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ORIGINAL RESEARCH

Xray Exposure Time in Dedicated Academic Simulation Programs Is Realistic of Patient Procedures

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Objective: To ascertain whether simulated endovascular procedures are comparable to real life operating room (OR) procedures, particularly with regard to irradiation time.
Methods: This was a retrospective study comparing simulation with clinical data. Fluoroscopy time and overall operation time were compared between simulated abdominal aortic endovascular repair (EVAR) and iliac procedures that were performed, respectively, from 2016 to 2019 and from 2015 to 2019, and clinical EVAR and iliac procedures performed in the OR between January 2018 and November 2021.
Results: Within the defined periods, 171 simulated procedures (91 EVAR, 80 iliac) and 199 clinical procedures (111 EVAR, 88 iliac) were performed. For both EVAR and iliac procedures, median total procedure time was much longer during real surgery ($p < .001$). However, median total fluoroscopy time remained the same, whether the procedure was real surgery or performed on the simulator, for iliac procedures (8.47 minutes in the OR, 8.35 minutes on the simulator, $p = .61$) and for EVAR procedures (14.80 minutes in the OR, 15.00 minutes on the simulator $p = .474$).
Conclusion: Simulated endovascular procedures are comparable with real life OR procedures, particularly with regard to irradiation time when integrated in a dedicated curriculum.

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INTRODUCTION

In the last few decades, there have been restrictions in training opportunities for new vascular surgeons as a result of the reduction in weekly working hours (European Working Time Directive) and budgetary constraints. This has resulted in alterations to training procedures. Performing surgery for the first time on an actual patient is no longer acceptable as this can lead to medical errors resulting in litigation, complications with prolonged hospitalisation, and thereby economic repercussions.[1] For endovascular procedures, simulation has been demonstrated to be a useful tool for vascular surgeons as it allows skill acquisition and increases knowledge of the tools used.[2—5]

Despite the technological development of endovascular simulators, there remains a need to prove that performances assessed on these simulators can actually be transferred to clinical practice. Can performance of endovascular procedures be assessed by the ability to navigate inside the vascular tree, as well to complete the procedures efficiently and safely? One of the major drawbacks of endovascular procedures is that they are performed under Xray control. Radiation exposure can cause potential complications for patients as well as operating room (OR) staff.[6,7] Consequently, assessment of total irradiation exposure is a necessary metric that must be integrated into the curriculum. The latest developments in the endovascular simulation field include patient specific simulation that allows a patient tailored approach, enabling the surgeon to perform real cases on a virtual patient before performing procedures on actual patients.[4] However, an academic curriculum is necessary to make simulated procedures realistic to the clinical procedures including all steps.

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Table 1. Statistical time analysis for EVAR and iliac procedures

Time analysis	OR	Simulation	p value
EVAR procedures			
Total procedure time – min	88.00 (72.5, 107)	44.00 (37.0, 52.0)	<.001
Total fluoroscopy time – min	14.80 (12.4, 20.3)	15.00 (12.0, 19.0)	.47
Iliac procedures			
Total procedure time – min	45.50 (31.8, 66.5)	33.00 (24.4, 40.0)	<.001
Total fluoroscopy time – min	8.47 (4.30, 13.9)	8.35 (5.71, 12.5)	.61

Data are presented as median (interquartile range). EVAR = endovascular aneurysm repair; OR = operating room.

It is particularly important to confirm that simulated and clinical procedures take similar durations. Radiation exposure time can be extracted easily from simulation devices as well as C arms. Although it is difficult to differentiate timing of digital subtraction angiography (DSA) from fluoroscopy, total irradiation exposure time could provide two assessment metrics: (1) correlate simulated and clinical procedures to improve educational curriculum in simulation; (2) correlate simulated and clinical procedures to improve radioprotection education.

This study aimed to ascertain whether simulated endovascular procedures are comparable with real life OR procedures, particularly with regard to irradiation time.

METHODS

Materials

Simulated procedures were performed on the ANGIO Mentor simulator from 3D Systems (formerly Simbionix, Cleveland, OH, USA). On this simulator, several realistic EVAR and iliac cases are integrated by the industry with different levels of difficulty.

Simulated procedures

All simulated procedures were performed by vascular residents in the same room at the Education Centre of GEPROVAS (Strasbourg, France). These simulations were carried out during the final evaluation in the setting of a workshop. The workshop took place during two sessions of two days of practice. The residents worked in pairs on each simulator, alternating between teaching sessions supervised by senior surgeons and evaluation sessions also supervised by senior surgeons, without any interaction with the trainee. During a workshop, they benefited from eight teaching and four assessment sessions. The training protocol for this workshop was developed between the research teams of the Education Centre of Strasbourg and Stanford. For each assessment procedure, total procedure time and total irradiation time were collected retrospectively. Simulated EVAR and iliac procedures were respectively performed between 2016 and 2019 and between 2015 and 2019.

