Published in final edited form as:

Int J Urol. 2017 March ; 24(3): 239–240. doi:10.1111/iju.13258.

Antegrade ultrasound contrast injection facilitates accurate nephrostomy tube positioning during percutaneous nephrolithotomy

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PCNL is the preferred treatment for large upper urinary tract stones or those refractory to shockwave therapy.¹ Because of growing concerns regarding ionizing radiation exposure from fluoroscopic guidance, PCNL is increasingly carried out using ultrasound guidance.² In addition to eliminating ionizing radiation exposure, this technique is safe, effective and offers several distinct advantages over fluoroscopy, including improved visualization of surrounding visceral organs and posterior calyces.³

Placement of a NT and verifying its correct position in the renal pelvis at the end of PCNL under ultrasound guidance remains a challenge. NTs have been designed to be visible by fluoroscopy and are often difficult to visualize using gray-scale (B-mode) ultrasound. This makes it difficult to verify their final position solely using ultrasound, and in some cases, fluoroscopy is inevitably required.

CEUS has been available for evaluation of intra-abdominal organs for several decades. The addition of microbubble-containing ultrasound contrast agent facilitates diagnostic accuracy by enabling real-time dynamic assessment of organ perfusion with excellent spatial and contrast resolution.⁴ Vascular injection of these contrast agents has been used to identify and characterize tumors in the liver and kidney. Additionally, antegrade ultrasound contrast injection can be used for ultrasound visualization of the renal CS.^{5,6} Antegrade contrast injection through a NT is also capable of showing ureteral patency after PCNL.⁵

This note describes a pilot of a novel CEUS application utilizing intraoperative ante-grade ultrasound contrast injection to guide NT insertion and verify tube positioning after PCNL.

Intraoperatively, we placed an externalized ureteral catheter for CS dilation with retrograde saline injection as required before positioning the patient prone. We utilized ultrasound

Conflict of interest: None declared.

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guidance (Hitachi Aloka Alpha 7 with a 3.5-MHz convex abdominal transducer; Hitachi Aloka Medical America, Wallingford, CT, USA) in all steps including percutaneous renal access, tract dilation and identification of residual stone fragments after lithotripsy.⁷ An 18-G needle was used to establish renal access through which a working coaxial wire was placed into the renal pelvis. Over this wire, a balloon dilator created an access tract, and a 24-Fr sheath was utilized for stone clearance. After stone clearance was confirmed, a guidewire was left in the proximal ureter, and a 10-Fr Cope loop catheter (Cook Medical, Bloomington, IN, USA) was advanced over the guidewire under gray-scale ultrasound monitoring. The guidewire was then withdrawn, and the NT was deployed in the CS (Fig. 1a,b).

The present study included 17 consecutive ultrasound-guided PCNL procedures carried out in 16 patients (11 women and five men) between April and August 2016. The mean patient age was 55.3 ± 15.9 years (mean $\pm$ SD), and the mean body mass index was 33.6 ± 12.8 kg/m². Left-sided renal stones were found in 11 procedures, and the mean stone size was 40.9 ± 29.6 mm. Preoperatively, seven kidneys showed no hydronephrosis, seven mild and three moderate.

Difficulty was encountered in visualizing the NT with conventional ultrasound (Fig. 1b). To assess the tube position after deployment, we switched to CEUS mode, and injected 1.5 mL of ultrasound contrast intraluminally through the tube (Optison – Perflutren Protein Type-A Microspheres Injectable Suspension; GE Healthcare, Chicago, IL, USA), followed by 5 mL of normal saline flush. The ultrasound contrast rapidly filled the NT and renal CS, and could be seen as high-signal areas on the contrast-enhanced screen (Fig. 1c). Subsequently, the distal loop of the deployed tube was easier to identify, verifying proper positioning within the renal pelvis (Fig. 1d). During live ultrasound imaging, the NT, DC and CS could be seen clearly under contrast-enhanced mode (Video S1). The operating surgeon carried out all imaging procedures and contrast injection, and no fluoroscopy was required during the NT placement. A postoperative plain abdominal radiograph confirmed proper tube positioning in all cases. No adverse events related to ultrasound contrast injection occurred. At 1 month after surgery, plain KUB radiograph and renal ultrasound confirmed stone-free status in all patients.

This proof-of-concept investigation shows that NT position can be evaluated and confirmed using CEUS with antegrade contrast injection after PCNL. This technique might have some limitations. For example, in obese patients with deep-positioned kidneys, inferior quality of imaging could limit the applicability. Additional studies are underway to validate this technique and examine its cost-effectiveness.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This study was supported by NIH R21-DK-109433 (TC, JM, SW) and NIH K12-DK-07-006: Multidisciplinary K12 Urologic Research Career Development Program (TC).

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Abbreviations & Acronyms

CEUS	contrast-enhancedultrasound
CS	collecting system
DC	distal curl
KUB	kidney, ureter and bladder
NT	nephrostomy tube
PCNL	percutaneous nephrolithotomy

Fig.1.

(a) Illustration showing a kidney in axial orientation with a NT and its DC entering the renal CS. (b) Grey-scale ultrasound image shows the NT after deployment, whose position is difficult to identify in the CS. (c) After ante-grade ultrasound contrast injection, the contrast rapidly fills the NT and renal CS, which are seen as a high-signal area. (d) The DC of the NT is also identified as a high-signal area in the renal CS.