**Running Head:** Primary vs. Redo robotic pyeloplasty in adults

# Title**: Robot-assisted Laparoscopic Pyeloplasty in Adults: A Comparison Analysis of Primary versus Redo Pyeloplasty in a Single Center**

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## ABSTRACT

**Purpose:** Approximately 10% of all primary pyeloplasty will require at least one secondary intervention. Our aim was to analyze whether secondary repair will pose additional challenges during robotic pyeloplasty compared with the primary pyeloplasty.

**Material and Methods:** 114 patients who underwent robot-assisted laparoscopic pyeloplasty (RALP) between February 2015 and August 2018 were retrospectively reviewed. Patients were divided into; primary and secondary repair pyeloplasty. The demographics, intraoperative parameters, postoperative parameters, and success rate of these two groups were collected and compared. Primary RALP data were further stratified into those who previously underwent ipsilateral endourological surgeries (IES) at the obstruction site and those who did not, to evaluate the effect of IES has on the outcome of RALP. Success was defined as symptomatic and radiological relief.

**Results:** Of the 114 patients, five complicated cases (three horseshoe kidneys, one duplicated system, and one retrocaval ureter) were excluded from the comparison. The

remaining 96 primary and 13 secondary repairs were compared. Intraoperative and postoperative parameters showed no significant difference between the two groups. The results of 99 patients (87 vs. 12 in primary vs. secondary, respectively) were available after 27.5 months mean follow-up. The overall success was 92%, 8 patients failed (5 vs. 3 in primary vs. secondary, respectively) and required further surgical interventions.

**Conclusion:** Though surgically challenging with increased recurrence rates according to the literature we reviewed. However, our data failed to show any significant difference between the primary and redo RALP perhaps due to the smaller size in the redo RALP group.

**Keywords:** primary pyeloplasty; secondary pyeloplasty, robot-assisted laparoscopy; comparison, outcomes

## INTRODUCTION

Open pyeloplasty has been the gold standard treatment for the management of ureteropelvic junction obstruction (UPJO) for more than a century with an excellent success rate of up to 100% [(1)]. Nevertheless, reports indicate that approximately 11.4% of post-pyeloplasty patients will require at least one redo procedure, and within one year in up to 87% [(2)]. Unlike primary pyeloplasty, the redo approach is particularly challenging due to the disrupted anatomical planes, decreased vascularity to the ureteropelvic junction (UPJ) area, and scar tissue around the previously repaired site. Several minimally invasive techniques such as balloon dilatations, retrograde or antegrade endopyelotomy, conventional laparoscopy, and lately robotic approach have been reported in the literature to replace open repair in redo pyeloplasty for their lower morbidity. Nevertheless, techniques such as endopyelotomy have shown significantly lower success rates than open redo pyeloplasty [(3)].

In the last 2 decades, robot-assisted laparoscopic approach has gained significant attention. Compared with traditional laparoscopy, da Vinci® robotic system (Intuitive Surgical, Inc., Sunnyvale, CA) provides a better hand instrument and vision which has tremendously improved the speed of intracorporeal suturing in all laparoscopic reconstructive surgeries. For the above advantages, many centers, including ours, have utilized da Vinci® robotic

system when dealing with failed pyeloplasty for its excellent image quality and better fine dissections which is very vital for this technically demanding procedure.

In the literature, we found numerous studies addressing the novelty, operational safety, efficacy, and success of the robotic pyeloplasty, some studies compared with traditional laparoscopy, and open technique. However, only a few reports have compared primary with redo pyeloplasty in the robotic setting. Therefore, we aimed to evaluate the surgical and clinical outcomes of robotic redo pyeloplasty compared to primary pyeloplasty.

