Endoscopic Combined Intrarenal Surgery Can Accurately Predict High Stone Clearance Rates on Postoperative CT

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OBJECTIVE To determine stone clearance rates using endoscopic combined intrarenal surgery (ECIRS) and assess the accuracy of intraoperative prediction of stone-free (SF) status compared to postoperative CT scan.

METHODS A single institution, prospectively maintained database of ECIRS was queried for procedures performed 8/2017 to 1/2018. Retrograde access was performed using a ureteral sheath and flexible ureteroscope. Percutaneous nephrolithotomy was performed through a 30fr or 18fr sheath in prone position. Residual stone status was estimated at the end of each procedure and was verified with postoperative CT scan. SF was defined as no single stone >2mm^3 on CT.

RESULTS One hundred and ten procedures were reviewed. Average age was 58.9 ± 12.6 years (range 26-87) and 69 (63%) were male. The mean stone size was 33.3 ± 23.5 mm (range 4-140 mm). Ninty-three patients (84.5%) were endoscopically estimated to be SF, of which 84 (90% of predicted SF cohort, 76% of total cohort) were confirmed SF via CT scan. The sensitivity for estimating SF status with ECIRS was 65.4% (95%CI 44.3%-82.8%), specificity was 100% (95%CI 95.7%-100.0%) and accuracy was 91.8% (95%CI 85.0%-96.2%). SF patients had significantly smaller stones than those with residual fragments (28.5 ± 2.1 vs 48.4 ± 5.7mm, P <.0001). On logistic regression, the factors associated with residual stones were preoperative stone burden (OR 1.03 per mm, 95%CI 1.01-1.05, P = .0004) and fluoroscopy time (OR 1.01 per minute, 95%CI 1.0-1.02, P = .0081).

CONCLUSION ECIRS accurately predicts clinical SF status and may obviate the need for additional CT scans. Consistent with prior studies, the primary determinant of residual stone after percutaneous nephrolithotomy is initial stone size. UROLOGY 133: 46–49, 2019. © 2019 Elsevier Inc.

Percutaneous nephrolithotomy (PCNL) is often the preferred treatment modality for nonlower pole stones >20 mm^2 and for lower pole stones >10 mm^2 due to high stone clearance rates.[1,2] To ensure stone-free (SF) status, inspection of the collecting system with fluoroscopy and flexible nephroscopy is recommended.[3] However, up to 20% of patients deemed SF at the time of surgery still have residual fragments greater than 4 mm. In 1 study, the sensitivity surgeons' estimation of SF status was 100% but the specificity was only 39%.[4]

Recently, endoscopic combined intrarenal surgery (ECIRS) with retrograde ureteroscopic and antegrade percutaneous renal access (also termed endoscopic guided access [EGA]) has been shown to be safe and effective for the management of large stones.[5,6] In addition to facilitating percutaneous access, these techniques may also improve stone clearance rates.[7] In a 2014 survey of endourologists, 12% were using this combined approach for PCNL.[8]

The purpose of this study was to assess how accurately surgeons assess SF status using ECIRS and to determine what factors contribute to residual fragments after PCNL.

PATIENTS AND METHODS

A prospectively maintained database of ECIRS was queried for procedures performed between 8/2017 and 1/2018 by 2 surgeons (JA and JD). All procedures were performed in the hospital setting or in an ambulatory surgery center (ASC), as previously described.[9] Criteria for performing PCNL was based on guidelines taking into account stone size, location, anatomy, and prior ureteroscopic attempts. Retrograde access was obtained using an 11/13fr 36 cm sheath placed in the supine position. The patient was then repositioned into prone, split leg position, and flexible ureteroscopy (URS) was performed [Flex-Xc, Karl Storz Endoscope]. Percutaneous access was obtained in the prone position, guided by endoscopy and low dose fluoroscopy pulsed at 8 frames

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per second. ECIRS was performed through a 30fr (standard) or 18fr (minimally invasive PCNL) sheath (Karl Storz-Endoskope). Stones were fragmented using Holmium:YAG laser (Lumenis) or Swiss Lithoclast (Boston Scientific) lithotripter. A ureteral stent was placed in all patients followed by a hemostatic plug in the tract of the access sheath.[10] No patients received a nephrostomy tube.

At the end of each procedure, patients' residual stone status was estimated by the surgeon to be either "stone free" (SF, cumulative stone <2 mm) or "residual fragment" (RF, cumulative stone >2 mm). This was determined using fluoroscopy, rigid and flexible nephroscopy and via retrograde URS of all calyces. A CT scan was performed on the first postoperative day (when done in the hospital setting) or prior to stent removal (when done in the ASC setting). SF was defined as cumulative stone <2 mm on CT in maximal diameter. The primary endpoint was missed residual fragment as defined by any fragment >2mm. The secondary endpoint included secondary procedure required for any residual stones. Characteristics of SF patients and accurately-estimated patients were analyzed using *t* tests, logistic regression, and linear regression with significance defined $P < .05$. Statistics were performed using Microsoft Excel for Mac Version 16 and StataMP.

