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THE LAST IMAGE

3D printed model-based simulation of laparoscopic surgery for descending colon cancer with a concomitant abdominal aortic aneurysm

D. Hojo[1] · T. Nishikawa[1] · T. Takayama[2] · M. Hiyoshi[1] · S. Emoto[1] · H. Nozawa[1] · K. Kawai[1] · K. Hata[1] · T. Tanaka[1] · Y. Shuno[1] · M. Kaneko[1] · K. Sasaki[1] · K. Murono[1] · H. Ishii[1] · H. Sonoda[1] · K. Hoshina[2] · S. Ishihara[1]

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Colorectal cancer (CRC) with abdominal aortic aneurysm (AAA) is more common in the elderly population. Laparoscopic surgery (LS) for such complicated conditions has been performed, albeit the risks of AAA rupture during forceps manipulation under limited view.

An 89-year-old man had an endovascular aneurysm repair (EVAR) for AAA (Fig. 1a), but the aneurysm size gradually increased due to type II endoleak in the lumbar artery despite coil embolization (Fig. 1b). The maximum diameter of the aneurysm was 69 mm, and an open aneurysmorrhaphy along with lumbar artery ligation was planned to prevent rupture. Advanced descending colon cancer was detected preoperatively and diagnosed as UICC stage T3N0M0 (cStage IIa). The patient was at a high risk of colonic obstruction as the tumor had invaded the entire circumference of the colon (Fig. 1c). So, we decided to perform laparoscopic descending colectomy, prior to the aneurysm surgery.

We created the three-dimensional (3D) model of AAA and colon based on CT images (Fig 2a) with sculpted skin cover mimicking a pneumoperitoneum (Fig. 2b–d) to confirm the safety of the procedure. On this model, we attempted both the conventional and specific port arrangements. In the conventional position trial, as we had suspected, we could not maneuver the forceps from the ports on the right side to go around the splenic flexure, the descending (Fig. 3a) and sigmoid colons (Fig. 3b). In the specific position trial, such maneuvering was possible (Fig. 3c, d) in spite of the difficulties we observed under continuous simulation in resecting the vessels in the sigmoid mesocolon because the AAA was overlying these arteries. Hence, we decided to perform the resection via a lateral approach and allocate the role of each port per section of the colon during mobilization (Fig. 4a–c).

The ports were arranged following the 3D model simulation (Fig. 5a, b), and the surgery proceeded with the selected ports used to work the forceps and camera (Fig. 5c, d). The LS was completed without any damage to the abdominal aorta and the patient was discharged from the hospital with no complications. No adhesion was observed when subsequent open AAA surgery was performed 4 months later.

In conclusion, the 3D printed model was helpful for determining the port site and visualizing the vascular structures while performing LS under difficult conditions.

✉ D. Hojo
HOJOD-SUR@h.u-tokyo.ac.jp

[1] Department of Surgical Oncology, Faculty of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

[2] Department of Vascular Surgery, Faculty of Medicine, The University of Tokyo, Tokyo, Japan