## MATERIAL AND METHODS

From February 2015 to August 2018, 114 consecutive patients underwent robot-assisted laparoscopic pyeloplasty (RALP) at Tongji Hospital, Urology department using da Vinci Si robotic system for UPJO management. During preoperative imaging work-up, a multislice computed tomography (CT) scan, intravenous urography, magnetic resonance urography (MRU) or retrograde urography were utilized to localize and evaluate the extent and the degree of the obstruction. Diuretic 99mTc-mercaptoacetyltriglycine (MAG3) renography examination was performed if an ipsilateral renal parenchymal loss is suspected. Once the diagnosis was established, a complete preoperative work-up containing; detailed history, physical examination, renal function test, blood chemistry, urinalysis, coagulation study, and blood screening study was conducted. An informed consent document was obtained from each patient before any surgery was carried out.

Our institution's ethical committee approval was obtained to conduct this retrospective review. After that, we collected the data and divided patients into two groups; primary RALP and secondary RALP (after open or laparoscopic primary pyeloplasty has failed). The surgical and clinical outcomes of these two groups were compared and analyzed. Preoperative parameters such as; age, sex, body mass index (BMI), symptoms, obstruction side, history of prior surgery, type of previous intervention, and associated conditions were recorded. Intraoperative, and postoperative parameters such as; American Society of Anesthesiologists (ASA) score, estimated blood loss (EBL), operative time, complication rates, length of hospital stays (LOS), double J (D-J) removal time, follow-up period, and recurrence rates between the groups were also collected and analyzed. In the primary RALP group, some patients had a history of ipsilateral endourological surgery (IES) such

as percutaneous nephrolithotomy (PCNL), ureteroscopic laser lithotripsy (URL), and endopyelotomy at the obstruction site for stone or UPJO treatment. We compared patients with IES history to those who did not undergo any prior ipsilateral surgery at obstruction site to evaluate the effect of IES on the outcome of RALP.

During the follow-up, CTU or MRU was used as the first choice in the postoperative imaging review. However, some patients chose ultrasound imaging for its convenience, lower price, and absence of radiation. The first examination was conducted one month after the double J stent removal, and then every six months. Success was defined as symptomatic and radiological relief; symptomatic relief is accounted according to patients subjectively reporting that their pain has subsided and they are no longer using any pain medication. Radiological success is achieved if the hydronephrotic state is not severed compared to before the surgery, and no apparent radiological evidence of any obstruction seen at the operated site.

**Statistical Analysis**

We have used version 16 of the Software of Statistical Package for the Social Sciences (SPSS) to compare our data. Fisher's exact test was performed in all categorical data for the group comparison (except obstruction side in Table 1 for which we performed a Pearson's Chi-squared test). For the continuous data, since data was not normally distributed, we performed a Man-Whitney U test to compare the groups, and the results are presented as median and range (except the BMI for which we performed a student t test and the results are shown as mean and ± SD). $P<0.05$ was considered to be statistically significant.

**RESULTS**

Of 114 patients, seventy-percent were symptomatic while the rest presented with asymptomatic hydronephrosis. Transperitoneal approach with dismembered pyeloplasty was performed in all operations using da Vinci® $S_i$ robotic system under two experienced surgeons (each surgeon performed >1500 robotic procedures). The primary pyeloplasty group comprised of 101 subjects while the secondary pyeloplasty group contained 13 patients. Of the 101 primary pyeloplasty patients, five anatomically complicated cases

(three horseshoe kidneys, one duplicated system, and one retrocaval ureter) were excluded from the comparison analysis since these conditions could have extra surgical challenges and have a tendency to alter the results. The remaining 96 vs. 13 patients of primary vs. secondary RALP, respectively, were compared. **Table 1** shows the overall demographic data of the two groups. Intraoperative and postoperative parameters are shown in **Table 2**. The previous failed interventions of the secondary RALP group were five open pyeloplasties and eight conventional laparoscopic pyeloplasties, and the meantime from their primary surgery was 5.6 years (range, five months to 20 years).

