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# Remote training and evaluation of a simulator-based training course for complex endovascular procedures

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**Summary**

*Background* Intimate knowledge of the materials used in endovascular aortic interventions is essential for trainees and supporting staff taking part in an endovascular intervention. Training courses can help to familiarize trainees with the equipment. However, the pandemic has changed the landscape of hands-on training courses significantly. Therefore, we developed a training course including an educational recording of the procedure to transfer knowledge about the materials used during endovascular interventions and radiation exposure reduction.

*Methods* We produced a video depicting cannulation of the left renal artery in a silicon cast of an aorta and its major side branches under C-arm fluoroscopy. A presentation using the video was given to the trainees. The trainees were randomized into a control and an intervention group. Their performance was filmed and rated on a standardized five-point scale in the style of the OSATS global rating scale. The intervention group was remeasured after additional training time.

*Results* In total, 23 trainees participated in the training and agreed to have their performance recorded. The control and intervention groups showed no difference in the assessed performance metrics during their initial attempt. However, after receiving additional training, the intervention group significantly improved in all evaluated metrics.

*Conclusion* Our data add to the growing evidence that simulator-based training can help to increase trainees' understanding and performance of relevant skills. A standardized and evidence-based validation process for simulators could improve their acceptance in the medical field.

**Keywords** Simulator training · Patient safety · Team training · Endovascular surgery · EVAR · Vascular surgery · Radiation · Radiation safety · Radiation exposure · Fluoroscopy

## Introduction

Endovascular aortic interventions require an in-depth knowledge of the materials used, such as the various catheters, sheaths, wires, stents, and other devices. The workspace during endovascular interventions extends away from the patient and all the way to the end of the wire, and most of the team will touch the equipment travelling up and down the line. This contrasts with open surgery, where the operating surgeon handles most of the instruments that come into contact with the patient. An intimate knowledge of these materials is essential for trainees and supporting staff taking part in an endovascular intervention.

Training courses can help to familiarize trainees with the equipment and simulator-based training can provide an opportunity to handle the equipment before taking part in surgery [1].

Endovascular surgery not only includes significant risks for the patient, but for the operation team as well. Long-term radiation damage in surgical teams is a reality we must face and an area in which our

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knowledge will most likely increase over the coming years [2].

For these reasons, we developed a training course and video designed to transfer knowledge about the materials used during endovascular interventions, the handling of the materials, and radiation exposure reduction.

## Methods

### Institutional review board approval

The ethics committee of the City of Vienna approved the collection of the participants data during a live radiation training under the identifier EK 18-075-0618. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki declaration of 1975, as revised in 2008.

### Participants

The participants consisted of surgical residents, medical students, and scrub nurses who were expected to participate in real-life endovascular procedures. Before participating in the training, they received a standardized refresher on X-ray exposure, radiation safety, and handling of the C-arm.

### Materials

Central to our simulation was a negative cast of a 3D print of a patient's aorta made from silicone. When placed under a Ziehm Vision RFD (Ziehm Imaging GmbH, Nuremberg, Germany) and primed with silicone spray and water, the image rendered resembles an overlay after angiography (Figs. 1 and 2).

We filmed and cut a video depicting cannulation of the left renal artery. The goal of the training was to cannulate the left renal artery using a soft wire and an appropriate catheter and to switch to a semi-stiff wire. A standardized layout of different wires and catheters was available to the trainees.

### Study design

The trainees received the training video before the training date and were asked to study it (Video 1). A standardized presentation using the video was given to each group of trainees directly before the training session. The trainees were randomized to a control
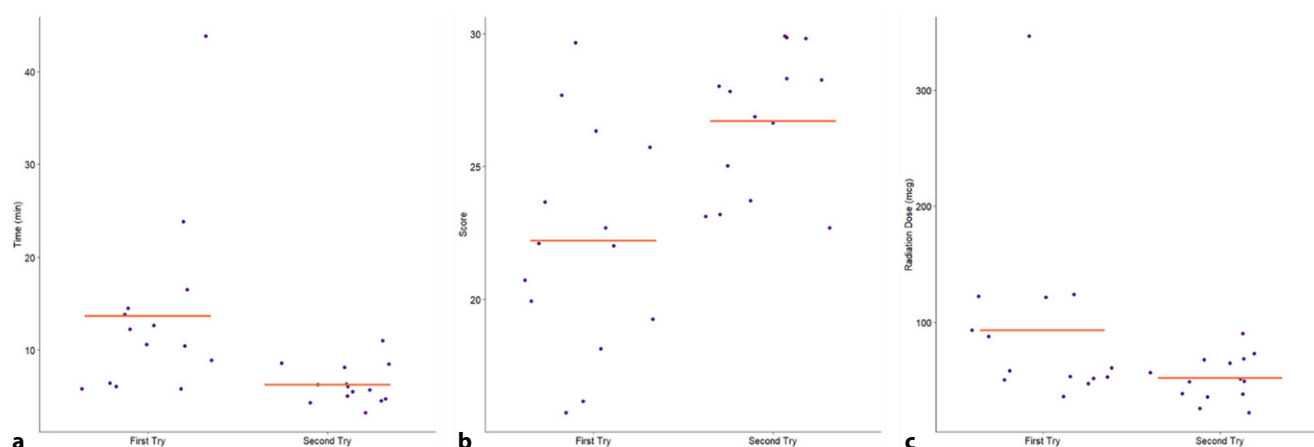


