A Simulator for Teaching Transrectal Ultrasound Procedures

How Useful and Realistic Is It?

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Introduction: We describe a new simulator for teaching transrectal ultrasound (TRUS) and present the results of a preliminary evaluation of the simulator's realism and usefulness for training.

Methods: A simulator for abdominal ultrasound was adjusted by the developer to enable simulation of TRUS by providing an opening for inserting a dummy rectal probe. To enable TRUS simulation, data from ultrasound prostate imaging of eight real patients obtained with our regular ultrasound machine were transferred to the simulator by connecting the computer of the simulator to the ultrasound machine. These data were used to create images in the TRUS simulator. Residents and urologists used the simulator to perform TRUS in one of the eight patient cases and judged the simulator's realism and usefulness.

Results: We were able to construct an initial urological module for the TRUS simulator. The images shown on the monitor of the simulator are quite realistic. The simulator can be used without difficulty to collect data, to create cases, and to perform TRUS. The absence of an option for prostate biopsy and the lack of tissue resistance were mentioned as two important shortcomings. Forty-seven participants rated the simulator's overall realism and usefulness for training purposes as 3.8 (standard deviation: 0.7) and 4.0 (standard deviation: 0.8) on a five-point Likert scale, respectively.

Conclusions: The simulator we describe can be used as a training tool for TRUS. It enables training with different patient cases and minimizes the burden to patients. Simulation of prostate biopsies should be added to increase the model's usefulness.
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Key Words: Education, Simulation, Training, Transrectal ultrasound.

Transrectal ultrasound (TRUS) is widely used to diagnose benign prostate hyperplasia, to measure prostate volume, and in performing transrectal prostate biopsies to diagnose prostate cancer.[1,2] Because TRUS can cause discomfort to patients and requires skills in three-dimensional (3D) orientation and interpretation of findings, a realistic TRUS simulator, which does not burden patients, seems desirable to facilitate training. Little research has been done on TRUS simulators. A 1990 article described a TRUS simulator in which the prostate was simulated by a Foley catheter balloon, but this simulator was not satisfactory.[3] More recently, Sclaverano et al[4] described the first version of a simulator for ultrasound-guided prostate biopsy. New simulators are under development, but validation studies have not yet been published.[4] The ultrasound simulators that are currently used in medical training offer no option for TRUS.[5–10] A simulator for abdominal ultrasound was adapted to simulate ultrasound imaging of the urogenital tract by the developer of the simulator.[5,9] We describe this new TRUS simulator and evaluate its realism and usefulness for training purposes.

METHODS

An existing simulator for abdominal ultrasound[7,9] was adjusted by the developer to enable simulation of TRUS. An opening for insertion of a dummy rectal probe was created in the foam rubber mannequin, and a dummy rectal probe was provided. The adapted ultrasound simulator (Sonofit, Darmstadt, Germany) is composed of a personal computer trolley, software, a mannequin, and a tracking device (Ascension Technology Corp., Burlington, VT) attached to a dummy probe (Fig. 1). The simulator has a data collection and management mode for use by supervisors and a training mode for students. In the data collection mode, the computer is connected to an ultrasound machine, and data are downloaded while ultrasonography is performed in a real patient using a 3D ultrasound scanner or a freehand 3D technique. In this way, real-3D ultrasound data are obtained. The simulator software uses the tracking device to measure the position of the probe as it is moved

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Figure 1. The transrectal ultrasound simulator set up for training.

during examination of the patient. The mannequin is equipped with an electromagnetic localization system, and the probe contains an electromagnetic sensor. To simulate 2D ultrasound images, the 3D data that are loaded onto the system during the real-time procedure are virtually placed in the mannequin and retrieved in accordance with the position of the probe. Parameters such as depth settings, ultrasound gain, and contrast are used to calculate images at a frame rate of approximately 20 images/s to provide real-time feedback during simulated ultrasound.[5]

