* Value
Age (years)[a]	58.1 ± 8.1	57.4 ± 8.7	.713
Sex (Male/Female)	22/13	21/12	.947
BMI (kg/m^2)	25.1 ± 1.6	24.7 ± 1.9	.337
Side, Left/Right	18/17	19/14	.611
Maximum tumour size (cm)	2.8 ± 0.6	2.9 ± 0.5	.513
R.E.N.A.L. score	6.3 ± 1.2	6.2 ± 1.0	.625
Blood Loss (mL)	115.7 ± 57.9	137.9 ± 68.5	.153
WIT (min)	21.8 ± 3.5	25.6 ± 4.0	< .001
Postoperative complications,[b]	1/35	1/33	1.0
Pulmonary infection (I)	1	0	
Bleeding (III)	0	1	
Postoperative pathology			
Clear cell carcinoma	33	32	
Papillary cell carcinoma	2	1	

Abbreviation: QUILL™ SRS, QUILL™ Self-Retaining System.

* Data are presented as means ± standard error of the means ($\bar{x} \pm s$).

[a] The mean ± standard deviation of the mean.

[b] Clavien-Dindo grade.

Table 2. Multiple linear regression analysis: Predictors of warm ischemia time and blood loss.

Parameters	Dependent Variable: WIT		Dependent Variable: Blood Loss	
	β	*P* Value	β	*P* Value
Maximum tumour size	-1.152	.501	96.238	.000
R.E.N.A.L. Score	1.506	.085	-8.756	.421
Suture method	-4.109	.000	-11.395	.329
BMI	0.151	.552	-2.620	.412

Abbreviations: WIT, warm ischemia time; BMI, body mass index.

a retroperitoneal approach. A 10 mm trocar was placed 2 cm above the iliac crest at the middle axillary line into a 30° inspection glass; another 10 mm trocar was placed under the costal margin along the posterior axillary line as the major operating channel. A 5 mm trocar was placed under the costal margin along the anterior axillary line as the accessory channel. The renal pedicle was blocked by blocking the renal artery alone with a bulldog clip after isolation. In cases where an accessory renal artery was present on preoperative computed tomographic angiography, the artery was also blocked using a bulldog clip after being set free. The renal parenchyma was cut 0.5 cm away from the tumor margin by opening the renal capsule using an electric hook and then cutting off the entire tumor and a portion of the renal tissue using sharp scissors. Electrical coagulation was used to stanch the bleeding if the blood vessels were clearly observed. Methods for renal suture and renorrhaphy in group 1. Group 1 received a QUILL™ SRS. The suture was tightened unidirectionally and did not backslide because of the immobilization of the multiple barbs within the tissue. A series of 3-0 QUILL™ SRS were used to repair the impaired collecting system. A HEM-O-LOK clip was placed at the end of a 15 cm long suture inserted from outside the kidney, and the inner layer was sutured and closed the collecting system. The needle was withdrawn from outside the renal capsule, and knotting was unnecessary because of fixation of the suture to the barbs. Additional 0 size QUILL™ SRS sutures were used to suture the second layer of the renal parenchyma. A HEM-O-LOK clip was also placed at the end of the sutures, and each suture was pulled tightly after the stitching. The sutures did not backslide due to the anchoring of the unidirectional barbs on the suture. Renorrhaphy was completed using the same approach (**Figure 2**).

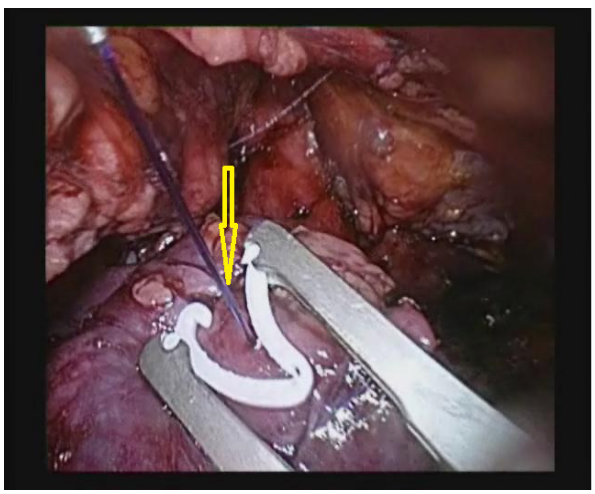

Figure 3. Photograph of an absorbable suture in a patient in group 2.

