SHORT COMMUNICATION

A training simulator for ultrasound-guided percutaneous nephrostomy insertion

¹B G ROCK, MA (Cantab), MRCP, FRCR, ¹A P LEONARD, MRCS, FRCR and ²S J FREEMAN, MRCP, FRCR

¹Peninsula Radiology Academy, Plymouth International Business Park, Plymouth, PL6 5WR, UK, and ²Imaging Directorate, Derriford Hospital, Derriford Road, Plymouth, PL6 8DH, UK

ABSTRACT. Increasing trainee numbers and changes to working patterns have resulted in a scarcity of training opportunities for training-grade doctors wishing to learn nephrostomy tube insertion techniques. A method of introducing trainees to the skills required to perform percutaneous nephrostomy in a safe, non-threatening environment, without risk to patients, is desirable. Commercial and biological nephrostomy phantoms are available, but they are expensive and not widely available, and a cheap, safe, valid alternative is desirable. We describe a simple technique for producing a gelatin-based phantom, which we suggest has face and content simulator validity. The use of this nephrostomy phantom could optimise existing clinical training opportunities through familiarisation with nephrostomy technique and equipment, and development of the psychomotor skills required for successful nephrostomy insertion prior to undertaking supervised procedures on patients.

Received 14 September 2009
Revised 18 October 2009
Accepted 20 October 2009
DOI: 10.1259/bjr/42026587

© 2010 The British Institute of Radiology

Skills in ultrasound-guided percutaneous nephrostomy insertion are desirable for trainee radiologists. Nephrostomy is often the method of choice for emergency decompression of an obstructed renal system, particularly in the presence of urinary infection. This intervention is frequently required as an "on-call" procedure. Moreover, the skills required for ultrasound needle guidance and the Seldinger technique are cross-transferable, being of use in the drainage of collections elsewhere in the body and in the performance of ultrasound-guided biopsies. Preferably, trainees should acquire these skills in a safe, non-threatening environment, without patient risk.

Commercial nephrostomy phantoms are available and biological phantoms have been described [1, 2], but both of these have disadvantages (including cost and hygiene considerations, respectively). Gelatin-based phantoms have been described for developing ultrasound-guided biopsy technique [3, 4], but these do not facilitate the complex procedural sequence required to insert a drain into a dilated pelvicalyceal system. A gelatin-based system has recently been described that allows ultrasound-guided puncture of a simulated pelvicalyceal system [5], but the costs and complexity of production may be prohibitive for routine use by trainees. We therefore describe a cheap and relatively simple technique, adapted from previously described methodology [3, 4], for producing a gelatin-based phantom that permits ultrasound-guided puncture, wire insertion, serial dilatation and drainage of a

fluid-filled cavity that simulates the dilated collecting system of a hydronephrotic kidney.

Methods and materials

The fingers of a disposable vinyl glove were tied half-way along their length to simulate the renal pelvicalyceal system, and the excess vinyl from the finger tips was trimmed. Silicone tubing (300 mm) was inserted into the free end of the glove, which was sealed around the tubing using an elastic band. The system was irrigated with water, and air was aspirated using a 20 ml syringe (Figure 1).

This simulated renal pelvicalyceal system was inserted into a polythene bag that was intended to mimic the renal capsule, creating a potential space around the glove to allow a simulated gelatin renal parenchyma to be fashioned. A plastic funnel was inserted beside the silicone tubing into the free end of the polythene bag to facilitate introduction of gelatin. The bag was secured around the silicone tubing and funnel nozzle using a further elastic band (Figure 2).

The middle segment of a 500 ml plastic soft drink bottle was removed and a 40 × 20 mm opening was cut into its side to produce a split mould of 120 mm in length. The simulated kidney was inserted into the mould and the mould sides were secured using adhesive tape (Figure 3).

A sachet of bovine gelatin (Dr Oetker, Leeds, UK) was dissolved in 300 ml of water and 3 ml of cornflour was added to provide echotexture. This mixture was poured into the polythene bag via the funnel around the simulated renal pelvicalyceal system, air was expelled from the bag and the funnel was removed. The simulated kidney was left to set in a refrigerator.