The surgical details of our approach have been previously well described by other investigators [(4)]. A double J ureter stent was placed before the completion of each anastomosis (see **Figure 1**). No patient required conversion to an open approach. In the comparison analysis, none of the intraoperative and postoperative parameters we compared showed significant between the two groups.

The primary RALP group contained two sets of patients; 32 patients who had prior ipsilateral UPJ surgeries (the list of their previous surgeries is shown in **Table 3**), and 64 patients who did not have any previous ipsilateral surgery. 30 patients (two patients with a history of open lithotomy were excluded from this subgroup comparison) who previously underwent IES were compared with the 64 patients who did not receive prior ipsilateral surgery to evaluate the effect of IES on RALP outcome. The analysis results showed no significant difference between the two subgroups (see **Table 4**).

We encountered one case of antegrade double J insertion failure in the primary RALP group, which required intraoperative use of a retrograde ureteroscope for stent placement. Six patients required postoperative cystoscopic stent pulling into the bladder to prevent further stent migration. The ureter stent was challenging to be removed under cystoscope in one case, which required the use of ureteroscopy under general anesthesia.

Ten patients were lost to follow-up; for this reason, the results of the remaining 87 vs. 12 cases in primary vs. secondary RALP, respectively, were used when comparing the follow-up period and success rates. Finally, in **Table 5**, we have summarized previously published articles comparing primary vs. secondary RALP.

## DISCUSION

Minimally invasive techniques and open approach for primary pyeloplasty are abundant in the literature, unlike redo pyeloplasty studies, which are very limited. One explanation could be the rarity of persistent and recurrent UPJO due to the high success rates of the primary pyeloplasty, particularly when an open technique is utilized in the primary setting. Several causes that may lead to the failure of the primary pyeloplasty have been suggested including; formation of periureteric fibrosis due to urine extravasation after pelviureteral anastomotic failure, thermal damage to the ureteral blood supply, and missed lower pole crossing vessel during the initial surgery [(5)]. Furthermore, the dissection and repair of failed pyeloplasty's are technically very challenging, due to abdominal adhesions and periureteric fibrosis.

Techniques such as; placement of ureter stents, balloon dilations, and endopyelotomy are among the least invasive procedures for the management of UPJO. Some of the techniques were associated with superior surgical and clinical outcomes compared with others when dealing with recurrent UPJO. For instance, Abdel-Karim et al. reported higher EBL and pain score, and prolonged operative time and LOS in open redo pyeloplasty (ORP) compared with laparoscopic redo pyeloplasty (LRP) [(5)]. Similarly, a meta-analysis study comprising 88 LRP vs. 153 ORP has shown significantly reduced LOS in the LRP with no significant difference in the success rate, although the operative time was shorter in the ORP [(6)]. Furthermore, endopyelotomy technique as a secondary intervention has also shown to decrease the LOS compared with ORP [(7)]. However, the success rates were significantly higher in LRP compared with endopyelotomy, 87.5% vs. 74%, respectively [(8)].

Recognizing the increased challenge when doing subsequent reconstructive surgeries, we expected a significant rise in surgical time, complication rates, and EBL in redo pyeloplasty. Nevertheless, our analysis failed to show any significant difference in terms of operative time, EBL, complication rates, and recurrence. Unlike ours, Baek et al. [(9)] and Atug et al.

[10] found significantly longer operative time, console time, and dissecting time in the secondary RALP group when compared with primary RALP. Thom et al. [11] have also significantly increased EBL in the redo robotic pyeloplasty compared with primary RALP. Similarly, a newly published meta-analysis study by Dirie et al. [12] (containing; 613 vs. 107 patients in primary vs. redo RALP, respectively) found significantly increased operative time, EBL, and recurrence in redo robotic pyeloplasty compared with primary RALP.

On the other hand, the literature concerning previous abdominal surgeries (PAS) and their impact on the subsequent abdominal surgeries are conflicting; some reported that PAS has no adverse effect on secondary operations [13] while others reported the opposite. Two recent studies; one laparoscopic radical cystectomy and one robot-assisted laparoscopic partial nephrectomy have found a higher EBL in those patients who had previous major abdominal surgery compared to those who did not [14, 15].