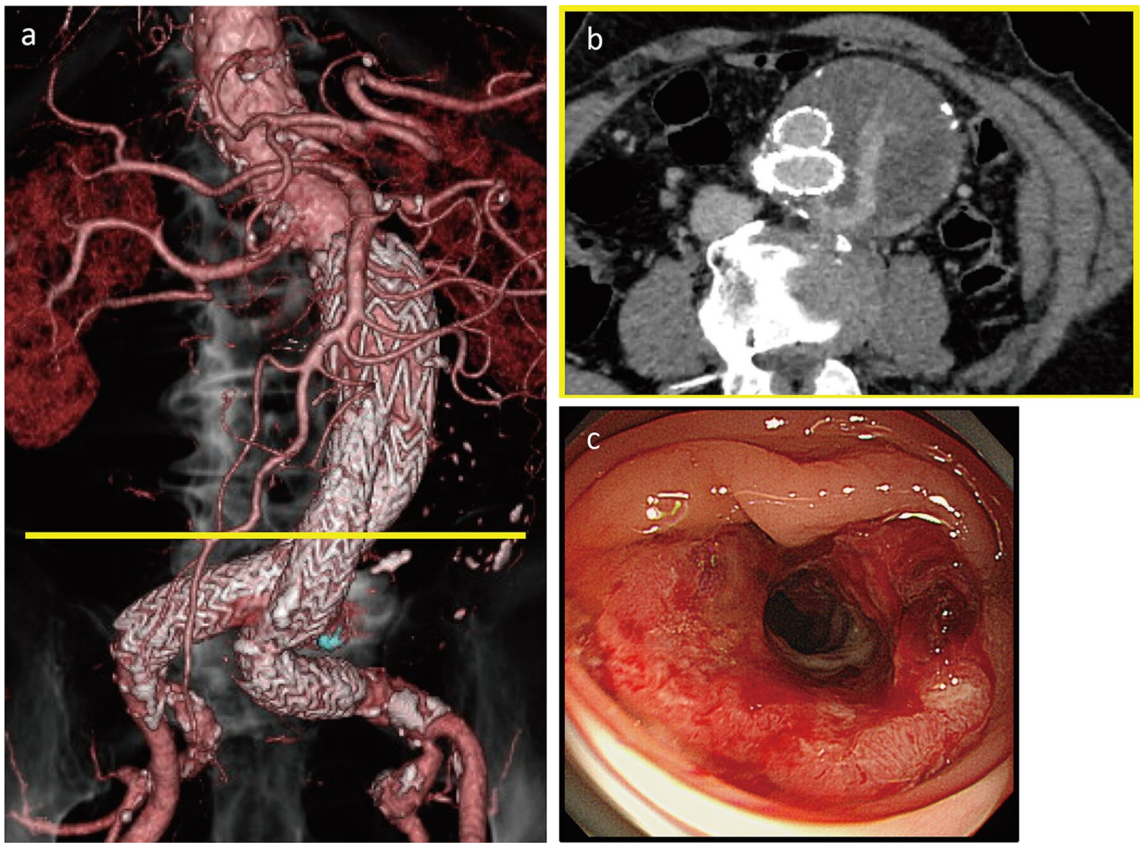

Fig. 1 **a** Previous endovascular aneurysm repair (EVAR) performed for abdominal aortic aneurysm (AAA). **b** Type II endoleak from the lumbar artery despite coil embolization. **c** Stenosis on preoperative colonoscopy due to cancer of the descending colon

