Simulation of real-time ultrasound-guided renal biopsy

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Percutaneous renal biopsy has an essential role in the diagnosis and treatment of multiple kidney disorders. Unfortunately, this invasive procedure is associated with increased risk for adverse, even lethal, outcomes. Simulation training has been shown to improve procedure competencies; therefore, we developed an inexpensive simulation tool for teaching and practicing real-time ultrasound-guided percutaneous renal biopsy. This model mimics human kidney biopsy conditions in terms of kidney size, depth, tissue echogenicity, and overall structural characteristics. The preparation is simple, consisting of inserting a porcine kidney phantom under a turkey breast, using standard ultrasound imaging and semiautomatic needles, and allowing repetitive sampling. Our tool for initial renal biopsy training and for maintenance of already acquired skills has received positive feedback from fellows in major adult and pediatric nephrology training programs.

Future controlled studies are needed to establish the efficacy of this simulation training in reducing discomfort and adverse renal biopsy outcomes in patients.

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humans by providing comparable ultrasonographic image in terms of biopsy needle guidance (Figure 2c), as well as muscle and kidney tissue resistance to passing biopsy needle. These characteristics were preserved even when the tools was used multiple times by a large number of trainees (for example, \( n = 14 \)) during an entire teaching session. Feedback on this tool by novice first-year fellows, as well as biopsy-proficient second-year fellows and attending physicians, was overwhelmingly positive. Therefore, we incorporated this renal biopsy simulation into the core curriculum of our nephrology training programs.

**DISCUSSION**

In this article we describe an inexpensive, logistically straightforward tool for a simulation of real-time ultrasound-guided renal biopsy that mimics characteristics of this procedure in humans regarding key radiographic and structural tissue characteristics. A possible alternative to this approach is a simulation of real-time ultrasound-guided renal biopsy on minimally embalmed human cadavers. Although this alternative approach may more closely resemble actual biopsy procedure in humans, its use may be limited by logistical issues associated with this approach (for example, securing cadavers for such training and transport of ultrasound imaging system between areas dedicated to patients and cadavers).

Although we found this biopsy simulation tool useful for training of pediatric and adult kidney biopsies, it does not appropriately simulate the increased depth of kidneys in some patients (for example, in overweight adults it may exceed twice \( \sim 5 \) cm thickness of a large turkey breast). To improve attainment of skills required for biopsy of such deeper kidneys, we increased length of biopsy needle trajectory through turkey breast by approaching the kidney phantom with biopsy needle under more acute angle.

Although renal fellows and practicing attendings in our nephrology training programs evaluated the above-described renal biopsy simulation tool very positively, rigorous assessment of this phantom is needed as well as formal evaluation to determine effectiveness of such simulation training in reducing adverse renal biopsy outcomes and patients’ subjective experiences with this procedure.

**MATERIALS AND METHODS**

**Preparation of the renal biopsy simulation tool**

This simulation tool can be prepared with logistically simple approach and minimal time requirements. The cost of required material (turkey breast and two porcine kidneys) at local butcher shops or grocery stores was approximately $20. Because turkey breast thickness limits the depth of kidney phantom, we purchased the largest available turkey breasts. We prepared this simulation model by inserting a frozen kidney into a hand-made pocket under each side of thawed turkey breast (Figure 1). To prevent air-trapping around the kidney and consequent ultrasonographic artifacts, we performed pocket formation and kidney insertion under water seal. We created the water seal by placing the breast into a large plastic bag (that was inserted for better stability into a large box) and filling it with water. When both kidneys were successfully placed under each side of the breast, excess of water was descanted and the plastic bag was tightly secured near the opening in the breast that was used for the kidney insertion. Finally, we placed the bag with the breast into a slightly smaller box to allow positioning of the inserted kidneys into nearly horizontal position. This box was lined up with another plastic bag to prevent potential fluid leakage. When completed, this simulation tool was stored for 1 day at \( 4 \) \( ^\circ \)C to allow the kidneys to melt completely. We handled the turkey, porcine, or sheep tissues in latex or nitrile gloves. In case of accidental contact, hands were scrubbed vigorously with soap for at least 20 s. All surfaces that were in contact with these tissues were disinfected.

**Real-time ultrasound-guided renal biopsy simulation**

After initial review of the basic principles of ultrasonographic guidance and renal biopsy procedures, the fellows observed an experienced operator perform several real-time ultrasound-guided biopsies using the simulation tool. After that, individual fellows practiced real-time ultrasound-guided renal biopsy procedure repeatedly until they
attained reasonable accuracy and gained confidence. Guidance and feedback were provided immediately by an experienced operator.

This simulation was performed using standard ultrasound imaging instruments (for example, Diagnostic ultrasound system Aplio Model SSA-770A; Toshiba Medical Systems Corporation, Tochigi-Ken, Japan). Biopsies were performed with semiautomatic needles (for example, Bard MaxCore Instrument with 18-gauge, 20 cm long needle, 22 mm through; CR Bard Inc., Murray Hill, NJ, USA).

DISCLOSURE
All the authors declared no competing interests.

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