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SURGICAL TECHNIQUE

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Repair of the descending thoracic aorta using minimally invasive endoscopic Robot-assisted surgery: a feasibility study with the DaVinci XI system in a cadaver model

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Abstract

Development of minimally invasive techniques has led to the clinical routine application of Robot-assisted surgery. Here, we demonstrate for the first time Robotic-assisted surgery (DaVinci XI) of the descending thoracic aorta in a *Thiel* cadaver model and discuss its potential value in the endovascular era.

Keywords: Robot-assisted surgery • Minimally invasive endoscopic surgery • Aortic repair • DaVinci XI system • Cardiovascular surgery • Thoracic descending aorta

INTRODUCTION

Minimally invasive endoscopic and Robot-assisted surgery has been established as a clinical standard for a broad range of surgical procedures during the last 2 decades [1]. However, Robot-assisted surgery remains largely underdeveloped in cardiovascular surgery mainly due to successful evolution of interventional procedures and discipline-specific pitfalls [2]. Despite thoracic endovascular aortic repair has become a standard clinical procedure with beneficial outcome for many patients; various indications could not be sufficiently treated solely by endovascular surgery. However, conventional open surgery of the descending thoracic aorta is still associated with relative high trauma, morbidity and mortality [3]. Therefore, the here described experiments have evaluated the feasibility of performing Robot-assisted surgery (DaVinci XI robotic system; Intuitive, Sunnyvale, USA) of the descending thoracic aorta in *Thiel* cadavers describing user experiences and technical description for potential clinical translation.

MATERIAL AND METHODS

The study was approved by the local ethics committee of the University Medical Center Schleswig-Holstein, Kiel, Germany (protocol identification: D400/21).

All surgical procedures were performed in 2 *Thiel* cadavers of which cadaver 2 had an aneurysmatic alteration [4]. Projection of the intercostal spaces for potential trocar placement and cross-clamping was determined by CT (Computer Tomography) scans of non-pathological and aneurysmatic aortas prior to the experiments. Both cadavers were positioned on the right side in a 45° rotation (Fig. 1A). The DaVinci XI system (Intuitive, Sunnyvale, USA) was also placed on the right side of the cadavers and the 8 mm DaVinci trocars for the instruments were placed in the fourth, sixth, eighth and tenth intercostal space in the anterior axillary line and additionally 2 assistant ports for cross-clamping and suction were placed in the fifth and ninth intercostal space (midaxillary line) after small skin incision of 1 cm (Fig. 1B and C). Insufflation of CO_2 (2 l/8 mmHg) was provided via the intercostal port.

The second arm of the DaVinci XI enabled permanent retraction of the left lung, vessel exposure, and side branch coagulation. The camera (30° degree) was placed slightly above the instruments for a better anterior and side view of the thoracic aorta over the camera port. After the left pleural cavity was accessed, the lung was retracted and the preparation of the descending thoracic aorta was started using Maryland Bipolar Forceps, Monopolar curved scissors and Fenestrated bipolar forceps (Intuitive) (Fig. 2A). Proximal access was achieved by circumferential preparation of the descending thoracic aorta distal of the left subclavian artery. Side branches of the descending thoracic aorta were carefully dissected on both sides of the aorta and the Large-Clip-Applier was used for clipping side branches with Hem-o-lok® large polymer clips (Teleflex, Morrisville, NC,