Address correspondence to: BG Rock, Peninsula Radiology Academy, Plymouth International Business Park, Plymouth, PL6 5WR, UK. E-mail: bgrock@doctors.org.uk

Figure 1. Simulated renal pelvicalyceal system created using a vinyl glove.

A total of 29 sachets of gelatin were dissolved in 4000 ml water. A 110×210×340 mm plastic box was lined with opaque polythene plastic sheeting and the gelatin solution was poured into the lined mould. The mixture was allowed to set in a refrigerator until the gel became viscous. Desiccated coconut (20 ml) was then added to provide echotexture. The simulated kidney was then removed from the plastic mould, the free end of the polythene bag was trimmed, and the "kidney" was embedded in the gelatin within the plastic box, the free end of the silicone tubing protruding from the gel. The simulated kidney was orientated so that the long axis of the "kidney" lay parallel to the long (340 mm) axis of the container, allowing the simulated calyces to be

Figure 2. Polythene bag secured around simulated renal pelvicalyceal system to mimic renal capsule and form a space for creating the simulated renal parenchyma.

Figure 3. Simulated renal pelvicalyceal system and capsule within split mould.

approached via the 210 mm axis of the container (Figure 4).

The system was allowed to set in a refrigerator overnight. The free ends of the opaque polythene plastic sheeting were secured around the gelatin block using adhesive tape. The gelatin block was removed from the plastic container, and the sides of the phantom were reinforced with adhesive tape to provide support and structure (Figure 5).

Results

The phantom provides a simulated structure that resembles a hydronephrotic kidney into which needles, wires and drains can be inserted under ultrasound guidance. Fluid can be aspirated from the simulated renal pelvis to verify correct placement. Fluid can also be replaced into the simulated pelvis following repeated punctures using the tubing and a 20 ml syringe.

Although the simulator's validity has not been formally assessed, visually, the ultrasonographic appearances resemble a hydronephrotic kidney (Figure 6); hence, we suggest that the system has face validity. From our experience, the psychomotor skills required to perform a simulated percutaneous nephrostomy on the

Figure 4. The simulated kidney is embedded within gelatin solution.

phantom, in terms of hand-eye co-ordination and replication of procedural sequence, closely resemble those required for an actual nephrostomy. The "feel" of

Figure 5. Final appearances of the nephrostomy phantom.

Figure 6. Ultrasonographic appearances of the nephrostomy phantom.

the system (e.g. the puncture of the "renal capsule") also resembles the actual procedure, and thus we propose that the simulator also has content validity. The system can be re-used several times (we have used the same simulator to train up to six trainees) before multiple punctures of the vinyl glove preclude further drainage attempts. The simulator takes approximately 1–2 h to produce, and initially costs approximately £15 to manufacture. Subsequent incremental costs reduce dramatically following the initial purchase of the moulds and tubing.

Conclusion

A method for introducing trainees to the skills required to perform percutaneous nephrostomy in a valid simulated environment without patient risk is desirable. We propose that use of this nephrostomy phantom could optimise existing clinical training opportunities by familiarising trainees with nephrostomy procedural technique and equipment, and with the required psychomotor skills, in preparation for the performance of *in vivo* nephrostomy.

References

1. Hammond L, Ketchum J, Schwarz BF. A new approach to urology training: a laboratory model for percutaneous nephrolithotomy. *J Urol* 2004;172:1950–2.
2. Strohmaier WL, Giese A. Ex-vivo, training model for percutaneous renal surgery. *Urol Res* 2005;33:191–3.
3. Nicholson RA, Crofton M. Training phantom for ultrasound guided biopsy. *Br J Radiol* 1997;70:192–4.
4. Phal PM, Brooks DM, Wolfe R. Sonographically guided biopsy of focal lesions: a comparison of freehand and probe-guided techniques using a phantom. *Am J Roentgenol* 2005;184:1652–6.
5. John BS, Rowland D, Patel U, Pilcher J, Anson K, Nassiri D. Evaluation of the accuracy of 3-dimensional ultrasonography of the kidney using an *in vitro* renal model. *J Ultrasound Med* 2009;28:155–62.