RESULTS

A total of 110 procedures were reviewed. Patient demographics are illustrated in Table 1. Average age was 58.9 ± 12.6 years (range 26-87) and 69 (63%) were male. The mean BMI was 30.8 ± 7.0, mean ASA was 2.5 ± 0.6 and 62 (56%) were left sided procedures. Stone and operative characteristics are illustrated in Table 1. The mean stone size was 33.3 ± 23.5 mm (range 4-140 mm). PCNL access was standard in 94 (85.5%) and Minimally Invasive PCNL in 16(14.5%). ASC procedures were done in 58 (52.7%) and 52(47.3%) were conducted in the hospital. The mean fluoroscopy time was 72.9 ± 44.7 seconds (range 14-241 seconds).

Of our cohort, 93 patients (84.5%) were endoscopically estimated to be SF, of which 84 (90% of predicted SF cohort, 76% of total cohort) were confirmed SF via CT scan. Seventeen patients (15.5%) were known to have residual stone at the end of PCNL (Table 2). Patients with known residual stone at the end of ECIRS had a mean stone residual fragment size of 14.6 mm (range 5-30 mm). Of these patients, 3 elected observation, 7 were planned for a second look PCNL and 7 were planned for a second look URS. Nine patients (9%) were intraoperatively thought to be SF but were shown to have residual fragments on postoperative CT scan. The mean stone size of these residual fragments was 7.6 mm (range 4-8 mm). Seven patients elected observation and 2 patients elected salvage URS.

Table 2. Intraoperative prediction of residual fragments compared with postoperative CT scan

		Postoperative CT Scan	
		RF	Stone-free
Intraoperative prediction of stone-free	RF	17	0
	Stone-free	9	84

RF = residual fragment.

Table 3. Logistic regression model for residual stone on CT

Characteristic	Odds Ratio	95% Confidence Interval	*P* Value
Age ≥65	0.92	0.34–2.47	.86
Sex	1.85	0.70–4.87	.20
Side	1.30	0.56–3.04	.54
Location of surgery	0.87	0.34–2.09	.75
BMI ≥30	1.45	0.59–3.57	.41
Preoperative stone burden (mm)	1.03	1.01–1.05	.0004
Fluoroscopy time (s)*	1.01	1.00–1.02	.0081
Sheath	1.40	0.37–5.36	.61
Attending	0.97	0.39–2.38	.94

* Low dose fluoroscopy at 8 frames per second.

The 26 patients (24%) with residual stones had significantly larger preoperative stone burdens than those who were SF (48.4 ± 5.7 vs 28.5 ± 2.1 mm, $P < .0001$). The mean residual stone size was 12.2 ± 8.0 mm. Overall, accuracy of intraoperative prediction of stone clearance was 91.8%. The sensitivity for estimating SF status with ECIRS was 65.4% (95%CI 44.3%-82.8%) and specificity was 100% (95%CI 95.7%-100.0%) (Table 2).

Logistic regression revealed that larger preoperative stone burden and longer fluoroscopy time were the only factor associated with residual stones on postoperative CT (OR 1.03, 95%CI 1.01-1.05, $P = .0004$ and OR 1.01, 95%CI 1.0-1.02, $P = .0081$, respectively). The type of access sheath, BMI, age, and the location of procedure were not independent predictors of either endpoint (Table 3).

DISCUSSION

In this study, we investigated the surgeons' ability to predict SF status at the end of ECIRS and evaluated the predictors for residual stone fragments. Larger preoperative stone burden and longer fluoroscopy time were the factors associated with residual stones.

Table 1. Patient and stone characteristics

Results	N	%	Mean	SD	Min	Max
Age (y)			58.9	12.6	26	87
Male/female	69/41	63/37				
BMI			30.8	7.0	16.5	54
ASA			2.5	0.6	1	4
Preop stone burden (mm)			33.3	23.5	4	140
Left side	62	56.4				
ASC	58	52.7				
Standard tract	94	85.5				

Patients are routinely counseled on the need for secondary procedures prior to undergoing PCNL. However, data on the surgeons' ability to predict SF status at the end of PCNL is lacking. Recently, Nevo et al studied the surgeon's judgment regarding the SF status at the end of PCNL based on fluoroscopy and extensive nephroscopy. In their study of 312 patients, 290 patients were deemed "stone free" (<4 mm fragment) however nearly 20% of these patients had a significant residual stone (>4 mm) on post-operative CT scan.[4] These findings are in agreement with similar studies illustrating a 26%-28% residual fragment rate on postoperative CT scan despite being predicted without RF.[11,12]