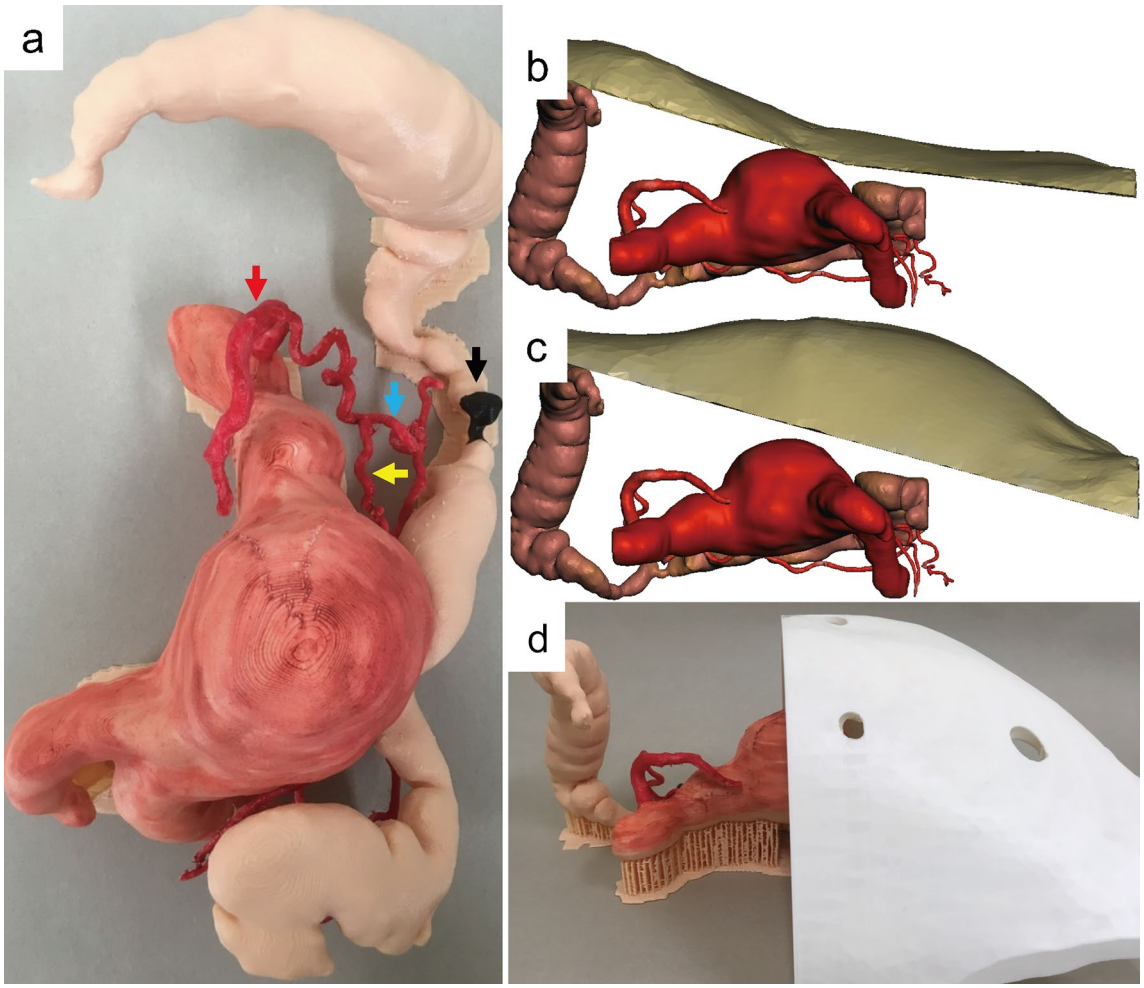

Fig. 2 **a** 3D printed models of the colon. The tumor (black arrow) and the AAA, superior mesenteric artery (red arrow), Riolan's arch (yellow arrow), and marginal artery (blue arrow) can be seen. **b** 3D image of the skin without pneumoperitoneum. **c** Sculpted 3D image of the skin with pneumoperitoneum. **d** 3D printed models of the position of pneumoperitoneum

