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Live Renal Ultrasonography Facilitates Double-J Ureteral Stent Insertion at the Bedside: A Pilot Study for the COVID-19 Era

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Abstract

Objectives: To investigate the feasibility and efficacy of live renal ultrasonography to guide Double-J ureteral stent placement at the bedside.
Patients and Methods: Between April 12 and June 5, 2020, patients presenting with acute ureteral obstruction requiring decompression were prospectively selected for ultrasound-guided bedside ureteral stent placement. During stent placement, upper tract access confirmed using ultrasound with or without retrograde injection of ultrasound contrast before Double-J stent insertion. A postprocedural abdominal X-ray was obtained for stent position confirmation.
Results: Eight patients (four men and four women) were offered bedside ultrasound-guided ureteral stent placement, and all eight consented to proceed. Stents were placed in seven of eight patients. One patient had an impacted ureterovesical junction stone and stricture requiring ureteroscopy and laser lithotripsy in the operating room. All patients tolerated procedures without immediate complications.
Conclusion: Live renal ultrasonography can facilitate a high success rate for bedside ureteral stent placement outside the operating room. This approach is an attractive alternative to fluoroscopy-guided stent placement in the operating room and is of particular value in the COVID-19 era when judicious use of these resources is salient.

Keywords: ultrasound, ureteral stent, nephrolithiasis, hydronephrosis, bedside procedure

Introduction

Acute ureteral obstruction often requires decompression with a ureteral stent. In the United States, this procedure is typically performed in the operating room under general anesthesia with fluoroscopic guidance. The unique pressures that the COVID-19 pandemic introduced to our health care system have motivated us to re-examine this practice and adapt to these new demands. Specifically, we felt it important to reduce the need for anesthesia and conserve operating room resources associated with this common urologic procedure. We hypothesized that performing bedside ureteral stent insertion with live ultrasonography guidance could achieve these goals while maintaining patient safety and comfort.

First described by Clayman and Kramolowsky in 1986,[1] bedside ureteral stent placement was shown in a larger series by Nourparvar and colleagues in 2016 to be safe and well tolerated using local anesthesia only.[2] The success rate was 71% without image guidance, and unsuccessful stent placement at bedside required immediate follow-up intervention in the operating room. Despite the modest success rate, the benefit of performing bedside ureteral stent placement was underscored by a cost analysis showing the bedside procedure is up to 10-fold less costly compared with the same procedure done in the operating room.[2,3]

We sought to evaluate live renal ultrasonography as an imaging tool to enhance the success rate of bedside ureteral stent placement. Modern ultrasound can provide high-quality observation capable of accurately assessing wire and stent position, but it has generally been reserved for special situations when fluoroscopy is contraindicated, such as pregnancy.[4] For a bedside procedure, the use of ultrasound is especially attractive because of its low cost, portability, and availability throughout the hospital. Furthermore, ultrasound allows retrograde injection of ultrasound contrast agents (e.g., Optison™) to better delineate renal anatomy and confirm access.

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A video demonstrating this technique is available online.

This pilot study was designed to evaluate the feasibility and efficacy of ultrasound-guided bedside ureteral stent placement as an alternative intervention for ureteral obstruction in the COVID-19 era.

Patients and Methods

A prospective cohort pilot study was performed at a single academic tertiary care hospital. Institutional review board approval was obtained to review their outcomes (CHR15-17478). Between April 12 and June 5, 2020, patients presenting with an acute indication for ureteral stent placement were offered the procedure at bedside. Patients with hemodynamic instability, altered mental status, history of renal transplant, and pregnancy requiring intraoperative fetal monitoring were not offered a bedside procedure. During stent placement, criteria to abort included verbally assessed patient intolerance, inability to confirm access, and inability to advance the stent.

