Improving education on C-arm operation and radiation protection with a computer-based training and simulation system

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Abstract

Purpose  To discuss an approach to improve education in C-arm operation and reduction of radiation hazards based on a computer based training and simulation system called virtX.

Methods  virtX is equipped with a visualization of scattered radiation and means to include patient positioning changes in radiograph simulation. virtX was integrated in a course for ORP and evaluated based on questionnaires.

Results  Response rate was 73% (n = 77), mean age 35.4 (±9.2) and professional experience 11.2 ± 10.4 years. 91% use a C-arm regularly, 8% casually and 1% not. 78% agree that the translation of patient dummy positioning changes to simulated X-ray images is sufficiently realistic, 1% disagree (neutral 17%). 79% state that they acquired new knowledge concerning avoiding unnecessary radiation exposure, 10% do not (neutral 11%).

Conclusions  The virtX-approach of simulating radiograph generation including patient positioning and scattered radiation was evaluated positively concerning its suitability for imparting knowledge regarding radiation protection and C-arm operation.

Keywords  C-arm · Computer-based training · Simulation · Radiography · Radiation protection

Purpose

Mobile image intensifier systems (C-arms) are essential tools in the treatment of human and even animal emergency and trauma patients. These systems enable intra-operative radiograph generation to control and monitor the progress of surgical procedures. Operating a mobile X-ray modality presumes training in handling the hardware correctly, in achieving the correct adjustment corresponding to the surgical situation and in minimizing the radiation exposure of patient, surgeon and operating room personnel (ORP). Current training programs are often based on theoretical education and lack of imparting practical experience to the trainees. Possible reasons are that training with real radiation is potentially dangerous [1,2], which makes it prohibitive, and that radiation itself could not be perceived by any human sense. Aim of this paper is to demonstrate and discuss an approach to improve education in mobile image intensifier operation and radiation protection based on a computer-based training and simulation system called virtX that visualizes radiation and maps changes in the positioning of a virtual patient into simulated radiographs.

Methods

The virtX system

The computer-based training (CBT) and simulation system virtX was developed by an interdisciplinary team of medical
informatics, trauma surgeons and radiologists. It offers trainees the opportunity to practice different C-arm adjustment tasks from the daily operation workflow in a virtual or real environment with no X-ray exposure, but with visual feedback through a digitally reconstructed radiograph (DRR). The concept of the virtX system is depicted in Fig. 1 and a former version is also described in [3]. virtX consists of a virtual three dimensional (3D) scene of an operation theatre with interactive models of a C-arm, patient and operating table, a virtual radiograph generator, a CBT-module, a prototype visualization of the scattered radiation and a module, that transfers the movement of a real C-arm, operating-table (OR-table) and patient manikin to the virtual scene.

All relevant articulations of the three-dimensional model of the C-arm, the OR-table and the joints of the virtual patient as depicted in Fig. 2 (1, 3, 4 and 5) can be adjusted with interactive graphical control elements (Fig. 2, 7a–c) using a mouse or a keyboard. Depending on the exercise the trainee has to achieve the correct patient positioning, and the C-arm and table settings in the virtual scene. According to

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**Fig. 1** virtX system concept

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**Fig. 2** Graphical user interface of the virtX system

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1. view from behind the c-arm
2. digitally reconstructed radiograph (normal and inverted)
3. view from the image intensifier to the patient including laser cross
4. view from the ceiling
5. view from the position of the surgeon
6. exercise control and feedback
7. control panels for the C-arm (a), the table (b) and the patient (c)