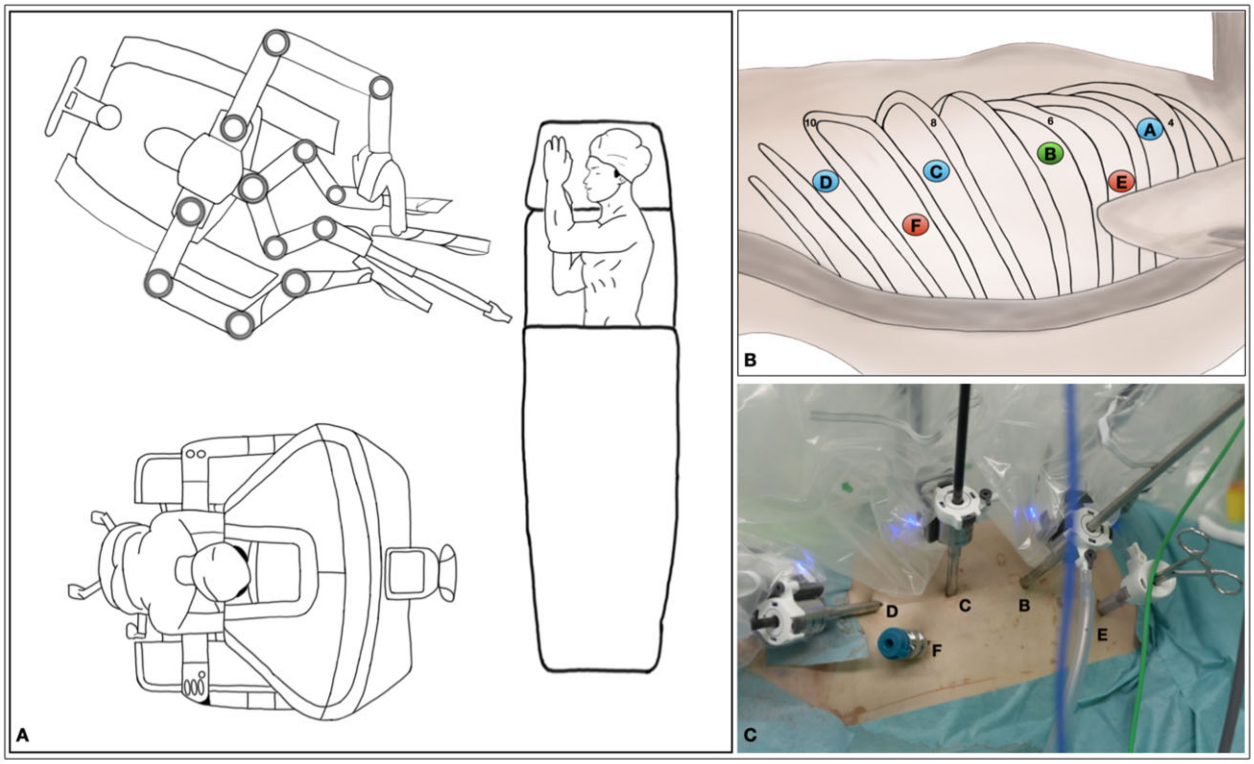

Figure 1: (**A**) Schematic representation of the operative setup: demonstration of the robotic system and the console. (**B**) Illustration of consecutive port placement in the thoracic region. Blue (A/C/D) = placement of the robotic arms, green (B) = endoscopic camera port and red (E/F) = assistant ports. (B–D) Setup of the training room and positioning of each port during thoracic surgery.

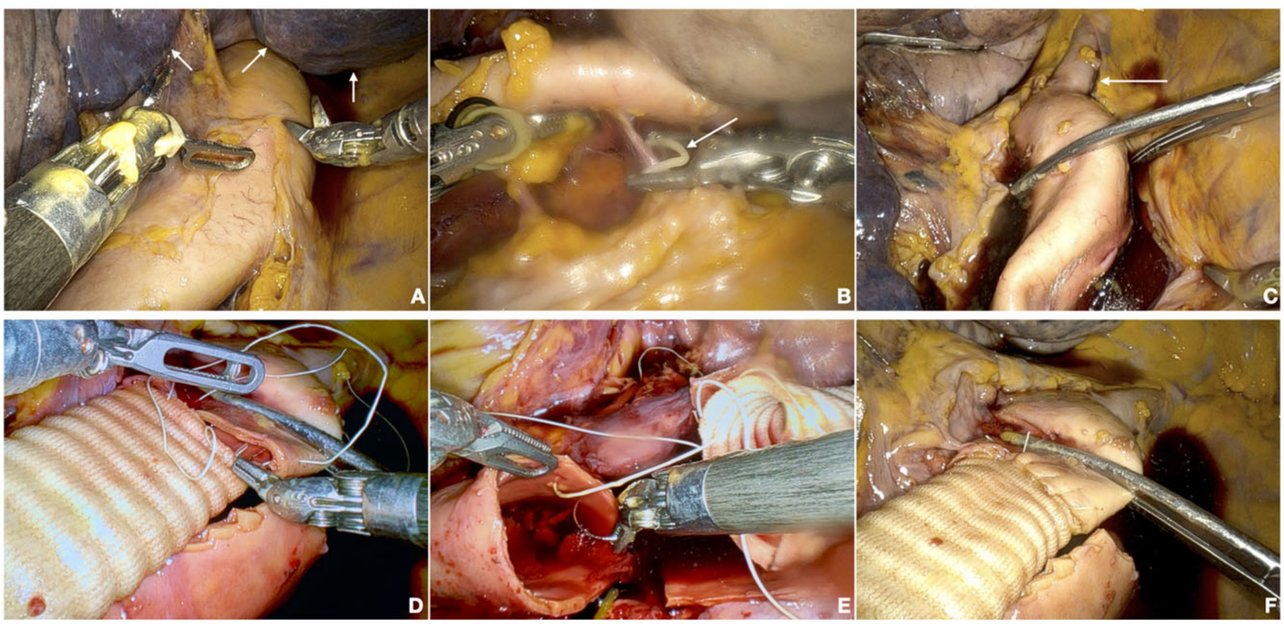

Figure 2: (**A**) Intraoperative preparation of the thoracic aorta with ventral mobilization of the left lung (white arrows). (**B**) Further preparation of thoracic side branches with subsequent clipping (white arrow). (**C**) Clamping of the proximal thoracic aorta below the left subclavian artery (white arrow). (**D**) Proximal anastomosis. (**E**) Distal anastomosis. (**F**) Final result of the proximal anastomosis.