In addition to the standard risks and benefits of ureteral stent placement, patients were explicitly counseled about the possibility of going to the operating room if the procedure was unsuccessful at the bedside. Patients were also given the option to go straight to the operating room before attempting the bedside procedure. After informed consent was obtained, patients were premedicated with an analgesic and anxiolytic cocktail; intravenous sedation requiring monitoring was not used. A preoperative antibiotic was given according to American Urological Association antimicrobial prophylaxis guidelines.[5]

Male patients were positioned supine, whereas female patients were positioned in a frog leg position. The genitals were prepped with an iodine-based solution and the patients draped in a standard manner. Cystoscopy was performed by the surgeon using an Olympus™ 17F cystoscope with saline irrigation. The ipsilateral ureteral orifice (UO) was identified, and wire access was established using either a Sensor™ hybrid straight tip or Terumo™ hydrophilic angle tip glide wire.

Renal ultrasonography (Hitachi Aloka Medical America/Fujifilm Sonosite) with a 3.5 MHz convex abdominal probe was then performed by the assistant to view the wire in the renal collecting system. Our technique and landmarks for observing the kidney in this setting are described in Supplementary Figure S1. If the location of the wire was unclear, a 5F exchange catheter was advanced over the wire through the cystoscope 20–25 cm proximal to the UO, and 5–10 mL of ultrasound contrast (1:1 saline and Optison perflutren lipid microspheres, GE Healthcare) was injected. Optison contains microbubbles of an inert gas and is thus highly echogenic when exposed to ultrasound. The presence of this contrast in the collecting system was used to determine whether it was safe to proceed with stent placement. Of note, contrast was observed with standard abdominal probe settings; a specialized contrast detection mode was not required.

The wire was then reinserted into the upper collecting system and its position in the kidney was observed inside the contrast with ultrasound imaging. A Double-J stent was inserted over a hybrid wire through the cystoscope using the 5F exchange catheter as a pusher as standard stent pushers were typically too short to deploy through the cystoscope. Deployment was guided primarily by direct cystoscopic observation of the distal curl whenever the proximal curl was not well observed using ultrasound. All stents were placed without strings attached. After the procedure, a plain film abdominal X-ray was obtained for confirmation of stent position.

Results

Fourteen patients presented with acute indications for ureteral stent placement. Of these, eight patients (four men and four women) met criteria for bedside ureteral stent placement (Table 1), and six patients were excluded for the aforementioned reasons (Supplementary Table S1). All patients who were offered bedside ureteral stent placement consented to proceed. Two patients were already admitted in the hospital for work-up or treatment of malignancy, and the rest were evaluated in the emergency department (ED) for ureteral stones. The location of obstruction was distal ureter or ureterovesical junction (UVJ; $n=4$), proximal ureter ($n=3$), or mid-ureter ($n=1$). Three patients had a negative COVID-19 test at the time of intervention. Four patients had not yet been tested before intervention, and one had been swabbed with the result pending.

Stents were placed at the bedside in seven of eight patients (88%, Table 2). Seven procedures were performed by urologic trainees, including postgraduation year (PGY)3-4 residents and fellows under attending supervision. The procedures were well tolerated by all patients, and no procedures were terminated because of patient discomfort. Notably, patients did not complain of worsening flank pain during injection of contrast, likely because we limited the volume injected to 10 mL. Local urethral analgesic was given in all cases in addition to oral and IV analgesics and anxiolytics

Table 1. Clinical Characteristics of Patients Who Underwent Bedside Ureteral Stenting

ID	*Age*	*Gender*	*Race*	*BMI*	*Type*	*Laterality*	*Location*	*Indication(s) for stent*	*Setting*	*COVID-19 status*
1	54	F	2	39	Malignancy	Right	Mid-ureter	AKI	Ward	Not tested
2	58	M	3	29	Malignancy	Left	Distal ureter	AKI	Ward	Not tested
3	54	F	4	25	Stone	Left	Distal ureter	Infection	ED	Not tested
4	57	M	2	26	Stone	Right	Distal ureter	Forniceal rupture and pain	ED	Negative
5	64	M	1	24	Stone	Right	Proximal ureter	Pain	ED	Negative
6	43	F	1	35	Stone	Right	Proximal ureter	Infection	ED	Pending
7	72	M	1	23	Stone	Right	UVJ	Pain, nausea, and vomiting	ED	Not tested
8	67	F	3	25	Stone	Right	Proximal ureter	Pain, nausea, and vomiting	ED	Negative

AKI = acute kidney injury; BMI = body mass index; ED = emergency department; F = female; M = male; UVJ = ureterovesical junction. Race: 1 = white/Caucasian, 2 = black/African American, 3 = Hispanic/Latinx, 4 = Asian/Pacific Islander.

