Updates in Surgery (2019) 71:185–186
https://doi.org/10.1007/s13304-019-00636-1

LETTER TO THE EDITOR

Use of 3D models for planning, simulation, and training in vascular surgery

Andrea Moglia[1] · Gregorio Di Franco[2] · Luca Morelli[1,2]

Received: 22 January 2019 / Accepted: 21 February 2019 / Published online: 25 February 2019
© Italian Society of Surgery (SIC) 2019

Dear Editor,

We read with great interest the article by Pugliese et al. entitled "The clinical use of 3D printing in surgery" recently published by Updates in Surgery [1].

In the past years, 3D printing has seen an almost exponential growth in several fields, including medicine and surgery, as testified by the increasing number of published articles. This success was fostered by technological progresses on manufacturing processes allowing to build layer by layer 3D objects at higher resolution.

In surgery, knowledge of patient anatomy has traditionally been based on analysis of 2D radiological images. The advent of computer-assisted surgery has improved the understanding of patients' anatomy in the preoperative phase, including complex cases, enabling reconstruction of virtual 3D models starting from radiological datasets, which can be viewed on computer screens. 3D printing pushes further comprehension of anatomy allowing surgeons to touch and feel a physical model, complementing visual with tactile feedback. The authors present the role of 3D printing for preoperative planning and intraoperative navigation in several surgical specialties, particularly in general and transplantation surgery, neurosurgery, and maxillofacial surgery [1]. Authors also comment how the most recent advances in the manufacturing process enable 3D printing of deformable and hollow structures such as vessels, allowing physical simulation of vessels clamping, stapling, and anastomosis, thus extending the use of this technology to vascular surgery. In this regard, we think that this technology could have a great impact in (endo)vascular surgeons' training for two main reasons. First, 3D printing could be particularly important for endovascular procedures which represent a radically new way to operate for vascular surgeons, in comparison with the open air or laparoscopic approach. Indeed, during endovascular procedures, e.g., endovascular aneurysm repair (EVAR), the surgeon deals with a closed abdomen, with limited information of vascular anatomy obtained by preoperative angiogram imaging (CTA) and intraoperative angiographic images visualized on the monitors [2]. Thus, the surgeon has no direct contact with the aorta, its branches, the aneurysm, and surrounding structures. Therefore, for these procedures the capacity to mentally reconstruct the vascular anatomy starting from CTA images is of paramount importance. In this scenario, the use of 3D models could lead to a revolution for planning, and probably, above all, for training young surgeons approaching endovascular procedures. In fact, thanks to the physical reproduction of a patient-specific model, it is possible to better understand the patient's anatomy in the preoperative stage; to accurately identify the location of key elements, such as the aortic landing zones and the side of a penetrating ulcer or intimal tear; and to define type, length, and oversizing of the endograft, thus reducing the risk of periprocedural complications [3]. Last but not least, the surgeon can rehearse the endovascular procedure before performing it on real patient to reduce the time of the procedure and the use of radiopaque contrast, thus decreasing the renal function insult, especially in patients with kidney failure; and the use of radiation, shortening the exposure of patient and staff to its hazardous effect [3].

However, because of the exponential adoption of the endovascular surgery, we are concerned that young vascular surgeons may become less familiar with treatment of open aortic aneurysm repair. This might eventually lead to the paradox that in the future only the most complex cases of aneurysm repair, such as ruptured aneurysms or those including multi-visceral vessels origins, may be treated with open surgery by non-experienced surgeons [4]. For these

✉ Andrea Moglia
andrea.moglia@endocas.org

1 EndoCAS, Center for Computer Assisted Surgery, University of Pisa, Edificio 102, via Paradisa 2, 56124 Pisa, Italy

2 General Surgery Unit, Department of Surgery, Translational and New Technologies in Medicine, University of Pisa, Pisa, Italy

reasons, we think that the second benefit of 3D printed models in vascular surgery may be training of young vascular surgeons in open surgical repair of complex aneurysms.

Overall, 3D printing has the potential to enable development of low-cost physical simulators for both vascular and open procedures. In this scenario, the 3D printed models represent an interesting solution to complement virtual simulators [5]. The challenge is how to integrate in surgical curricula 3D printed models. The answer is contingent on development of an objective assessment of skills acquired during training with 3D printed models and evidence demonstrating robustness.

In conclusion, the field of 3D printing is rapidly evolving by virtue of continuous progresses by manufacturers. At the same time, surgery is changing quickly, particularly vascular surgery where new skills are continuously required to treat patients at a safe and competent level using the latest devices.

Compliance with ethical standards

Conflict of interest Authors declare that they have no conflict of interest.

Research involving human participants and/or animals This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study formal consent is not required.

References

1. Pugliese L, Marconi S, Negrello E, Mauri V, Peri A, Gallo V, Auricchio F, Pietrabissa A (2018) The clinical use of 3D printing in surgery. Updates Surg 70:381–388
2. Gossetti B, Martinelli O, Ferri M, Silingardi R, Verzini F, IRENE Group Investigators (2018) Preliminary results of endovascular aneurysm sealing from the multicenter Italian Research on Nellix Endoprosthesis (IRENE) study. J Vasc Surg 67:1397–1403
3. Gomes EN, Dias RR, Rocha BA, Santiago JAD, Dinato FJS, Saadi EK, Gomes WJ, Jatene FB (2018) Use of 3D Printing in Preoperative Planning and Training for Aortic Endovascular Repair and Aortic Valve Disease. Braz J Cardiovasc Surg 33(5):490–495
4. Scarcello E, Ferrari M, Rossi G, Berchiolli R, Adami D, Romagnani F, Mosca F (2010) A new preoperative predictor of outcome in ruptured abdominal aortic aneurysms: the time before shock (TBS). Ann Vasc Surg 24:315–320
5. Vento V, Cercenelli L, Mascoli C, Gallitto E, Ancetti S, Faggioli G, Freyrie A, Marcelli E, Gargiulo M, Stella A (2018) The Role of Simulation in Boosting the Learning Curve in EVAR Procedures. J Surg Educ 75:534–540

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.