We collected data from TRUS procedures in eight patients by connecting the computer and the tracking device of the simulator to the ultrasound machine used to perform the real TRUS procedures. The reasons to perform TRUS in the real patients were an increase in prostate-specific antigen, lower urinary tract symptoms, and measurement of the prostate in patients eligible for brachytherapy. Five patients were diagnosed with prostate malignancy based on the histology of prostate biopsy. Three patients were diagnosed with benign prostate hyperplasia based on a combination of prostate-specific antigen, digital rectal examination, ultrasound, and histology of prostate biopsy. One case was used in a training session of a nationwide ultrasound course for urology residents in the Netherlands. In some countries, urological ultrasound procedures are performed by radiologists, but in the Netherlands, TRUS is routinely performed by urologists and urology residents. All the participating residents ($n = 40$) and the seven course instructors (practicing urologists) received a standardized introduction to the mechanism of the simulator and then used the simulator to perform TRUS in a simulation of a patient with an enlarged benign prostate. The participants had no previous experience with the simulator. After the training session, which lasted 20 to 30 minutes for each participant, the participants were given a questionnaire asking them to rate the realism and usefulness of the simulator on a five-point Likert scale (1 = not realistic, not useful and 5 = very realistic, very useful). Items on realism related to ergonomics, anatomy, instruments, image and colors, design, tissue resistance, and an overall score. The usefulness items related to hand-eye coordination, knowledge and handling of equipment, 3D orientation, recognition of pathology, and an overall score. The participants were also asked to write comments about any shortcomings of the simulator.

Approval from our institutional review board and informed consent from the patients and participants were obtained to carry out the evaluative study described. The data were processed anonymously as is required by the nationwide ethical and legal rules of conduct for medical research. There is no financial benefit for the research group related to selling rates of the simulator in the future. The developing company provided a model for research purposes only and had no other involvement in the study.

RESULTS

We did not experience major difficulties in collecting patient data. It took no more than ~5 minutes to set up the simulator, and the same amount of time was sufficient to check the recordings. Hyper- and hypoechoic areas can be recognized, and volume can be measured. Images of the prostate, including the seminal vesicles, in the transversal and sagittal planes can be simulated by rotating the probe and moving it from the base to the apex of the prostate. The training mode also offers options to describe the case and ask students questions. Additional information can be provided on screen together with the images.

The ultrasound images on the simulator are nearly identical to real ultrasound images (Fig. 2). All kinds of pathologic findings can be collected and stored in the computer of the simulator. Patient cases stored in the computer of the simulator can be used repeatedly for training purposes in a skills laboratory. The simulator costs approximately €50,000 and optional devices, such as a puncture needle, patient cases, and a transesophageal probe are available at extra cost.

Limitations of the Simulator

The opening in the dummy in which the rectal probe is inserted is surrounded by foam plastic to simulate tissue resistance, but the external and internal anal sphincter are not simulated. This detracts from the realism of the sensation when the dummy probe is inserted. Color Doppler imaging can be included in the simulator, but arterial pulsations are not shown. Movements of the dummy rectal probe in the transversal and sagittal planes provide images that are comparable with real ultrasonography, but the correspondence is less good with images resulting from tilting the dummy probe.

The simulator does not include an option for prostate biopsy, but the gynecological version of the simulator allows for amniocentesis. To simulate an ultrasound guided prostate biopsy, a second tracking device might be attached to a puncture needle, which could be mounted on the rectal probe.

Evaluation of the Simulator

The 47 participants had a mean number of 4.9 (standard deviation [SD]: 5.4) years of experience with TRUS. The mean number of TRUS procedures performed was 550 (SD: 2250). The mean scores (on a five-point scale) on realism and usefulness were 3.8 (SD: 0.7) and 4.0 (SD: 0.8), respectively. The highest ratings were for training in 3D orientation (4.0, SD: 0.8) and recognition of pathology (4.1, SD: 0.9). The overall score on the realism of tissue resistance was 2.3 (SD: 1.0). Most of the participants' comments related to the inability to simulate prostate biopsy. Other comments concerned