Table 2. Procedural Details and Outcomes

ID	Surgeon level of training	Premedications administered	Anatomic challenges	Wire used	Size of stent	Contrast used?	Effective placement	Postprocedure disposition	Complications	Outcome at follow-up
1	Resident Resident	Lorazepam, oxycodone, and hydromorphone	High BMI, difficult to image kidney	Terumo™ Sensor™	6F × 28 cm Double-J stent	Yes	Yes	Acute care ward	None	Serial stent change
2	Resident Resident	Lorazepam, oxycodone, and hydromorphone	None	Terumo Sensor	6F × 28 cm Double-J stent	Yes	Yes	Acute care ward	None	Serial stent change
3	Resident Resident	Ketorolac, diazepam, oxycodone, and hydromorphone	Impacted stone and stricture at UVJ and unable to advance stent	Terumo Sensor	n/a	Yes	No	23-hour observation	None	Stone free after URS
4	Fellow Resident	Ketorolac, lorazepam, oxycodone, and hydromorphone	Enlarged median lobe and UO difficult to observe	Terumo Sensor	4.8F × 26 cm Double-J stent	No	Yes	23-hour observation	None	Stone free after URS
5	Resident Resident	Ketorolac, lorazepam, oxycodone, and hydromorphone	None	Sensor	4.8F × 28 cm Double-J stent	Yes	Yes	Discharge	None	Stone free after URS
6	Fellow Resident	Fentanyl	Polycystic kidneys	Sensor	4.8F × 26 cm Double-J stent	Yes	Yes	23-hour observation	None	Stone free after URS
7	Fellow Resident	Ketorolac, diazepam, and hydromorphone	History of prostatectomy and small UO difficult to observe	Terumo Sensor	4.7F × 26 cm Double-J stent	No	Yes	Discharge	None	Stone free after URS
8	Attending Fellow Resident	Ketorolac, lorazepam, and hydromorphone	None	Sensor	4.8F × 26 cm Double-J stent	No	Yes	23-hour observation	ED visit × 2 for stent pain	Stone free after URS

n/a = not applicable; UO = ureteral orifice; URS = ureteroscopy.

as listed in Table 2. Most procedures lasted <30 minutes from start of cystoscopy to deployment of stent. The procedure for patient 3 was terminated after 60 minutes.

Live renal ultrasonography was used in all cases to verify wire access and location, and ultrasound contrast was used in five cases as a second line of confirmation. The imaging from the bedside procedures was not recorded for publication, so representative images obtained during a supine percutaneous nephrolithotomy procedure simulating wire placement (Fig. 1A and Supplementary Video S1A) and contrast injection (Fig. 1B and Supplementary Video S1B) are shown. On postprocedural plain film abdominal X-rays, stents were found to be deployed across the area of obstruction in all cases (Fig. 2). Of note, redundancy of the proximal curl was noted in patients 4 and 5. For patient 5, the scout image from a subsequent abdominal CT scan showed resolution of the redundancy (Fig. 2, image 5a). Neither patient 4 nor patient 5 reported any discomfort related to their stents on follow-up.

Anatomic characteristics that added complexity were noted in five cases. Patient 1 had a large body habitus that made the kidney difficult to observe on ultrasound. Patient 4 had a large intravesical median lobe that impaired observation of the UO, which required additional maneuvering with the cystoscope to retract the lobe to expose the UO. Patient 6 had polycystic kidneys, but the collecting system was able to be clearly distinguished from her numerous renal cysts after injection of ultrasound contrast. Patient 7 had a history of radical prostatectomy and pinpoint UOs requiring a thorough and methodical examination of the bladder neck before wire access was achieved.