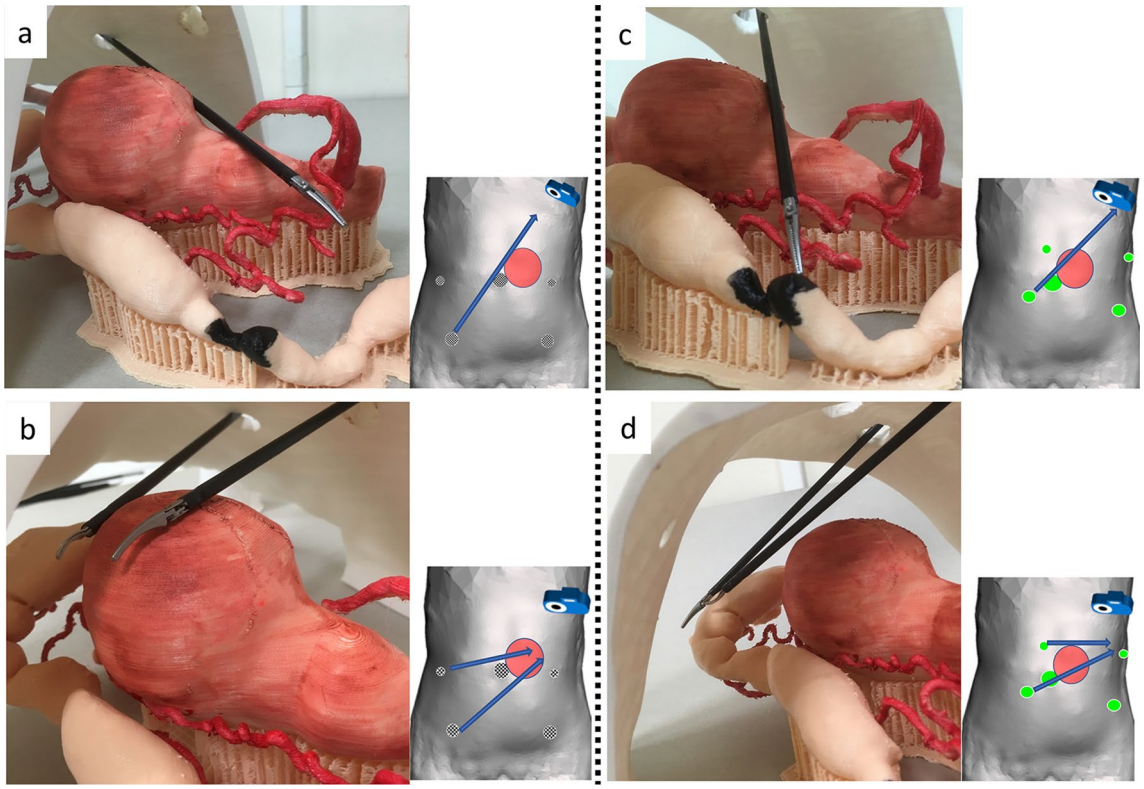

Fig. 3 **a**, **b** Five port sites arranged symmetrically. The forceps from the right-side ports could not reach the left semi-colon beyond the AAA. **c**, **d** Five port sites arranged closer to the left and cranial positions. The forceps from the right side ports could reach the left semi-colon overlying the AAA

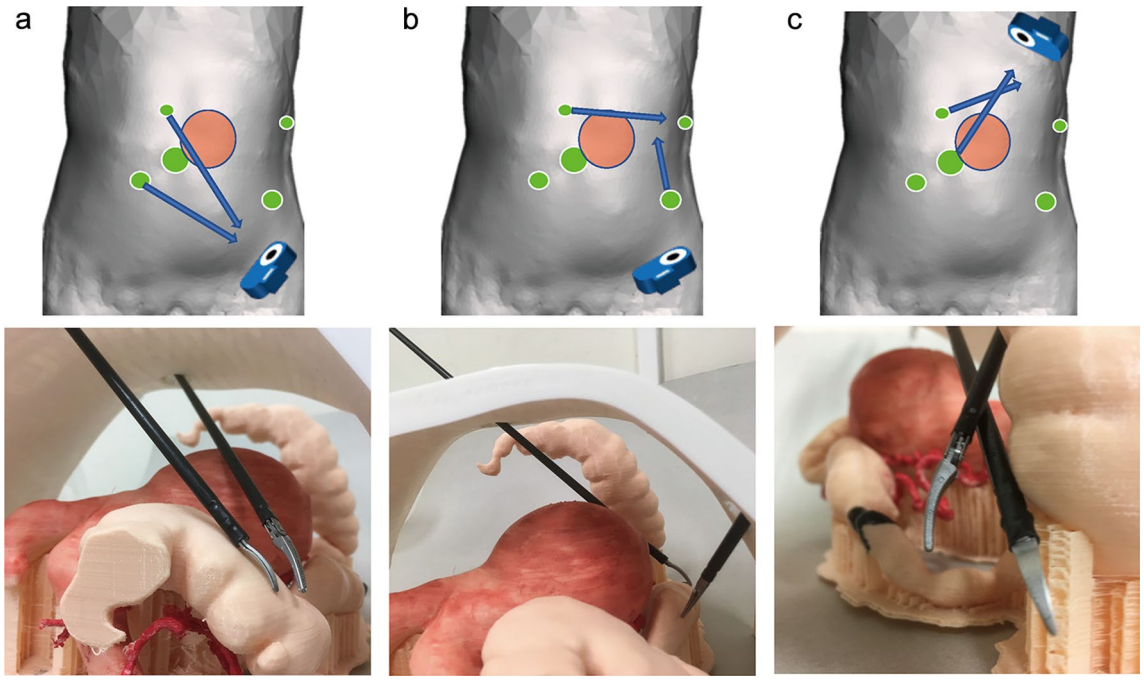

Fig. 4 Simulation on the 3D model with specific port arrangement for each part of the colon. **a** During the mobilization of the sigmoid colon, the right caudal and right cranial ports were selected as working ports. **b** The right cranial and left caudal ports were selected as working ones when the descending colon was mobilized. **c** On the mobilization of the splenic flexure, the right cranial and navel ports were selected as working ports

