Use of a vegetable model as a training tool for PCNL puncture

Maneesh Sinha, Venkatesh Krishnamoorthy

Department of Urology, NU Hospitals, Bangalore, Karnataka, India

ABSTRACT

Introduction: Training residents to perform a PCNL puncture is hampered by the non-availability of a good inanimate model that can be used for demonstration and practice. The ethics of surgical training during actual surgeries is being questioned and the role of simulation is increasingly important. Virtual reality trainers, however, are prohibitively expensive and the use of animal models is fraught with regulatory and ethical concerns. We have devised a model that can be used to teach the concept of depth perception during a PCNL puncture.
Methods: A bottle gourd was used to mimic the posterior abdominal wall. Cotton pledgets dipped in intravenous contrast were fitted into 4 mm holes made at staggered levels in the bottle gourd which was strapped onto the operating table with the cotton pledgets facing away from the surgeon. Surgeons with varying degrees of experience made fluoroscopy-guided punctures onto the cotton pledgets. We recorded the time taken for puncture in seconds and the distance of the needle exit site from the center of the cotton ball. Speed was measured by recording the fluoroscopy time in seconds on the C-arm. Accuracy was documented by using a Vernier caliper to measure the distance from the edge of the target to the actual puncture. One second of fluoroscopy time and 0.1 mm distance were each given one point. The total points accumulated over a set of 10 punctures was added to give a total score. Longer fluoroscopy times and inaccurate punctures resulted in higher scores.
Results: A surgeon with more than 1000 PCNLs to his credit had a score of 99. The average score of five residents was 555.
Conclusion: The bottle gourd model provides an ethically acceptable, inexpensive, easy to replicate model that can be used to train residents in the PCNL puncture.

Key words: Bottle gourd, PCNL, puncture

INTRODUCTION

Learning how to make a percutaneous nephrolithotomy (PCNL) puncture remains one of the more difficult aspects of endourology training. Converting the visuo-spatial information provided by the fluoroscopic image into the psychomotor ability to make an accurate puncture is always a struggle for the trainee. Most modern surgeons have learnt their punctures on real patients. In the charged atmosphere of an actual operating theater, the usual situation is of an extremely anxious trainee attempting a puncture under the supervision of an impatient trainer on an absolutely clueless patient!

One way of circumventing this problem is to train on a simulator. In the past decade, simulator training has been accepted as an adjunct to surgical training.[1] Available simulators are virtual reality models (VR) or animal models.[2-4] VR models give a good visual and haptic feedback but are not universally accessible due to prohibitive costs. Frugality in training models is an important concern in order to make them widely available. Animal models tend to be cumbersome and entail elaborate precautions and regulations. Keeping these considerations in mind, we have developed an easily replicable vegetable simulator which can orient the trainee to depth and distance perception during a PCNL puncture.

METHODS

There are two essential components of a PCNL puncture that a simulator must reproduce. The first is a tissue-like

For correspondence: Dr. Maneesh Sinha,
Department of Urology, NU Hospitals, CA 6, 15th Main, 11th Cross,
Padmanabhanagar, Bangalore - 560 070, Karnataka, India.
E-mail: dr.maneesh@nuhospitals.com

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medium for the needle to go through and the second is a target representing the calyx. After trying a few fruits and vegetables, we hit upon the bottle gourd as a suitable candidate. While selecting the vegetable, the emphasis was on easy, universal availability. Solid tissue with consistency close to human tissue was also a prerequisite. The bottle gourd was finally chosen because its depth corresponded to the measured depth of the calyx on the computed tomography (CT) scan. Its length allowed multiple targets to be created on a single specimen. Additionally, being a relatively drier vegetable, it was less messy in the operating theater. The force needed during puncture was slightly more than what is experienced in patients, but it served the primary purpose of helping the trainee coordinate two-dimensional visuospatial fluoroscopic information with three-dimensional hand-eye movements.

The second component was to create the target. Analysis of normal CT images at our institution yielded the depth and width of a normal adult posterior calyx to be 5-7 cm and 2-6 mm, respectively. We routinely use 14 guage, 7.5 cm intracath needles to make our PCNL punctures and we have infrequently needed longer needles. The model, however, works equally well with the longer two- or three-piece needles used by most urologists. Shan *et al.* measured the skin to calyx distance on dorsal CT scans to be 7.85 cm in the upper calyx and 9.25 cm in the lower calyx.[5] However, these patients had a mean body mass index of 28.66 and an abdominal girth of 100.79 cm and were, therefore, much larger than our average patients. Licheng describes mean puncture depths to be 52.54 cm on standard dose CT.[6] The flexibility of our model allows a surgeon to choose the size of the vegetable on his own. While the bottle gourd itself is available in diameters of 5 to over 10 cm, the plant world offers us an infinite variety of options to choose from.