The lone failure occurred in patient 3 and was attributed to a 4 mm stone that was impacted at the UVJ and subsequently found to also be associated with a mild stricture. The patient had a history of prior ureteroscopies. During this procedure, wire access was achieved and confirmed on ultrasound, but neither the 5F exchange catheter nor the 4.8×26 cm Double-J stent were unable to be advanced past the stone. Moreover, retrograde injection of ultrasound contrast was not observed in the collecting system. The bedside procedure was aborted, and the patient was taken to the operating room for semirigid ureteroscopy and laser lithotripsy, during which the impacted stone and distal stricture were diagnosed. The stone was removed, and an indwelling stent was left in place and removed on follow-up. She was discharged from the hospital on postoperative day 1.

Four of the six patients in the ED were observed overnight, whereas two were discharged immediately after the procedure. At 2–3 months' follow-up, all patients with stones had undergone definitive surgery and were stone free. The two patients with malignant ureteral obstructions had improved renal function and were scheduled for serial stent exchange. Patient 8 had two subsequent ED presentations for flank pain associated with her stent. Stent migration was ruled out with abdominal imaging (not shown). Her symptoms resolved after ureteroscopy and laser lithotripsy. Finally, all patients underwent at least one COVID-19 test after stent placement, all of which have been negative at 2-month follow-up.

Discussion

We conducted this study as part of an effort to identify strategies to improve urologic health care delivery in the COVID-19 era. To our knowledge this is the first case series examining the efficacy of ultrasound-guided bedside ureteral stent as an alternative to the traditional paradigm of fluoroscopic stent placement in the operating room under general anesthesia; to this end, we achieved an 88% success rate.

Our results corroborate the 2016 study done by Nourparvar and colleagues that bedside stent placement is safe and well tolerated, and we demonstrate the utility of live renal ultrasonography to improve the success rate by confirming access. In our study, the only patient who required a follow-up procedure in the operating room after failure of bedside stent placement had both a stricture and impacted stone that did