Operating room procedures

OR procedures were performed by trainees under the supervision of experienced surgeons. These operations were conducted between January 2018 and November 2021 at the University Hospital of Strasbourg. Those who went through an additional procedure at the same time (e.g., another type of angioplasty or stenting, femoral bifurcation endarterectomy, femorodistal or femorofemoral bypass) were excluded. Total procedure time as well as the total irradiation time were gathered. Data were extracted retrospectively from a software program containing all surgical procedures in the hospital. Only procedures coded to French social security by the references (1) EDFA003 (intraluminal dilatation of the common iliac artery and/or external iliac artery with stenting, by transcutaneous arterial approach) for iliac procedures and (2) DGLF001 (placement of covered bifurcated aorto-bi-iliac stent, by transcutaneous arterial approach) for EVAR procedures were included. According to the present authors' departmental policy, these procedures are mostly performed by supervised trainees. The majority of iliac and femoral angioplasties are performed by residents, and the majority of EVAR are performed by fellows and residents.

Statistical analysis

Results are expressed as median and interquartile range for each group. Statistical analysis was performed using the statistical functions from the *scipy.stats* module under Python (version 3.7.4). Statistical comparisons between OR and simulated procedures were performed with the Mann–Whitney U test. Results were considered statistically significant when the p value was $<.050$.

RESULTS

Within the defined periods, 171 simulated procedures (91 EVAR, 80 iliac) and 199 clinical procedures (111 EVAR, 88 iliac) were performed.

For both EVAR and iliac procedures, as detailed in Table 1, median total procedure time was much longer during real surgery ($p < .001$). For instance, the median total procedure time for an EVAR procedure in the OR was approximatively 90 minutes while an EVAR procedure can be achieved within 45 minutes on the endovascular simulator.

However, median total fluoroscopy time remained equivalent, whether the procedure was real surgery or performed on the simulator. For all EVAR procedures, 14.80 minutes of fluoroscopy were needed in the OR while 15.00 minutes were required on the simulator to achieve the procedure (Fig. 1). For all iliac procedures, 8.47 minutes of fluoroscopy were needed in the OR while 8.35 minutes

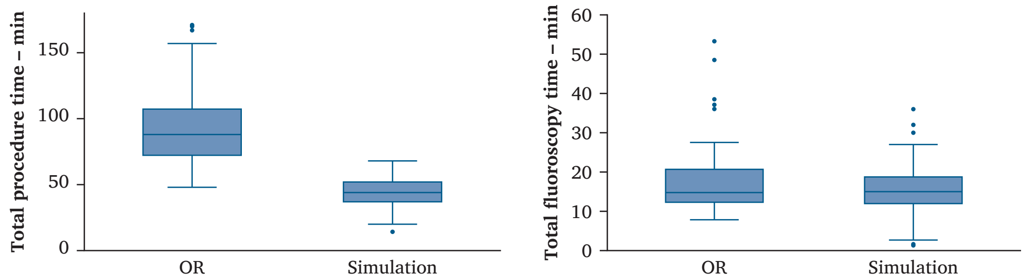

Figure 1. Time comparison between a real and a simulated endovascular aneurysm repair (EVAR) procedure: total procedure time (left) and total fluoroscopy time (right).

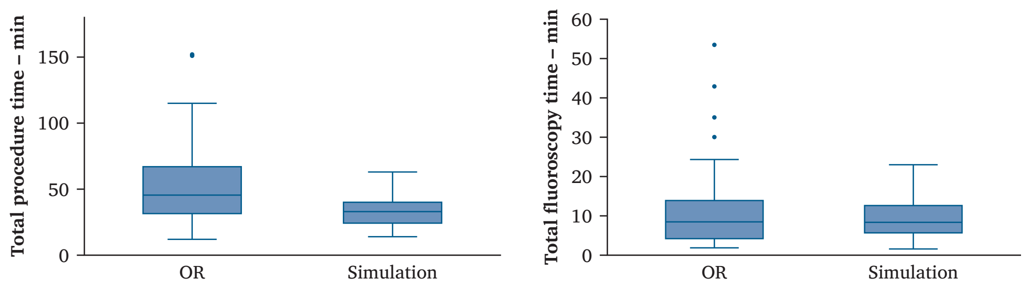

Figure 2. Time comparison between a real and a simulated iliac procedure: total procedure time (left) and total fluoroscopy time (right).

were required on the simulator to achieve the procedure (Fig. 2).

