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Percutaneous renal access training: content validation comparison between a live porcine and a virtual reality (VR) simulation model

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OBJECTIVE

- To compare the content validity (realism and usefulness) of percutaneous renal access (PRA) obtained on a live porcine model and a high-fidelity computer-based surgical simulator (PERC Mentor, Simbionix; Lod, Israel) in our skills laboratory for trainees interested in PRA training, so as to determine which of the two is a more appropriate and effective training model.

MATERIALS AND METHODS

- In all, 24 'experts' performed PRA in a live porcine model and using the PERC Mentor.
- The porcine model access required a live anaesthetized pig with a pre-placed ureteric catheter. The access was done with flouroscopic guidance using a 22-G 'skinny' needle (Cook Medical, Bloomington, IN, USA).
- Then the specific task of PRA using a similar case scenario was done using the PERC Mentor.
- The experts rated the models using a questionnaire based on a 5-point Likert scale, consisting of 10- and three-items of realism and usefulness, respectively.

RESULTS

- Of the 10 items of realism assessed, the porcine model was rated as better than the PERC Mentor for 'overall realism', 'movement of the kidney', 'tactile feedback of perinephric space', 'fluoroscopic realism' and 'complications encountered' (All $P < 0.001$).
- It was inferior to the PERC Mentor for 'orientation to the flank', 'aspiration', 'repetitive performance' and 'organisational feasibility' (All $P < 0.001$).
- 'Tactile feedback of successful access' was similar in both models (mean [SD] points, 4.24 [0.7] vs 4.6 [0.5]).
- Of the three items of usefulness, 'overall usefulness' (4.6 [0.6] vs 4.65 [0.5]) and 'use as a training tool' (4.32 [0.5] vs 4.75 [0.4]) was similar; however, the porcine model was a much better assessment tool ($P < 0.001$).

CONCLUSIONS

- Both models have relative advantages and disadvantages. The live porcine model is a more realistic assessment tool for PRA. The specific advantage of the PERC Mentor is of repetitive tasking and easier set up feasibility.
- The overall usefulness was same for both the models.

KEYWORDS

percutaneous renal access training, PERC Mentor, live porcine model

INTRODUCTION

Various models have been described for use in percutaneous renal access (PRA) training [1]. These include low-fidelity bench models, high-fidelity computer-based bench simulation models, *ex vivo* dead animal models and live *in vivo* animal models [2–4]. The appropriate usefulness of these models has been studied individually. There are no publications that directly compare these models. In the surgical skills laboratory of our institute, we incorporated a live porcine model and a high-fidelity simulation model for trainees interested in PRA. The purpose of the present study was to evaluate as to which model was more appropriate for PRA training.

MATERIALS AND METHODS

The study was conducted in the Surgical Skills Laboratory, Muljibhai Patel Urological Hospital, India. The participants included were 'experts' who performed the PRA in both the models. 'Expert' was defined as a participant that had done >50 cases of percutaneous nephrolithotomy (PCNL). In all, 24 experts including participants of a PCNL workshop and institute consultants were included in the study.

A live anaesthetized pig for the animal model (Group 1) and the PERC Mentor (Simbionix; Lod, Israel) for the high-fidelity computer-based surgical simulator model (Group 2) were used for the study. The participants first performed PRA in the porcine model. Success was defined as achieving PRA without the passage of a guidewire. After appropriate anaesthesia, before PRA, the pig underwent bilateral ureteric catheterization for opacification of the collecting system. The pig was then placed prone (Fig. 1) on a specially designed couch to accommodate the bend of the C-arm. With the use of a real-time C-arm, and as and when required contrast study for delineation of pelvicalyceal anatomy, an

FIG. 1. PRA in a live anaesthetised porcine model in the skills laboratory.

TABLE 1 The mean (SD) points rated by the experts on the modified Likert scale (1–5 points) of the content validity questionnaire

Questionnaire	Mean (sd) model score: Live porcine	Simulator	*P**
Realism:			
Over all realism	4.44 (0.7)	2.75 (0.8)	<0.001*
Movement of kidney	4.96 (0.2)	3.15 (0.7)	<0.001*
Orientation to flank	2.36 (1.1)	4.3 (0.5)	<0.001*
Tactile:			
Perinephric space	3.64 (0.8)	1.4 (0.6)	<0.001*
Puncture	4.24 (0.7)	4.6 (0.5)	0.02
Fluoroscopic orientation	4.64 (0.5)	3.05 (0.7)	<0.001*
Aspiration	3.2 (0.9)	4.2 (0.6)	<0.001*
Complication	4.36 (0.5)	1.9 (0.8)	<0.001*
Repetition	3.52 (0.4)	4.85 (0.4)	<0.001*
Organisation feasibility	3.04 (1.0)	4.85 (0.4)	<0.001*
Usefulness:			
Overall usefulness	4.6 (0.6)	4.65 (0.5)	0.38
Training tool	4.32 (0.5)	4.75 (0.4)	0.001*
Assessment tool	4.68 (0.5)	2.75 (0.9)	<0.001*

**P < 0.001 statistically significant.*

expert performed the PRA. Selective calyceal puncture, usually at the posterior lower pole calyx, was carried out with a 22-G 'skinny' needle (Cook Medical, Bloomington, IN, USA) under fluoroscopic control. The expert, based on his judgement of the flank, decided the access site on the skin of the pig. An independent observer judged the successful PRA. Only experts with successful PRA were considered for the questionnaire-based assessment of the construct validity.