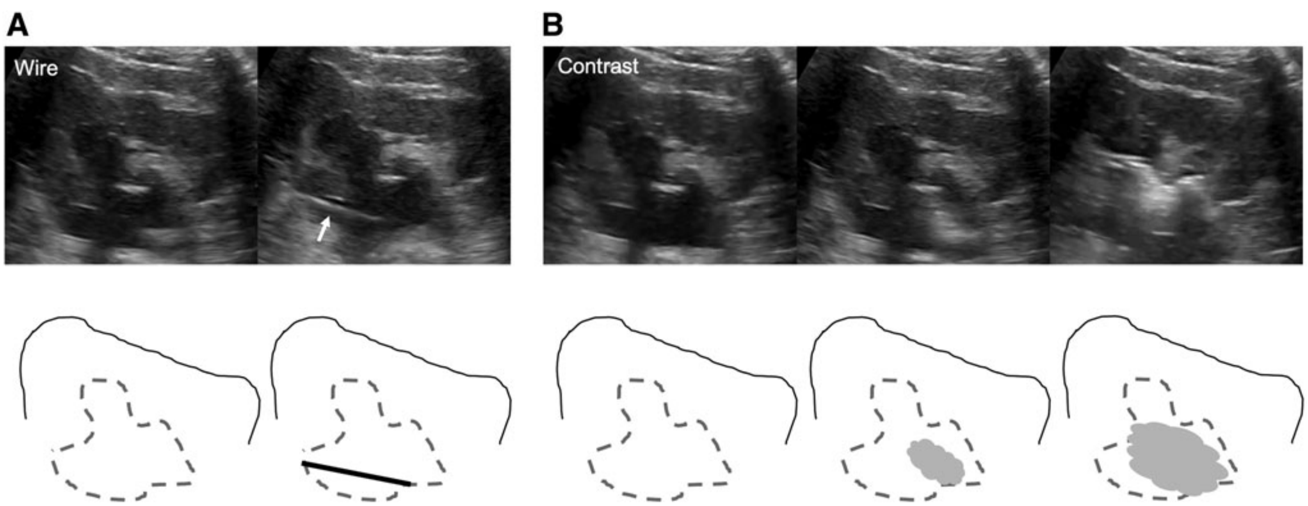

FIG. 1. Ultrasound imaging of wire insertion and ultrasound contrast injection in collecting system. **(A)** Kidney with dilated collecting system before (*left*) and after (*right*) insertion of wire (*white arrow*). Schematic shown hereunder with cortex outlined with thin *solid black line*, collecting system outlined with *dashed gray line*, and wire within the collecting system represented by *thick solid black line*. **(B)** Injection of ultrasound contrast in three frames. Schematic shown hereunder, with ultrasound contrast represented by *gray* cloud within collecting system. Recorded video is available in supplementary material.

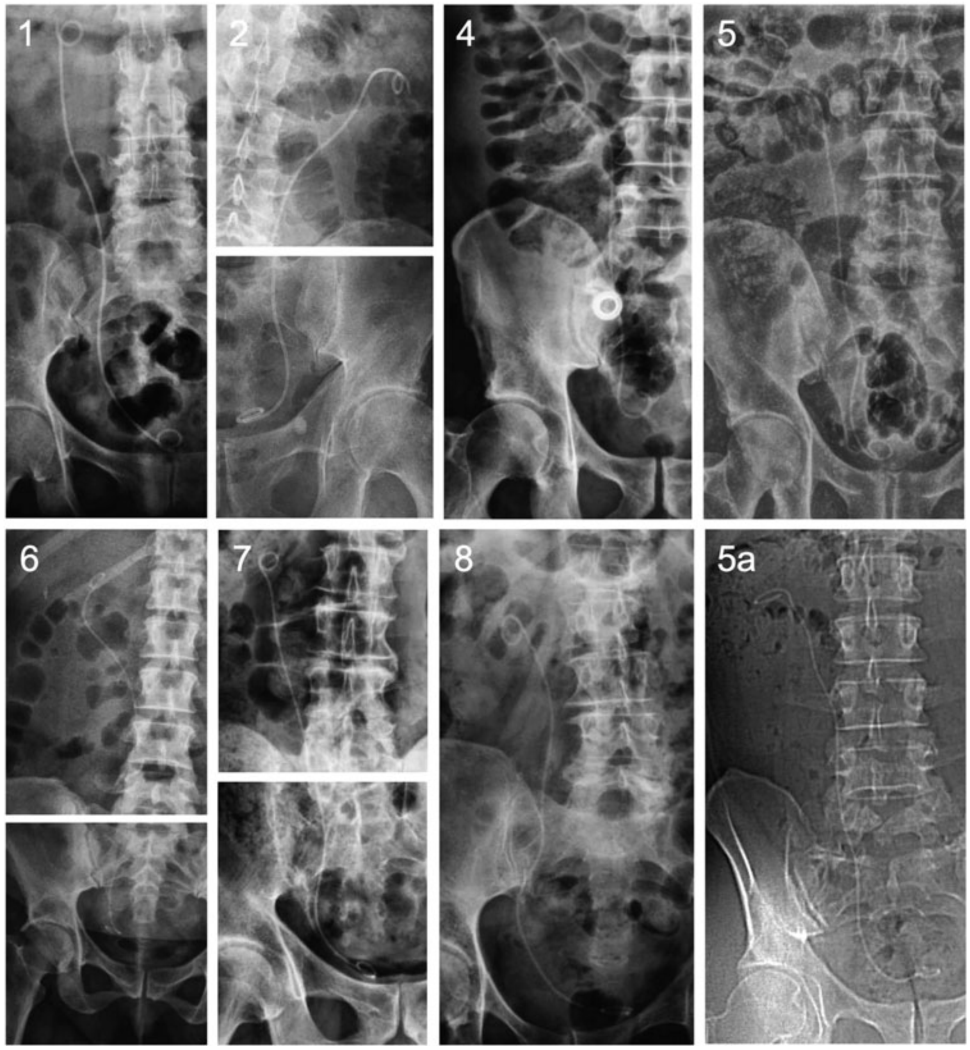

FIG. 2. Postprocedural abdominal X-ray to confirm stent placement. Patient 3 is not shown because procedure was aborted. Follow-up scout film of CT scan for patient 5 is shown in panel 5a.

not permit advancement of the stent despite achieving wire access. We also confirmed with our finance and billing department that avoiding operating room (OR) usage for these cases saved on average $6000 per case (cost estimate: $4000 for bedside stent placement and $10,000 for OR stent placement).