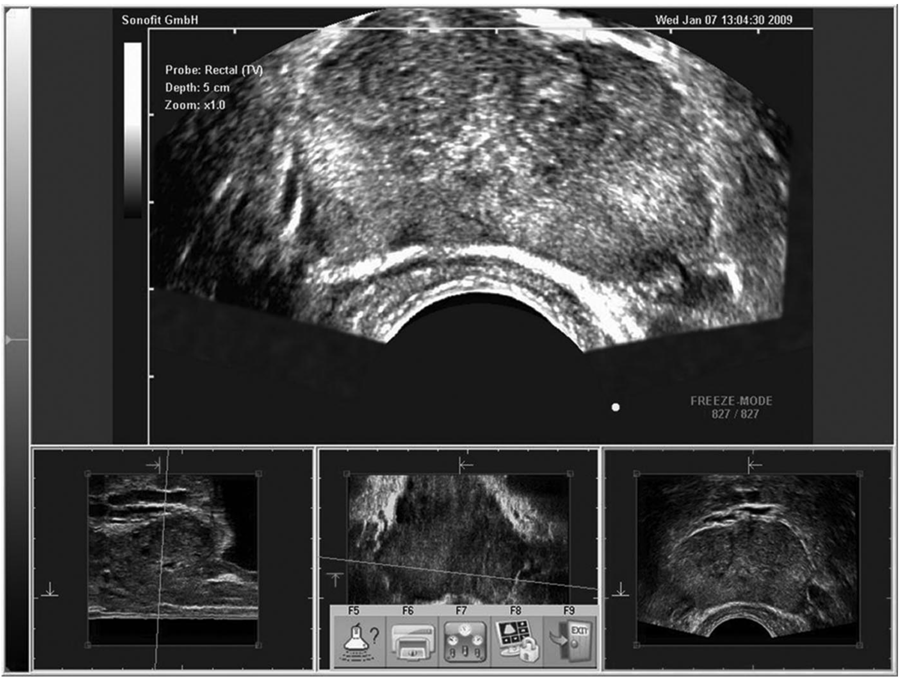

Figure 2. Transversal and sagittal images of the prostate on the simulator.

the need for greater variety of cases and simulation of tissue resistance. The comments are summarized in Table 1.

DISCUSSION

In the preceding sections, we described the use of an existing abdominal ultrasound simulator that was adapted to simulate TRUS and we used a questionnaire to evaluate its realism and usefulness. The adaptation of the simulator involved creating an opening in the mannequin and provision of a dummy rectal probe. Data from TRUS procedures in real patients are downloaded onto the computer of the simulator. The simulator provides lifelike ultrasound images that can be used for repeated practice. Different patient cases can be included and theoretical information can be added by supervisors. Limitations of the model are the restricted range of movement of the rectal probe and the absence of functionality for biopsies. According to the participants, the simulator was particularly useful for training in 3D orientation and identification of pathology. The scores on overall realism and usefulness were quite high compared with similar scores reported for other simulators.[11] Ratings were low in relationship to the realism of tissue resistance.

Table 1. Most Frequent Comments With Respect to Improvement of the Simulator

Comments From 33 of 47 Participants	No. Remarks	Percentage
The simulator should also allow for prostate biopsies	12	25
More pathology should be included	9	19
Tissue resistance is not realistic	8	17
The simulator does not include the digital rectal examination	4	8
The simulator does not offer a simultaneous view of the transversal and sagittal planes	4	8
The range of probe movement is limited	4	8
No 3D images are provided to guide the student	2	4
The mannequin cannot be positioned on its side	1	2
The simulator does not include placement of gold markers for brachytherapy	1	2
Other	3	6
Total	48	100

Although it may cause discomfort, TRUS is not a hazardous procedure, and the necessary skills can also be learned in real-time procedures with supervision from a surgeon. The software of the simulator that was adapted for TRUS also allows for simulation of liver biopsies and amniocentesis. In the future, it may well be feasible to increase the range of training options by adding prostate and kidney biopsies. This study was conducted in an early phase of the development of the simulator. We sought residents' and urologists' judgements of the usefulness of the simulator as an educational tool to inform the developers about the needs of the target group. Further studies will have to be performed when further adjustments and improvements have been made.[12]

The role of simulation in the training of medical professionals is increasing. Simulators are not only valuable as training tools but can also be used as standardized assessment tools. They allow trainees to make errors in a safe environment.[13,14] It is of paramount importance that a simulator is thoroughly validated before it is used for assessment purposes. The costs involved in training surgical residents is a matter of concern.[15] Simulators might be favorable from a cost perspective, but there is as yet no evidence of the financial benefits of simulator-based training for TRUS. Prices of simulators range from $5000 to $200,000, depending on the sophistication of the simulator. Factors that need to be taken into account in determining the cost-effectiveness of simulators include the time of trainees and instructors for simulation-based training at the expense of clinical work and the benefits in terms of patient safety.[16]

In conclusion, the TRUS simulator we investigated enables repeated use of ultrasound images of real patients for training purposes in a skills laboratory. It seems to be a promising educational tool to build competence in procedures involving TRUS without inconveniencing patients. However, simulation of prostate biopsies should be added to increase the usefulness of the simulator and justify financial costs. Further developments might lead to more widespread use of the simulator, and this would necessitate validation studies to ensure effective training.

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