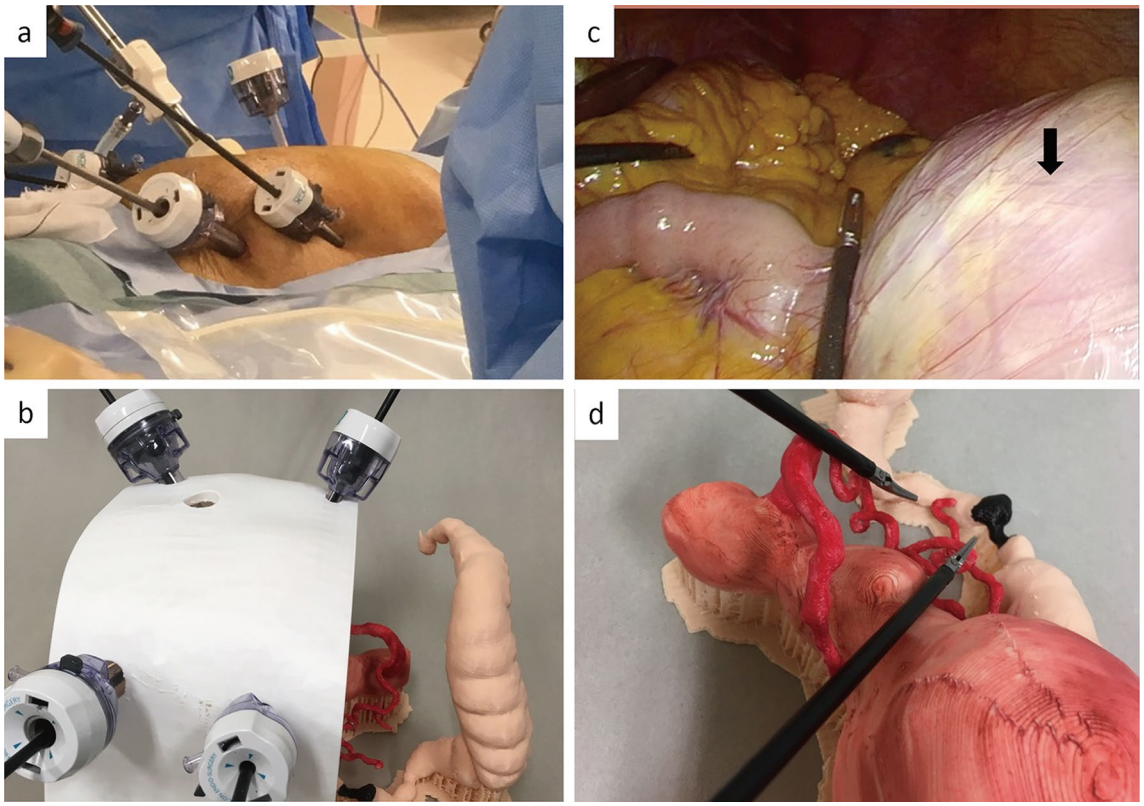

Fig. 5 **a**, **b** Laparoscopic surgery with specific port arrangement. **c** Image during operation. The AAA is visible on the right side of the screen (black arrow). **d** Same image as **c** on the 3D model

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Compliance with ethical standards

Conflict of interest There are no conflicts of interest to declare.

Ethical approval This study was approved by the Ethics Committees of the University of Tokyo (No. 3252-(7)).

Informed consent Informed consent was obtained from all individual participants included in the study.