The targets were made using contrast-impregnated, peanut-sized cotton balls embedded at staggered levels into one side of the bottle gourd. This replicated the calculus or contrast–filled calyx very realistically. Finally, to simulate the prone patient, the bottle gourd was strapped onto the operating table using adhesive plaster at either end. The surgeon stood on the side away from the targets and passed a needle under fluoroscopic guidance to target the cotton pledgets [Figures 1-6].

We used the triangulation technique of puncture, very similar to the technique described by Shergill.[7] With the C-arm in 0^0, the needle is inserted to the edge of the desired target. The C-arm is then rotated $10\text{-}30^0$ toward the surgeon. In this view, if the needle tip appears to have overshot the desired target, it lies superficial and if it appears not to have reached the target, it is pointing too deep. The correct orientation is achieved when in both 0 and 30, the needle tip appears to be pointing just at the edge of the target.

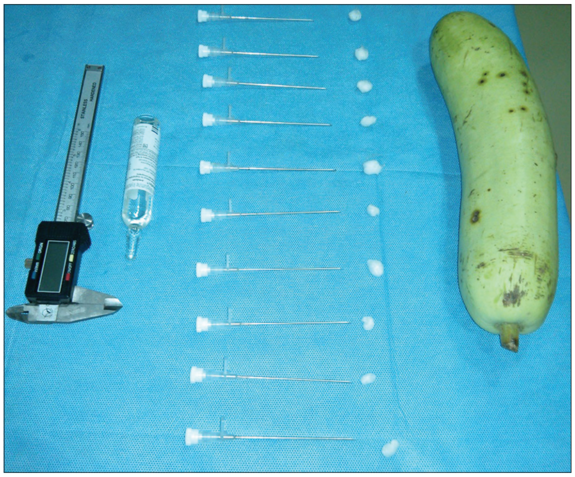

Figure 1: Raw materials needed include the bottle gourd, cotton pledgets, radiographic contrast, needles and a measuring scale

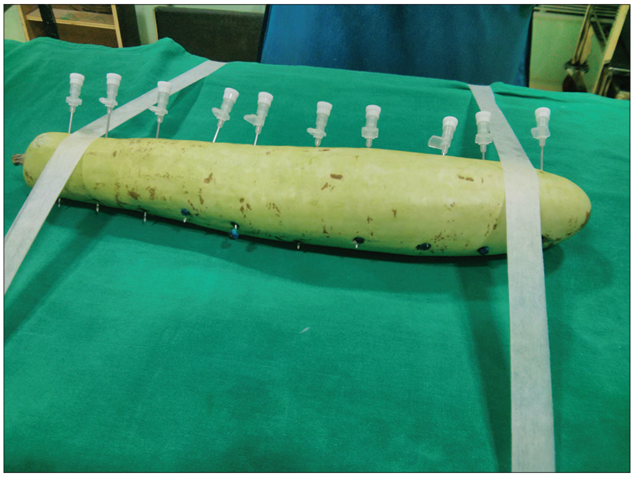

Figure 2: The model after punctures

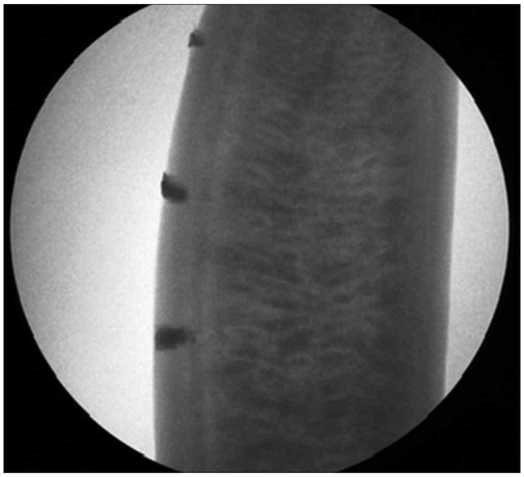

Figure 3: Radiographic appearance of model before puncture

The outcomes were measured in terms of speed and accuracy. The speed was measured by recording fluoroscopy time in seconds on the C-arm. Accuracy was documented by using a Vernier caliper to measure the distance from the edge of the target to the actual puncture. One second of fluoroscopy time and 0.1 mm distance were each given one point. The total points accumulated over a set of 10 punctures were added to give a total score. A greater score meant a poorer outcome.