**Fig. 1** C-Arm set-up



**Fig. 2** Aortic model

**Fig. 3** Group 2 (I) vs. group 2 compared for total time (**a**), score (**b**) and radiation dose (**c**) (II)

and an intervention group. Both groups participated in an inaugural training session. Their performance was rated on a standardized five-point scale in the style of the Objective Structured Assessment of Technical Skills (OSATS) global rating scale ([3]; Fig. 3). Because multiple tasks, e.g., exact handling of the wires and catheters, fluoroscopy, collimation, and C-arm setting had to be observed simultaneously, we filmed the trainees' performance from multiple angles to allow the observer to review the performance of the trainees after each session. Additionally, we recorded the total time of each session and the radiation time and dose. After the first training session, the intervention group had the opportunity to train using the simulator for another 30 min and to review the instructional video. Afterwards, they were asked to perform another training session, which was observed and rated.

Trainees were responsible for operating the C-arm and choosing the collimation and settings. The key switch was kept in an X-ray off position until appropriate settings were chosen by the trainees to ensure minimal radiation exposure.

## Statistical analysis

Descriptive statistics of the collected data include means, medians, and standard deviations (SD). Wilcoxon signed-rank and rank sum tests were used to compare group means. A $p$-value $< 0.05$ was considered statistically significant. Statistical analyses were performed in R using RStudio (Posit PBC, Boston, MA, USA).

## Results

### Participants characteristics

In total, 23 trainees participated in the training and agreed to have their performance recorded and rated. The trainees were continuously randomized to the control group ($n = 9$) or to the intervention group ($n = 14$). The intervention group consisted of 5 residents, 2 nurses, and 7 medical students, while the control group included 3 residents, 3 nurses, and 3 medical students. The mean age did not differ significantly between the two groups (29.9 in the control group vs. 26.3 in the intervention group, $p = 0.20$).
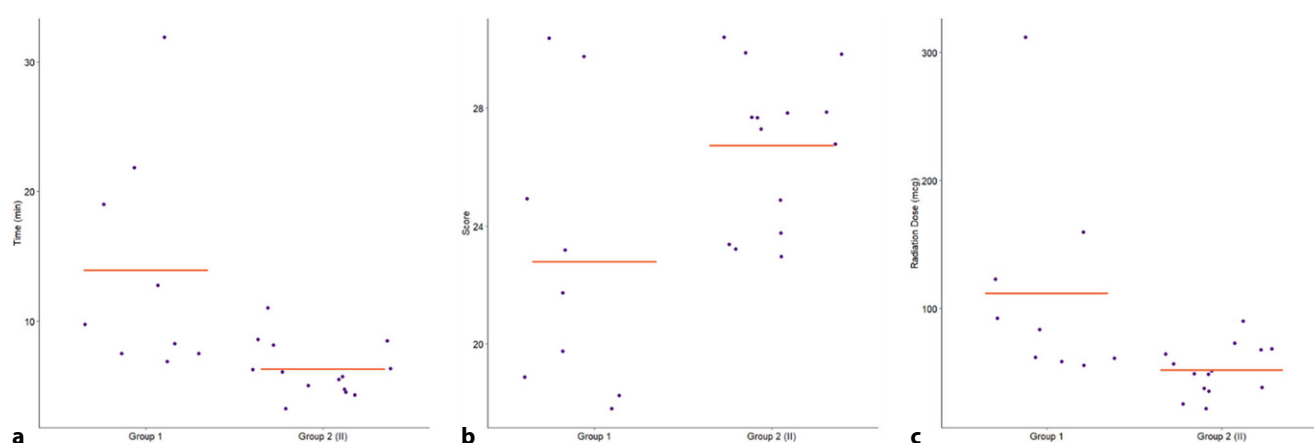