Conventional laparoscopy in redo pyeloplasty has shown poor outcomes when compared with laparoscopic primary pyeloplasty. Nishi et al. found an increased operative time, EBL, and complication rates in LRP when compared with secondary laparoscopic pyeloplasty [16]. Additionally, the longer learning curve and the technical challenges related to mastering intracorporeal suturing skills made conventional laparoscopy less popular approach than robotics in reconstructive urology. However, we should acknowledge the newly emerged technologies in traditional laparoscopy such as 3D laparoscopic cameras and robotized laparoscopic needle drivers; these technologies have demonstrated improved surgical outcomes in reconstructive surgeries [17, 18]. Improvements in conventional laparoscopy could be appreciated considering the higher cost required to purchase and maintain robotic machines, especially for those medical centers with smaller budgets.

Robot-assisted laparoscopy has been the cornerstone surgical modality for reconstructive urology including RALP surgery since its birth in the early 2000s. Robot-assisted laparoscopy has an excellent surgical and clinical record in both adults and children in the primary pyeloplasty. Autorino and colleagues [19] presented the largest review study to date in which they have critically analyzed a large data concerning robotic and laparoscopic pyeloplasty. Of the 841 RALP adult cases reviewed in the study, the operative time ranged

between 105-335minutes with only three conversions while reintervention and success rates were 1.8-13.1% and 81-100%, respectively.

Compared with the conventional laparoscopy, significantly shorter operative time, suturing time, and LOS were found in RALP [20]. Similarly, another study linked RALP with significantly improved obstruction, pain, and fewer secondary intervention needed [21]. Furthermore, Hemal et al. reported 10 cases of redo RALP with a 100% success rate after 7.4 months of mean follow-up [22]. Despite the growing popularity and the outstanding results with robotic surgeries, the high direct and indirect costs to purchase and maintain it makes robotic surgeries economically less competitive than open approach [23].

Besides the technique utilized, one should keep in mind that there are other factors such as the surgeon's experience, the preoperative severity of hydronephrosis, and renal function which can influence the surgical and clinical outcomes after pyeloplasty repair. For instance, some studies associated poor preoperative renal function and severe hydronephrosis with increased failure rates after the surgery [24, 25].

There are some limitations in our study that must be addressed such as; the retrospective nature, lack of long-term follow-up since failure can be seen even after many years later, lack of urographic imaging in all cases in the follow-up, and the small sample size of our cohort.

## CONCLUSIONS

According to the existing literature and our current study, robot-assisted laparoscopic pyeloplasty is an excellent surgical approach in primary pyeloplasty. Furthermore, our data failed to show any significant difference in terms of surgical and clinical outcomes between primary and redo pyeloplasty, perhaps the smaller data in our redo pyeloplasty. However, one must be aware the increased surgical challenges and the higher recurrence after surgery in the redo pyeloplasty according to the other similar literature we reviewed including recently published meta-analysis study.

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## CONFLICT ON INTEREST

Authors declare that there is no conflict of interest to disclose.