DISCUSSION

As expected, the study results showed that in the OR the median duration of the procedure is longer than on the simulators, which can be explained by the time to achieve and close the vascular access, to set up the percutaneous closure system or to puncture the artery under ultrasound detection and set up the sheath. However, similar median irradiation times were found between the OR and the simulators. The irradiation time is a more objective reflection of the time spent by the operator, showing that the cases integrated in the simulator correctly reflect real life. Simulator training has a real impact on the student's learning.

To achieve more similar operating times between the simulations and the OR, students are asked to remove the guidewires and catheters from the simulator, select the new material on the simulator and then re-introduce it. The procedure duration is more significant and the impact of this duration more realistic, especially on the trainees' concentration and tiredness.

Several articles written to date have shown that endovascular simulation appears to be well suited for skills training when integrated in a dedicated curriculum. Simulation facilitates learning of basic skills for handling guidewires and catheters, offers the opportunity to simulate scheduled patient specific procedures before performing them in the real clinical setting, and proves helpful for the better integration of material and delivery system knowledge and manipulation.

Knowing that simulators more and more reflect reality, cases can be created on simulators from real patients. Desender et al. showed in their pilot study that creating a realistic simulated case study may be useful to evaluate a real case and identify any pitfalls.[8] This can reassure a young practitioner before operating in the OR or even help a more experienced surgeon in difficult cases.

This study has several limitations. First, data were collected retrospectively, although all assessments were done with a training curriculum. Second, it was not possible to differentiate the fluoroscopy from DSA times. As a consequence, all irradiating time is recorded in the study under the term "fluoroscopy". Finally, although the simulated procedures were performed in a realistic environment, there was no communication or advice from the senior in simulated procedures in contrast to the real procedures, which could theoretically influence the fluoroscopy time.

In a future study, other information could be integrated such as the position of the C arm.

Conclusion

Simulated endovascular procedures are comparable with real life OR procedures, particularly with regards to fluoroscopy time, potentially reflecting irradiation, when integrated in a dedicated curriculum.

FUNDING

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CONFLICT OF INTEREST

None.

APPENDIX

Collaborators:

The following experts contributed as trained assessors during simulated procedures: Xavier Berard[1], Emilie Bonnin[2], Amelie Camin[3], Bettina Chenesseau[4], Frédéric Cochennec[5], Jean-Marc Corpateaux[6], Sébastien Deglise[6], Charline Delay[3], Benjamin Deltatto[7], Ambroise Duprey[8], Julien Gaudric[9], Yannick Georg[7], Zied Ghariani[7], Elixène Jean-Baptiste[10], Adrien Hertault[11], Vincent Meteyer[4], Mathieu Roussin[4], Francois Saucy[6], Fabrice Schneider[12], Lydie Steinmetz[7], and Fabien Thaveau[7]

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REFERENCES

1 Boyle JR, Ghuysen A, d'Orio V, Vega de Ceniga M, Chakfé N. Time to embrace simulation in vascular surgical training: little things matter. *Eur J Vasc Endovasc Surg* 2019;**58**:161—2.
2 Lee JT, Qiu M, Teshome M, Raghavan SS, Tedesco MM, Dalman RL. The utility of endovascular simulation to improve technical performance and stimulate continued interest of preclinical medical students in vascular surgery. *J Surg Educ* 2009;**66**:367—73.
3 Lee JT, Son JH, Chandra V, Lilo E, Dalman RL. Long-term impact of a preclinical endovascular skills course on medical student career choices. *J Vasc Surg* 2011;**54**:1193—200.
4 See KWM, Chui KH, Chan WH, Wong KC, Chan YC. Evidence for endovascular simulation training: a systematic review. *Eur J Vasc Endovasc Surg* 2016;**51**:441—51.
5 Aeckersberg G, Gkremoutis A, Schmitz-Rixen T, Kaiser E. The relevance of low-fidelity virtual reality simulators compared with other learning methods in basic endovascular skills training. *J Vasc Surg* 2019;**69**:227—35.
6 Rial R, Vañó E. Understanding the basis of radiation protection for endovascular procedures: occupational and patients. *EJVES Vasc Forum* 2021;**51**:20—2.
7 Hertault A, Maurel B, Midulla M, Bordier C, Desponds L, Saeed Kilani M, et al. Editor's choice — minimizing radiation exposure during endovascular procedures: basic knowledge, literature review, and reporting standards. *Eur J Vasc Endovasc Surg* 2015;**50**:21—36.
8 Desender L, Rancic Z, Aggarwal R, Duchateau J, Glenck M, Lachat M, et al. Patient-specific rehearsal prior to EVAR: a pilot study. *Eur J Vasc Endovasc Surg* 2013;**45**:639—47.