**Fig. 4** Group 1 vs. group 2 compared for total time (**a**), score (**b**) and radiation dose (**c**) (II)

**Table 1** Group means and standard deviation

|  | Time | Score | Radiation |
|---|---|---|---|
| Group 1 | 13:54 (8:07) | 22.8 (4.44) | 112.0 (77.9) |
| Group 2 (I) | 13:48 (9:38) | 22.2 (4.13) | 93.2 (76.19) |
| Group 2 (II) | 6:16 (2:01) | 26.7 (2.55) | 52.1 (18.6) |
| *Group 1* control, *Group 2* intervention | | | |

**Table 2** *P*-values of Wilcoxon signed-rank/rank sum tests

|  | Time | Score | Radiation |
|---|---|---|---|
| 1 vs. 2 (I) | 0.829 | 0.899 | 0.201 |
| 1 vs. 2 (II) | 0.002 | 0.045 | 0.009 |
| 2 (I) vs. 2 (II) | <0.001 | 0.002 | 0.003 |
| *1* control, *2* intervention | | | |

### Performance assessment

The performance of the two groups during the first training session did not differ significantly as measured by total time needed to complete the task (intervention 13:48 min SD 9:38 vs. control 13:54 min SD 8:07, $p = 0.829$), grading on the five-point performance scale (intervention 22.2 SD 4.13 vs. control 22.8 SD 4.44, $p = 0.899$), or total radiation exposure (intervention 93.2 cGy/cm$^2$ SD 76.19 vs. control 112.0 cGy/cm$^2$ SD 77.8, $p = 0.201$).

After the intervention group had undergone additional training and had the opportunity to review the instructional video, they performed significantly better when compared to the control group (Fig. 3) or their own first attempts (Fig. 4). The total time to complete the task after the intervention was 6:16 min SD 2:01 vs. 13:53 min SD 8:07 in the controls ($p = 0.001$), the overall score was 26.7 SD 2.55 vs. 22.2 SD 4.13 ($p = 0.002$), and the radiation dose was 52.1 cGy/cm$^2$ SD 18.6 vs. 93.2 cGy/cm$^2$ SD 76.2 ($p = 0.003$; Tables 1 and 2).

### Conclusion

German-speaking countries have traditionally used an apprenticeship-based training to educate their surgical staff. The quality measurement of the training is based on the number of operations performed and the absolute time spent working in a clinical role. The non-clinical part of a surgeon's education is subsumed under hours spent on certified external courses or symposia. There are few legal requirements for standardized communication training and team training in the curriculum or as part of the ongoing education as a senior healthcare provider.

Patient safety and quality of care increase when healthcare providers train together to become a more efficient team [4, 5]. While training and evaluation tools for surgical education exist, their everyday use is limited by a combination of the growing scarcity of healthcare resources and a lack of legal requirements [1].

Our data add to the growing evidence that simulator-based training can help to increase trainees' understanding and performance of relevant skills [6–8]. Our simulator-centered training course provides trainees with the opportunity to experience the tasks and challenges faced by other members of an endovascular intervention team, a requirement for cross-training.

Recruitment of participants into this study began at the outbreak of the COVID-19 pandemic in Europe. Further enrolment of participants was planned, but ended due to the rising incidence of COVID-19 and subsequent contact restrictions in Austria. The resulting sample size is therefore smaller than initially planned and represents a limitation of this study.

Observer bias is one of the limitations of this study, since we were unable to blind the observer in our setup. For future studies, we plan to bypass this by filming the gloved hands of participants and directly recording the C-arm interface, allowing for a blinded observation of the tasks by multiple observers. The inter- and intra-observer reliability of the setup could be evaluated using this improved study design. This design could allow us to perform remote training sessions with the experienced observer physically absent from the individual training session. It would also enable us to perform longitudinal skill assessments spanning months or years to document the trainee's progress.

Our study design is limited by the fact that we did not collect data on real-life team performance. It remains to be investigated whether training on this simulator improves patient safety and outcomes. Testing for these parameters would be resource intensive and possibly prohibitive for future simulator development.

However, it has been previously discussed that effective training enhances team performance [9]. A standardized and evidence-based validation process for simulators and simulator-based courses could improve their acceptance in the medical field.

Simulator-based courses have the potential to enhance the learning curve of surgical trainees and provide a safe opportunity for team training.

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