Methods for renal suture and renorrhaphy in group 2. Group 2 received standard absorbable sutures. The suturing and knotting involved in the repair of the open collecting system were performed using 1 or more 15 cm long 4-0 absorbable sutures. The suturing and ligation to the broken ends and bleeding points on the wound surface were completed. All of the knots were placed within the wound surface. The renal parenchyma was sutured continuously using 25 cm long 0 size absorbable sutures (the actual length used in LPN can be 15-25 cm long, which varies according to the tumor size and wound area, based on our experience), and a HEM-O-LOK clip was placed at the end of the sutures. The needle was inserted from outside the renal capsule and then withdrawn through the opposite capsule. After each stitch, the suture was pulled tightly, and a HEM-O-LOK clip was placed on the side on which the needle was withdrawn to avoid backsliding of the suture (**Figure 3**). After completing the renorrhaphy, the suture was cut, the Bulldog clip was loosened to restore the renal blood flow, and the restoration of normal renal blood supply was confirmed.

Statistical Analysis

Statistical analyses were performed with the Statistical Package for the Social Science (SPSS Inc, Chicago, Illinois, USA) version 16.0. Measures of central tendency in continuous data were presented as means ± standard error of the means ($\overline{x} \pm s$).The differences in continuous variables between two groups were compared using independent *t*-tests and the associations of categorical variables were analyzed using chi-square tests. Multivariate linear regression analysis was performed to determine the independent predictors of WIT and blood loss. All statistics were tested using the two-tailed method. $P < .05$ was considered statistically significant.

RESULTS

Baseline and Perioperative Data

The baseline and perioperative data of the two groups are summarized in **Table 1**. No significant differences in the baseline data were observed between the groups. Renorrhaphy was successfully completed without any conversions to an open procedure or nephrectomy in both groups. The two groups did not show significant differences in the perioperative outcomes except for the WIT

(21.8 ± 3.5 min vs. 25.6 ± 4.0 min, $P < .001$). For postoperative complications, one patient suffered pulmonary infection in group 1. After antibacterial treatment, the patient recovered. In group 2, there was 1 case of postoperative bleeding, which was cured by performing interventional angiography of the renal artery and super-selective embolization.

Multiple Linear Regression Analysis

The associations between possible risk factors and WIT/blood loss in patients subjected to LPN were analyzed using logistic regression analysis, which included maximum tumor size, R.E.N.A.L. score, suture method and BMI. The results are summarized in **Table** 2.

As shown in **Table 2**, the WIT decreased when the QUILL™ SRS was performed ($\beta = -4.109$, $P < .05$) and suture methods were an independent predictor of WIT. However, they were not predictive for blood loss ($P = .329$).

DISCUSSION

There have only been a few reports on the use of QUILL™ sutures in urological surgery, laparoscopic pyeloureteral anastomosis, and vesicourethral anastomosis.[12] No study has been conducted to evaluate the use of these sutures in partial nephrectomy until now; this is the first report on the use of QUILL™ sutures in renal tissue suturing and repair during LPN.

This study evaluated the safety and efficacy of QUILL™ SRS for renorrhaphy during LPN. In group 1, one patient presented with pulmonary infection after operation, which was proved unrelated to the new suture method. This finding indicates that QUILL™ SRS sutures are safe for use as renal sutures. Furthermore, logistic regression analysis showed that suture methods, rather than other factors, were an independent predictor of WIT. This finding suggests that QUILL™ SRS may benefit renal function protection by reducing the renal WIT during LPN. Moreover, patients with abnormalities in platelets or clotting time before operation were excluded from this study, which successfully avoided the possibility of bleeding caused by the hematological system. In addition, all the operations in this study were performed by the same surgeon, which greatly reduced the risk of bleeding caused by human factors. The regression analysis evidenced that suture methods were not associated with blood loss. Therefore, QUILL™ SRS is safe for renorrhaphy during LPN.