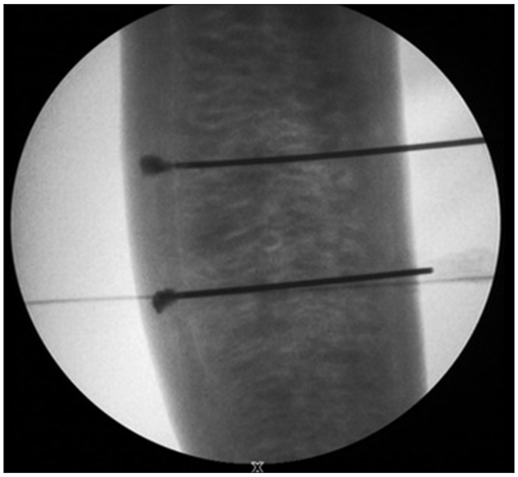

Figure 4: Radiographic appearance of model with the needle punctures

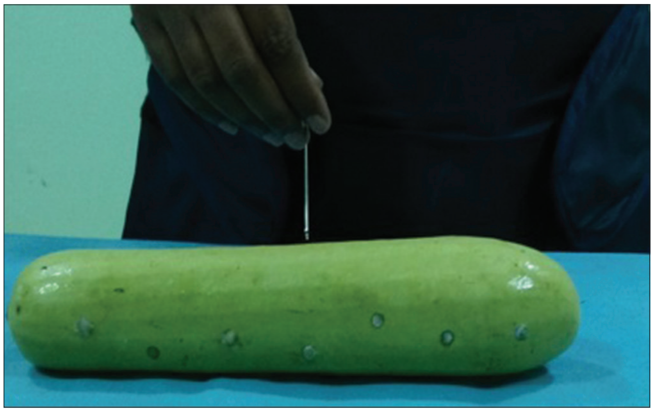

Figure 5: The surgeon stands on the side away from the targets to make the punctures

RESULTS AND DISCUSSION

The model and scoring systems were subjected to reverse validation. Three consultants with reasonable skills in PCNL and five resident Urology trainees were asked to make these punctures. The senior consultant with over 1000 PCNLs to his credit had a score of 99. The two junior consultants who were performing PCNLs on a regular basis had scores of 146 and 250. The mean score of five residents was 555. A simple way of analyzing the scores would be to imagine all punctures being accurate. The senior consultant would have taken less than 10 s for each puncture. Each resident would use up 1 min of fluoroscopy time to get their punctures right.

This model does have limitations. It does not replicate normal respiratory movements. We believe this feature to be unnecessary in a simulator. Once the needle passes across the renal capsule, the needle moves along with the respiratory movements and there is minimal relative movement between the calyx and the needle tip. However, we do acknowledge that the absence of respiratory movements is a serious limitation of this model and the trainee will need to reorient to respiratory excursions once actual PCNL punctures are attempted. Additionally, the rind of the bottle gourd allows less maneuverability than the posterior abdominal wall and renal capsule. We have circumvented this problem by coring out some of the outer skin at the site of the entry of the needle.

The advantages of this model are that it is inexpensive and easily replicable. It is also versatile as almost any vegetable of appropriate size and consistency can be used. We aim to prospectively validate this model to see if it can improve the trainee's ability to make a PCNL puncture. Further external validation is also needed before this model can be widely used.

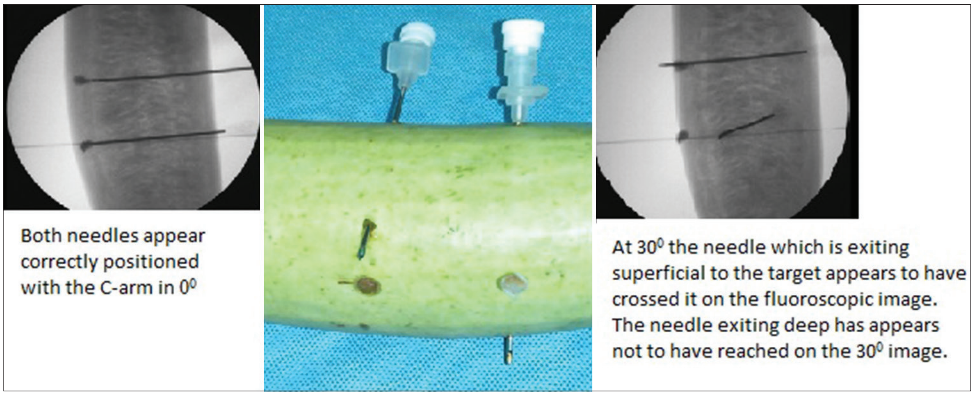

Figure 6: Direct visualization of the exit site in incorrect punctures helps the trainee orient himself to the information provided by the fluoroscopic images

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