EGA and combined intrarenal surgery was first published by Dr Grasso et al and further described by Khan et al.[5,13] The largest series was previously published by Monga et al. The study described 62 patients undergoing endoscopic guided PCNL with a cumulative stone diameter of 33 mm and a total fluoroscopy time of 3.2 minutes. In this study, only 2 patients required a secondary procedure for stone management.[14] A critique of this cohort was that there was no postoperative imaging obtained and thus strict SF rate could not be determined. Hamamato et al reported a SF rate of 86.7% in 60 patients undergoing ECIRS with a mini-PCNL.[7] In the Hamamato study, SF rate was confirmed by US and KUB at 1 month postoperatively. Our study is the first to prospectively compare surgeons' assessment of SF status at the end of ECIRS with confirmation by CT scan postoperatively.

This study group is the largest series assessing the surgeons' ability to predict SF status at the end of PCNL using fluoroscopy, nephroscopy, and retrograde URS. We found that 93 patients were predicted SF at the end of ECIRS of which 90% (84 patients) were confirmed SF. Nine patients (10%) had a mean residual stone fragment of 7.6 mm on postoperative CT imaging who were intraoperatively predicted to be SF. Our results affirm prior studies showing that increased stone burden increases the complexity of a procedure and could thus result in RF's. For every additional millimeter of stone size, odds of having residual stone fragments increased by 3%. Likewise, for every minute of extra fluoroscopy time, odds of residual stones increased by 1%. The incorporation of ECIRS can improve a surgeons' ability to accurately predict SF status at the end of PCNL compared to prior surgical techniques with the added benefit of retrieving fragments if need be. Our excellent, correctly predicted SF status was independent of preoperative stone burden. Due to the advantage of visualization from both above and below, our surgeons incorrectly predicted SF status very few times. This fact makes it difficult to determine statistically significant risk factors for inaccurate predictions. It should be noted that while it is possible to obtain fluoroscopy-guided access alone with subsequent placement of the uretreoscope to ensure a stone-free status, we do not recommend this approach. As the endoscope is already opened, it should be used for EGA which is safe and effective for large stones and can assist with difficult calyceal access.[13]

In our cohort, 26 patients (24%) had residual stones with a mean size of 12.2 ± 8.0 mm. Seventeen of these patients were known to have residual fragments with a mean size of 14.6 mm (range 5-30 mm). Seven of these patients underwent second look PCNL, 7 underwent second look URS, and 3 patients elected observation. Nine patients were thought to be SF at the end of PCNL were confirmed to have residual fragments on postoperative CT scan with a mean size of 7.6 mm (range 4-8 mm). Of these 9 patients, 7 elected observation and 2 elected for second look URS. The natural history of residual fragments has been well described by both Raman et al[15] and Emmott et al.[16] Raman et al. showed that of 42 patients who had residual fragments (median 2 mm, range 1-12 mm), 18 patients experienced a stone related event at a median of 32 months after PCNL. Our definition of SF echoes the findings of Raman et al noting that small stone dust of 1-2 mm are likely of no clinical consequence. Emmott et al similarly studied 263 patients with residual fragments (mean 4 mm, SD of 2.9). Of this group, 182 patients (69%) were event free during follow-up, 27 patients (9%) had a stone related even without reintervention and 54 patients (21%) had a stone related event with intervention. In their analysis, larger RF size was found to be predictive for higher rates of stone related events and reintervention rates. Similar results have been shown by The Endourology Disease Group for Excellence (EDGE) after URS.[17]

A major critique of ECIRS is that it requires 2 surgeons. In our cohort, the attending physician performed all procedures with either an endourology fellow or a urology resident. The use of ECIRS in a nonacademic setting maybe limited, and is a limitation of our project and its general applicability. In our practice, we do not routinely leave nephrostomy tubes unless there is evidence of renal pelvis disruption or concern for significant bleeding.

Our study is not without limitation. This is a single institution study based on 2 operating surgeons with a moderate sample size. Additionally, the timing of the CT scan was variable from inpatient procedures (CT done on postoperative day one) vs outpatient (CT done within 1 week of surgery and prior to stent removal). This could alter our results as small fragments may have passed during the difference in timing. Finally, a control cohort comparing SF prediction rates between ECIRS and non-ECIRS PCNLs would be a beneficial future study to further validate our findings.

CONCLUSION

ECIRS can accurately predict clinical SF status and may decrease the reliance on postoperative CT scans. Consistent with prior studies, the primary determinant of residual stone after PCNL is initial stone size.

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