Our study highlights several new benefits of this approach in addition to resource conservation. Perhaps the greatest advantage is the ability to safely perform the procedure in patients with uncertain COVID-19 status, as it was done in five of our eight patients. When bedside stent placement is effective and the operating room is avoided, the risk of anesthesia-related complications should the patient ultimately test positive are eliminated.[6] A bedside procedure also avoids generating intubation-related aerosolization of airway secretions and reduces the number of physicians involved in a patient's direct care. Fortunately, none of the patients in this study were COVID-19 positive either at the time of stent placement or afterward. Finally, patients did not require recovery from anesthesia, and two patients went home immediately after the procedure. A randomized controlled trial will be needed to determine whether the bedside approach reduces overall length of stay, but our initial results are promising.

Although the use of ultrasound in endourologic procedures has gained popularity in the United States for the past decade,[7] we recognize that many urologists do not have the same level of familiarity performing renal ultrasonography as they do with fluoroscopy. However, we believe that basic renal ultrasonography skills should suffice to perform an ultrasound-guided stent placement. Even if the wire cannot be found, observation of the kidney and collecting system is sufficient to detect the presence of ultrasound contrast and thus confirm access. Optison and similar products are available in most hospital pharmacies. An alternative to surgeon-performed imaging is to have an ultrasound technician perform the live ultrasonography portion.

Although the attending urologist in each case assumed full responsibility of decision making and were readily available to ensure patient safety, the technical aspects of the procedure—renal ultrasonography, cystoscopy, and wire manipulation—were well within the repertoire of mid-level and senior trainees. In our study, urology residents ranging from PGY3-4 and fellows performed seven of eight cases. Furthermore, the bedside setting permits trainees to perform a timeout and procedure verification, whereas at our institution and many others across the country, the same proceedings in an operating room would usually require the attending urologist. This allows teams to move forward with patient care more expeditiously.

In our experience, at least two members of the surgical team were required for each procedure. For future studies, it may be worthwhile to explore a standardized way to involve the nursing staff should a second physician be unavailable to assist. This may help increase applicability of this approach to the private practice setting without trainees.

There are several limitations to our study. Since this is a small pilot study conducted at a single academic center, we cannot provide robust statistical analysis to support the conclusion that ultrasound guidance improves the success rate of bedside ureteral stent placement. We also did not attempt any bedside procedures in hemodynamically unstable patients because of the concern that a failed procedure could exacerbate their clinical conditions and delay care. However, given the high success rate and our ability to rapidly mobilize personnel and equipment, one could argue that ultrasound-guided bedside stent placement may have a role in the management of critically ill patients provided that the proper support and monitoring is available. In future studies, it would be worthwhile to compare timing element between bedside and OR stent placement more deeply, that is, time from initial consultation to procedure finish, as the speed of stent placement is likely an additional advantage of the bedside approach that we did not quantify.

Conclusions

Live renal ultrasonography can facilitate a high success rate for ureteral stent placement outside the operating room. This approach is an attractive alternative to fluoroscopic-guided stent placement in the operating room and is of particular value in the COVID-19 era when judicious use of these resources is salient.

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Author Disclosure Statement

No competing financial interests exist.

Funding Information

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Supplementary Material

Supplementary Table S1
Supplementary Figure S1
Supplementary Video S1

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Abbreviations Used

AKI = acute kidney injury
BMI = body mass index
CT = computed tomography
ED = emergency department
n/a = not applicable
OR = operating room
PGY = postgraduation year
UO = ureteral orifice
URS = ureteroscopy
UVJ = ureterovesical junction