All the experts then performed the PRA on the PERC Mentor after orientation to the simulator by way of an introductory session and a trial run. A specific case scenario (PCN normal, no. 2) was chosen to resemble the lower pole access in the porcine model. Successful puncture was defined as aspiration of clear urine on the aspiration needle button of the task on the computer hardware.

For objective measurement of realism domains, there are no guidelines. The task of PRA was divided in 10 small constructs. The constructs were then framed as a questionnaire for objective grading. Hence, 10 realistic domains were assessed. The 'usefulness' domain was devised based on the utility of the laboratory training. It was divided in to an ill defined 'overall usefulness', and 'usefulness for training and assessment'. The standardized questionnaire in the English language was given to the experts for their opinion of the exercise. The experts rated the models using the questionnaire, which was based on a 5-point Likert scale, with 1 denoting very bad and 5 as excellent. In all, there were 13 questions, with 10 and three items of realism and usefulness, respectively (Table 1). Domains of 'overall realism', 'movement of kidney with respect to respiratory movements', 'orientation to the flank', 'tactile feedback of the puncture with needle in the perinephric space and within the pelvicalyceal system', 'ease of aspiration to confirm successful puncture', 'complication recognition', 'repetition of the task' and 'overall organisational feasibility' were evaluated to assess the realism of the training model. 'Overall usefulness' and 'usefulness of the model as a training and assessment tool' were the domains checked for usefulness. The results of content validity of both the models were compared using the Student's *t*-test, with $P < 0.001$ considered to indicate statistical significance.

RESULTS

In all, 27 experts performed the exercise; 26 performed successful renal access in the porcine model and 24 of these 26 participants performed successful access on the PERC Mentor. Three experts were thus excluded from the content validity questionnaire.

Table 1 shows the mean (SD) of the points rated on the modified Likert scale (1–5 points) of the content validity questionnaire. The live porcine model was rated better than the simulator model in certain aspects of realism and usefulness (Fig. 2) while inferior in other areas (Fig. 3).

DISCUSSION

There has been a paradigm shift in the way; a trainee is being trained to acquire technical skills before entering the operating theatre. In the case of PRA, previously a radiologist-guided access was used for clearing the stones in PCNL. A need was felt for the urologist to acquire the necessary skills for access, as it was the single most important factor to guide for the successful clearance of the stone. Despite more complex stones and higher access difficulty in the urology access group, access related complications and stone-free rates were comparable [5]. Various high- and low-fidelity models for acquiring skills are available for such purpose.

Stern *et al.* [1] published a review of the contemporary models available for such training. The relevant question, thus, is which model to choose for a safe, effective, appropriate, efficient and accessible training. To date, to our knowledge, there have been no studies comparing the different models for content validity. This might be explained by the fact that the simulator models differ vastly in terms of training. The low-fidelity models obviously would score lowly on the Likert scale. Therefore, a comparison is theoretically possible only between similar fidelity models. Even strict categorization

FIG. 2. Assessed questionnaire variables in which the live porcine model was better than the simulator model.

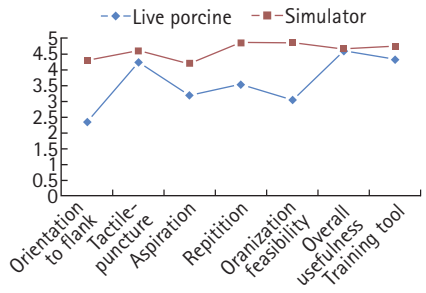
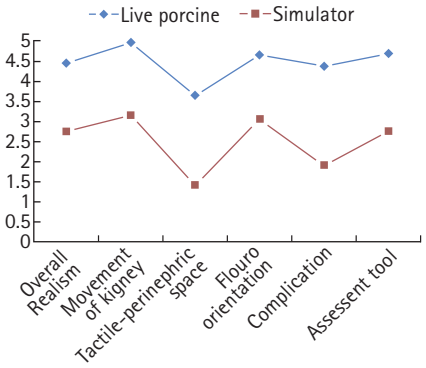


FIG. 3. Assessed questionnaire variables in which the simulator model was better than the live porcine model.



between the models for fidelity is has not published. The highest fidelity model after a human being would be a comparable size anaesthetized animal model. Currently, there is also a high-fidelity computer-based software model, the PERC Mentor that closely resembles the live situation. A comparison is therefore possible in the above-mentioned models for overall usefulness and realism. We compared the content validity of the high-fidelity simulator model and a live porcine model to reach a conclusion to such a question. A 5-point Likert scale was chosen to rate the questionnaire. While there is no consensus as to the usage of a standardized objective test, the Likert scale can provide a representative objective value to prove a hypothesis.