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| **Demographics[a]** | **Overall n (%)** | **Primary pyeloplasty** | **Secondary pyeloplasty** | **p - value** |
|---|---|---|---|---|
| No. of Patients | 109 | 96 | 13 | - |
| Sex, n (%) | | | | |
| Male | 74 (67.9) | 65 (67.7) | 9 (69.2) | .999 |
| Female | 35 (32.1) | 31 (32.3) | 4 (30.8) | |
| Age, years; median (range) | 29 (10 -70) | 33 (10 - 70) | 25 (18 - 51) | .156 |
| BMI, $kg/m^2$; mean ± SD | 22.6 ± 3.4 | 22.8 ± 3.3 | 21.7 ± 4.0 | .273 |
| ASA score, n (%) | | | | |
| I | 32 (29.3) | 28 (29.2) | 4 (30.8) | |
| II | 73 (67) | 64 (66.7) | 9 (69.2) | .999 |
| III | 4 (3.7) | 4 (4.1) | 0 | - |
| Presented symptom, n (%) | | | | |
| Flank pain | 31 (28.4) | 30 (31.3) | 1 (7.7) | .104 |
| Asymptomatic hydronephrosis | 32 (29.4) | 29 (30.2) | 3 (23.1) | .752 |
| Abdominal pain | 20 (18.4) | 17 (17.7) | 3 (23.1) | .703 |
| Others | 26 (23.8) | 20 (20.8) | 6 (46.1) | .076 |
| Obstruction side, n (%) | | | | |
| Left | 58 (53.2) | 49 (51.0) | 9 (69.2) | .217 |
| Right | 51 (46.8) | 47 (49.0) | 4 (30.8) | |
| History of ipsilateral urolithiasis, n (%) | | | | |
| Yes | 33 (30.3) | 30 (31.2) | 3 (23.1) | .751 |
| No | 76 (69.7) | 66 (68.8) | 10 (76.9) | |
| Crossing vessel, n (%) | 8 (7.3) | 7 (7.3) | 1 (7.7) | .999 |

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**Table 1.** Patient demographics (primary vs. secondary RALP)

**Abbreviations:** RALP, Robot-Assisted Laparoscopic Pyeloplasty**;** BMI, Body Mass Index; ASA, American Association of Anesthesiologists; SD, Standard Deviation.

[a] Categorical and continuous (except BMI parameter) data were compared using Fisher's Exact test and Man-Whitney U test, respectively.

**Table 2.** Intra and postoperative outcomes (primary vs. secondary RALP)

| **Parameters**[a] | **Overall** | **Primary pyeloplasty** | **Secondary pyeloplasty** | **p -value** |
|---|---|---|---|---|
| No. of Patients | 109 | 96 | 13 | - |
| Operative time[b] (min); median (range) | 0 (0 – 300) | 0 (0 – 300) | 100 (0 – 300) | .104 |
| EBL (ml); median (range) | 141 (47 – 375) | 137 (47 – 375) | 148 (79 – 308) | .340 |
| Complications, n (%)<br>Clavien II<br>Clavien III | <br>16 (14.68)<br>8 (7.34) | <br>14 (14.58)<br>7 (7.29) | <br>2 (15.38)<br>1 (7.69) | <br>.995 |
| LOS (days); median (range) | 6 (3 – 14) | 6 (3 – 14) | 6 (3 – 14) | .872 |
| Stent removal time (weeks); median (range) | 8 (4 – 10) | 8 (4 – 10) | 8 (4 – 10) | .636 |
| Follow-up period[c] (months); median (range) | 25 (6 – 57) | 25.5 (6 – 57) | 25 (15 – 56) | .807 |
| Recurrence rate[b], n (%) | 8 (8.1) | 5 (5.7) | 3 (25) | .054 |

**Abbreviations:** RALP, Robot-Assisted Laparoscopic Pyeloplasty; EBL, Estimated Blood Loss; LOS, Length Of hospital Stays; GA, General Anesthesia. [b] One subject's data was unavailable; [c] Contains 99 cases (87 vs. 12) since 10 cases were lost in the follow-up.

[a] Categorical and continuous data were compared using Fisher's Exact test and Man-Whitney U test, respectively.