Partial nephrectomy is the standard treatment for localized renal tumors, achieving the same outcome as radical nephrectomy with respect to the tumor control rate;[17] this approach benefits the patients by preserving the function of the affected kidney.[17-20] Laparoscopic partial nephrectomy has achieved the same efficacy as open surgery in terms of tumor treatment and renal function preservation, while offering the following advantages: less invasiveness, more aesthetic wounds, less severe postoperative pain, and faster recovery.[21] However, because this approach is technically difficult and risk its widespread use is limited because it requires performing renal tumor resection and renal suture, repair and knotting within a short period of time to reduce the renal WIT and preserve the residual renal function. This procedure presents a significant challenge for beginners and even experienced laparoscopic surgeons, as the process of suturing and knotting under laparoscopic guidance is difficult and time-consuming. Gill and colleagues reported that in 1800 cases of open and laparoscopic partial nephrectomy performed over the same period, despite the more complex conditions in the open surgery cases, the WIT in the patients who underwent laparoscopy was 10 min longer than that of patients who underwent open surgery.[21] The renal WIT can be reduced by simplifying the renal suturing and knotting process, thereby improving the surgical safety. Although hemostatic colloids are applicable for capillary hemorrhage from the wound surface after partial nephrectomy, suturing hemostasis is a better choice for noticeable hemorrhage or hemorrhage from the broken ends of small arteries. Furthermore, suturing can directly close the collective system, thereby reducing the incidence of postoperative urine leakage. During traditional laparoscopy, absorbable sutures are used to suture and close the renal collecting system and repair the renal parenchyma, either intermittently or continually. Because it is easy for the sutures to backslide, it is usually necessary for the surgeon to pull the sutures tightly with one hand, leaving the other hand to stitch. This strategy leads to inapposite sutures and an increased risk of postoperative bleeding and urinary fistula. Most surgeons adopt a modified suture method to reduce the technical difficulty and increase safety. Suture retraction was avoided by applying a HEM-O-LOK clip to fix the suture after each stitch; the number of knots was also reduced. Although this approach effectively simplifies the operation and improves the safety, repeatedly changing the needle carriers and HEM-O-LOK pliers increases the WIT. Moreover, the cost of surgery is increased due to the need for additional HEM-O-LOK clips.

QUILL™ is a knotless, self-retaining barbed suture (SRBS). There is one needle at each end of the suture, and a group of barbs is placed every 1 cm on the suture; these barbs change direction at the midpoint of the sutures. QUILL™ was first used for wound closure in plastic surgery and gynecology and obstetrics.[22,23] The initial application of SRBS in urological surgery was in pyeloureteroplasty and vesicourethral anastomosis, achieving good results in both in vitro and animal experiments.[12,13] Sergey Shikanov and colleagues reported that in pigs, the same effect was achieved during partial nephrectomy to close the collecting system and repair the renal parenchyma, indicating that this novel suture is safe and reliable in renorrhaphy.[24] Olweny and colleagues reported the use of another barbed suture, the V-LOC suture, during laparoscopic renorrhaphy and collecting system closure and compared it with traditional absorbable sutures; the former approach significantly reduced the intraoperative renal WIT. They also believed that barbed sutures would likely reduce the incidence of serious intraoperative bleeding.[25] Sammon and colleagues reported that during robot-assisted laparoscopic partial nephrectomy, the use of V-LOC sutures to suture and repair the kidneys and collecting systems improved the efficiency of the sutures, shortened the renal WIT, and was safe and reliable.[26] Jeon and colleagues reported that the use of V-LOC for kidney suturing in transperitoneal LPN noticeably shortens the WIT of the kidneys.[14] The same result was also

reported by Selcuk and colleagues.[15] Our results were consistent with those in literatures. However, none of the released studies focused on retroperitoneal partial nephrectomy. QUILL™ sutures solve the problem of knotting under laparoscopic guidance, thereby improving the efficiency of suturing. Because its own barbs can exert a unidirectional anchoring effect within the renal tissue, there is no backsliding after pulling the suture tightly, which facilitates two-handed suturing by the operator. The strain is evenly distributed to multiple barbs along the length of the suture, which allows the suture to exert a greater stretching force at the wound margin and satisfies the wound margin apposition. No complications were observed regarding the suture material being incompatible with the renal tissue, suggesting good histocompatibility. Additionally, there was no secondary bleeding or urinary fistula in group 1, indicating the safety of this approach. Because there was no need to produce knots under laparoscopic guidance or to change the HEM-O-LOK clips, the renorrhaphy time and WIT were significantly reduced, and improved renal function preservation was achieved.
This study had limitations. First, the results of this study were based on only one surgeon's experience. Therefore, the WIT and intraoperative hemorrhage volume values have limited generalizability. Second, because this study was retrospective in nature, the two groups were not selected through match-pair. Third, the sample size was small, and more cases remain to be analyzed in the future.

CONCLUSION

The novel QUILL™ SRS is as effective, efficient, and safe as a conventional technique in laparoscopic partial nephrectomy. Compared with the standard absorbable suture, QUILL™ SRS greatly shortened the renal WIT. Further studies are needed to corroborate these findings, but the present results indicate a promising development in reducing WIT during minimally invasive partial nephrectomy.

CONFLICT OF INTEREST

None declared.

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