SAFETY

Obviously, all the simulator models are safer than live or cadaveric models for viral transmission, radiation hazard and traumatic injuries. The live model requires the presence of veterinary staff. The pig has to be brought, kept in the isolation room, anaesthetized and moved to the access trolley. These preparations before the access skill require specialized paramedical staff. Once the pig is prone and fixed to the trolley, anaesthesia is induced and maintained, which requires the constant presence of a veterinary assistant. The puncture by itself can lead to blood contamination of the fingers and exposed surfaces, leading to a potential threat of viral transmission. The procedure also requires presence of the C-arm unit and its attendant radiation hazard to the trainee, paramedical staff and the trainer. The training session involving the renal unit has to be changed on an average after three trials in view of obscured anatomical field due to contrast extravasation. Frequent animal changes from the trolley, once again, increase the above-mentioned risks. On the other hand, there are no safety concerns on the simulator model. In the present study, these issues were not specifically checked in a direct comparison. But, indirect evidence to the above problems could be judged by the fact that the simulator model fared better than the live model for organisational feasibility, repetitive skill assessment, overall usefulness and as a training tool.

EFFECTIVENESS

The effectiveness of the model can be judged by the predictive validity of the simulation exercise. Very few studies have established the predictive validity any of the models. Margulis *et al.* [6] in an elegant study established that training in the live porcine model and PERC Mentor improved access skill on predictive validity testing. In content validity testing, ideally a more realistic model may be presumed to be more appropriate and effective as far as predictive validity testing is concerned. In the present study, the live porcine model was a more realistic model. Its overall realism was far better than the simulator. This may be due to the greater resemblance to the real-time situation of anaesthesia, a prone animal, a realistic C-arm unit, real-time retrograde contrast study, movement of the kidney, tactile feedback of the perinephric space and the actual pelvicalyceal system, complications and aspiration to confirm a successful puncture. Three aspects of realism, namely; orientation to the flank, tactile feedback to the puncture and aspiration were rated better in the simulator model. An accurate puncture site in the porcine model is difficult in view of a difficulty to appreciate the posterior axillary line and a more triangular cross-section of the abdomen. Conversely, in the PERC Mentor, a posterior axillary line is well made and is the actual landmark allowing the trainees to select a puncture site. In the porcine model, the aspiration of urine was problematic due to an undilated system. To overcome this problem, we started continuously filling normal saline from the ureteric catheter to keep the system dilated. Once the puncture was done, successful puncture was confirmed by way of urine egressing through the needle and simultaneous pushing of saline from below. This was relatively easy in the PERC Mentor in which computer soft ware assessed successful puncture.

APPROPRIATENESS

Overall usefulness, training tool and assessment tool are the fields, which reflect the appropriateness of a training tool. Overall usefulness is an ill-defined subject arena, whereby the experts rate the entire training exercise. Obviously, both the models are useful to the trainees when compared with no training at all. There was no statistical significant difference in overall usefulness. When the domain of 'training tool' was considered, the high-fidelity simulator was more appropriate. The conclusion could be biased by the fact that it scores highly on the domains of 'organisational feasibility', 'repetitive training', 'ease of set up', 'low running cost' and 'trainee safety'. However, it is interesting to note that for 'assessment tool', it was the live porcine model that was perceived to be more appropriate. This may be explained by the fact that it was more realistic to the live human scenario and would thus, be more appropriate as an assessment tool.

Efficiency

Efficiency can be judged by looking at the logistics of the model. The high-fidelity models definitely come at a very high price. However, once installed, the running cost of the model is very low. It can be easily set up when required, provided there is a space and an electricity supply. On the contrary, the live porcine model has lots of cons. It requires the

running cost albeit low for the animal; veterinary assistance, anaesthesia charges, radiation and biological hazard and difficult set up. The efficiency parameter has got a leaning towards high-fidelity simulator models. This aspect when analysed in the present study was reflected in the domains of 'repetition', 'organisational feasibility', 'overall usefulness and training tool'.

Accessibility

Accessibility depends on the financial recourses of the training institute. The models are both accessible if the facility exists in an institute. The major factor hindering the access is the high initial cost of the simulator and recurring cost of animals with approval of the Local Animal Ethics Committee in the live model. The 'overall usefulness' domain may reflect the accessibility of the model. Here, may be because of the fast repetitive training and low running cost, the simulator model appears to be far more accessible than the live porcine model.

In conclusion, both models have relative advantages and disadvantages. The live porcine model is more realistic than the high-fidelity simulator model. It is also a better assessment tool for the trainees with the advantage of being more realistic. However, because of the difficult organisational feasibility and requirement of additional instruments and personnel, a high-fidelity simulator does have an important role to play. Although, they come with a high price disadvantage, they are relevant because of the 'more usefulness' domain. The running cost is low. Repetition of the exercise without radiation and biological hazard is possible, thereby increasing its importance as a training tool.

CONFLICT OF INTEREST

None declared.

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Abbreviations: **PRA**, percutaneous renal access; **PCNL**, percutaneous nephrolithotomy.