**Table 3**. List of previous ipsilateral surgeries

| **Procedure** | **No. of Patients** | **Mean time from previous intervention, year (range)** |
|---|---|---|
| Ureteroscopic laser lithotripsy (URL) | 19 | 2.7 (6 month – 13 years) |
| Percutaneous nephrolithotomy (PCNL) | 6 | 1.2 (1 month - 3 year) |
| Both PCNL and URL | 3 | 6 (2 - 10 years) |
| Endopyelotomy | 2 | 0.3 (3 month - 4 month) |
| Open lithotomy | 2 | 8 (7 – 9 years) |

| Parameter[a] | No Previous Endourological surgery | Previous Endourological surgery | P-value |
|---|---|---|---|
| No. of patients | 64 | 30 | - |
| BMI, kg/m$^2$; mean ± SD | 22.2 ± 3.1 | 24 ± 3.6 | .014 |
| Operative time (min); median (range) | 140 (47 – 375) | 137 (80 – 295) | .984 |
| EBL (ml); median (range) | 10 (0 – 300) | 0 (0 – 300) | .136 |
| LOS (days); median (range) | 6 (3 – 14) | 6 (4 – 14) | .726 |
| Stent removal time (weeks); median (range) | 8 (4 – 10) | 8 (4 – 10) | .544 |
| Follow-up (months); median (range) | 26 (7 – 57) | 25 (6 – 53) | .917 |
| Recurrence rate, n (%) | 4 (6.9) | 1 (3.7) | .999 |

**Table 4**. Effect of previous ipsilateral endourological surgeries on outcome of RALP
**Abbreviations:** RALP, Robot-Assisted Laparoscopic Pyeloplasty; EBL, Estimated Blood Loss; LOS, Length Of hospital Stays.
[a] Categorical and continuous (except BMI parameter) data were compared using Fisher's Exact test and Man-Whitney U test, respectively.

**Table 5.** Summary of published articles comparing primary vs. redo RALP

| **Author** (year) | **No. of participants** | **Age (year)** | **Sex (M/F)** | **Crossing Vessel (n)** | **Operative time (min)** | **EBL (mL)** |
|---|---|---|---|---|---|---|
| | Primary/Redo | Primary/Redo | Primary/Redo | Primary/Redo | Primary/Redo | Primary/Redo |
| Atug (10) (2006) | 37/7 | 32.8/37.8 | (20/24)/ (2/5) | 16/2 | **219.4/279.8** | 49.5/52.5 |
| Mufarrij (26) (2008) | 117/23 | 38.2/40 | (52/65)/ (14/5) | 62/15 | 217.2/215.9 | 57.5/68.3 |
| Sivaraman (27) (2012) | 147/21 | 37.8/36.0 | (82/65)/ (12/9) | 63/12 | 125.9/190.4 | 42.9/86.2 |
| Niver (28) (2012) | 97/20 | 39.4/41.8 | (41/56)/ (9/11) | 64/16 | 218.7/217.9 | 62.8/98.8 |
| Thom (11) (2012) | 46/9 | 41[a] | 23/32[a] | NA | 192/205 | **90/125** |
| Baek (9) (2018) | 55/10 | 5.1/8.2 | (40/15)/ (9/1) | NA/NA | **143.2/187.7** | NA/NA |
| **Current study** | 96/13 | 35.4/27.5 | (65/31)/ (9/4) | 7/1 | 150.2/170.5 | 40.5/85.4 |

**Continue**

| **Author** (year) | **Complication rate** | **Conversion rate** | **LOS (days)** | **Follow-up (months)** | **Success[b] rate (%)** |
|---|---|---|---|---|---|
| | Primary/Redo | Primary/Redo | Primary/Redo | Primary/Redo | Primary/Redo |
| Atug (10) (2006) | 0/0 | 0/0 | 1.1/1.2 | 13.5/10.7 | 100/100 |
| Mufarrij (26) (2008) | 0/0 | 0/0 | 2.1/2.1 | 30.1/24.1 | 96.6/91.3 |
| Sivaraman (27) (2012) | 8/3 | 0/0 | 1.4/1.7 | 39[a] | 97.6% [a] |
| Niver (28) (2012) | 15/3 | 0/0 | 2.5/2.8 | 21.9/26 | 96.6/95 |

| | | | | | |
|---|---|---|---|---|---|
| Thom (11) (2012) | 1[a] | 1[a] | NA | 16[a] | **98/78** |
| Baek (9) (2018) | 0/1 | 0/0 | 1.4/1.2 | 10.5/13.6 | 98.2/100 |
| **Current study** | 21/3 | 0/0 | 6.3/6.6 | 27.4/28.1 | 94.3/75 |