USA) (Fig. 2B). For cross-clamping, 2 endoscopic DeBakey Clamps were applied (Fig. 2C).

Replacement of the thoracic descending aorta was conducted with a FlowWeave Bioseal®-Prothesis (Jotec, Hechingen, Germany, 20 mm × 15 cm) in continuous suturing technique using Goretex CV3/91 cm® Sutures (Gore, Newark, USA) (Fig. 2D + E). The graft was introduced in the chest via the assistant port (Fig. 1B + C; marker F). After the proximal anastomosis was completed, the vascular graft was stretched out with the robotic arm and trimmed before the distal anastomosis was performed.

Success of the procedure was defined by completing the thoracic aortal replacement, impartibility (tested by water injection) of the anastomosis and by preventing any injury of a priori defined 6 anatomic key structures: (i) major arterial and venous vessels, (ii) lung, (iii) diaphragm, (iv) oesophagus, (v) pericardium and (vi) phrenic and vagus nerve.

RESULTS AND DISCUSSION

Both experiments were performed without technical complications or injuries of the a priori defined 6 anatomic key structures. Preparation of the DaVinci XI and surgery itself were performed within an acceptable timeframe despite relative unexperienced users ($n = 3$). Preparation of the thoracic aorta was performed in 67 min (cadaver 1) and 64 min (cadaver 2) and cross-clamping was 39 and 44 min, respectively. Sufficient anastomoses of the proximal and distal thoracic aorta could be performed in both cadavers within 32 min (cadaver 1) and 35 min (cadaver 2) with commercially available instruments of the DaVinci XI (Fig. 2D). Interestingly, duration of preparation and aorta cross-clamping of the current study were comparable or even shorter to conventional open surgery of the thoracic aorta [5].

In general, the advantages of minimally invasive robotic surgery against open surgery have been described for various procedures mostly in general surgery, urology and gynaecology. The major advantages have been reported as less blood loss, less surgical trauma, less wound healing disorder and shorter in-hospital stay. Technical advantages of Robot-assisted endoscopic methods over open surgery are high-precision movements of the manipulators and 3D visualization with a five-fold magnification enabling vascular anastomosis sufficiently fast in confined spaces of the human body [1, 5, 6].

Nevertheless, there is still a lack of randomized trials comparing open versus minimally invasive endoscopic Robot-assisted surgery and appropriate data in vascular surgery are rare or not available [6–8]. Although endovascular therapy is often preferred by various authors because of faster recovery, this preference for improved short-term outcomes might be balanced with the superiority and durability of Robot-assisted endoscopic methods as comparable to open surgery [5, 7, 8].

Future steps, based on the here described protocol, will be the implementation of both experimental work and clinical translation including animal experiments for equipment and safety development as well as the beginning of a single-centre study for the clinical application of the DaVinci XI in aortic disease in the *Kurt-Semm-Center* for laparoscopic and Robot-assisted surgery.

The described experiments have several limitations: only 2 experiments were performed in human cadavers, no holistic perfusion model was conducted and only cadaver 2 had an aneurysmatic alteration in the descending thoracic aorta.

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Conflict of interest: All authors declare that they have no competing interests.

Reviewer information

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REFERENCES

[1] Mack MJ. Minimally invasive and robotic surgery. JAMA 2001;285:568–72.
[2] Lin JC. The role of robotic surgical system in the management of vascular disease. Ann Vasc Surg 2013;27:976–83.
[3] Gagné-Loranger M, Voisine P, Dagenais F. Should endovascular therapy be considered for patients with connective tissue disorder? Can J Cardiol 2016;32:1–3.
[4] Yiasemidou M, Roberts D, Glassman D, Tomlinson J, Biyani S, Miskovic D. A multispecialty evaluation of thiel cadavers for surgical training. World J Surg 2017;41:1201–7.
[5] Fujikawa T, Yamamoto S, Oshima S, Ozaki K, Shimamura J, Asada H *et al.* Open surgery for descending thoracic aorta in an endovascular era. J Thorac Cardiovasc Surg 2019;157:2168–74.
[6] Saaia SB, Rabtsun AA, Popova IV, Gostev AA, Cheban AV, Ignatenko PV *et al.* Robotic-assisted operations for pathology of the aortoiliac segment: own experience. Angiol Sosud Khir 2020;26:90–6.
[7] Štádler P. Role of the robot in totally laparoscopic aortic repair for occlusive and aneurysmal disease. Acta Chir Belg 2009;109:300–5.
[8] Štádler P, Matouš P, Vitásek P, Špaček M. Robot-assisted aortoiliac reconstruction: a review of 30 cases. J Vasc Surg 2006;44:915–9.