**Abbreviations: Bold data:** Indicates significance difference between the groups"; NA; Not available; **[a]:** Only overall results were reported; **[b]**: Success means "not requiring further intervention"; **Note**: The results in the table are expressed as "Mean values".

## Figure legend

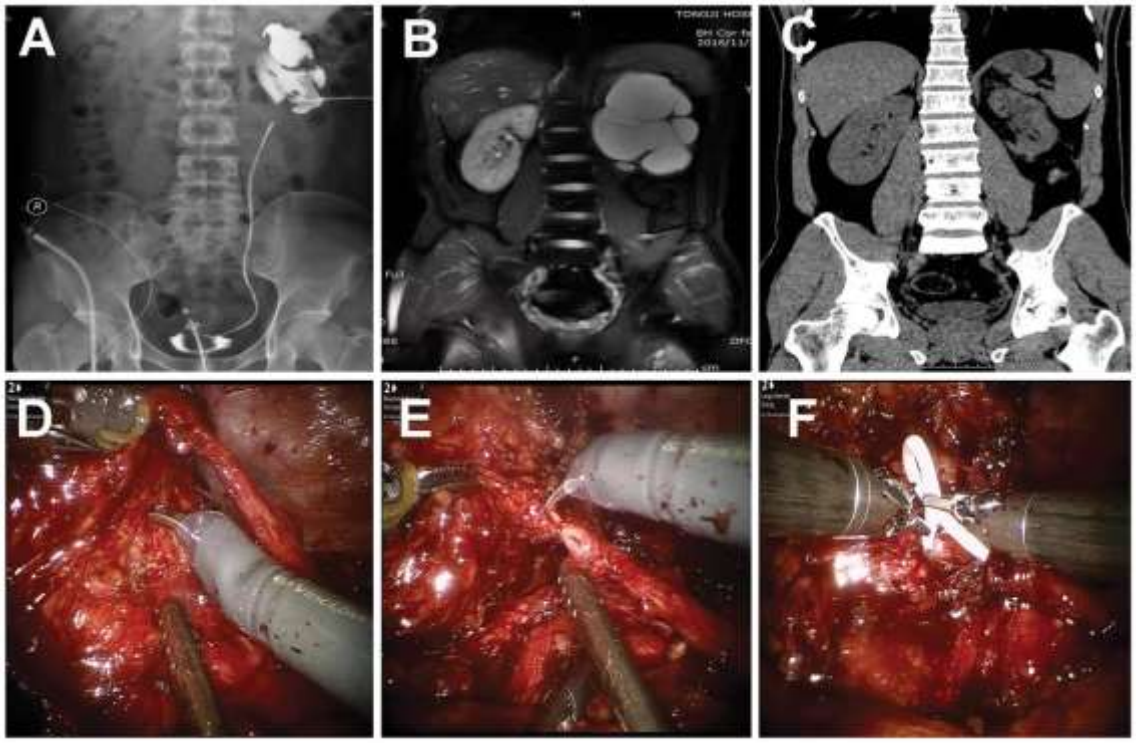


**Figure: 1** Robot-assisted laparoscopic dismembered pyeloplasty (RALP)

- **A)** Urography image (contrast media is injected percutaneously and retrogradely).
- **B)** MRU scan showing severe left kidney hydronephrosis due to UPJO
- **C)** CT scan taken 1 year after left side RALP
- **D)** Robotic dissection at the UPJ area
- **E)** Performing robotic dismembered pyeloplasty
- **F)** D-J stent placement before pelviureteral anastomosis completion