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BRIEF COMMUNICATION

Technical details and preliminary results of a full robotic type II endoleak treatment with the da Vinci Xi

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Abstract

Type II endoleak (T2E) represents a frequent and often challenging complication of endovascular aneurysm repair (EVAR). Endovascular treatment is the standard and most used strategy, but the recurrence after it remains high, especially due to lumbar arteries (LA) and inferior mesenteric artery (IMA) feeding. While conventional laparoscopy has been considered as an emerging method, robotic surgery is not reported yet for this indication. We herein describe our technique of minimally invasive T2E repair using a full robotic approach with the da Vinci Xi, reporting our preliminary experience with the first two patients who underwent this operation at our Institution. The procedure comprises two phases. The first phase consists of IMA ligation, left colon mobilization and infra-renal exposure of the anterior longitudinal ligament of the column and of the left side of the sac. The second phase entails the posterior aneurysm mobilization and the selective clipping of LA responsible of the T2E, as identified by the pre-operative CT scan. No intra-operative complications occurred and the average length of surgery was 183 min. The average length of hospitalization was 2.5 days. Robotic T2E repair can be considered a safe procedure and the da Vinci Xi, thanks to its increased dexterity and flexibility, allows to easily perform this multi-target operation (IMA and LA). The articulated instruments with motion scaling and tremor filtering facilitate a gently vascular dissection and an easy IMA and LA identification, dissection, and ligation. The TilePro function permits the operator to control from the console, with intra-operative color-Doppler ultrasound, the absence of residual endoleaks.

Keywords Endoleak · Abdominal aortic aneurysms · Robotic repair · Da Vinci Xi

Introduction

The most frequent complication after endovascular aneurysm repair (EVAR) is type II endoleak (T2E). Recent data described a prevalence of T2E ranging from 10 to 25% and current guidelines suggest its treatment in case of sac enlargement during the follow-up, to prevent potential sac rupture [1]. Endovascular embolization of the feeding aortic collaterals has been considered a first-line treatment in this setting [2]. However, the persistence or recurrence rates of T2E remain considerably high [3].

Albeit technically challenging, laparoscopic trans-abdominal approach is an appealing minimally invasive alternative and some studies have shown good long-term results [4, 5]. The advent of robotic technology in general and vascular surgery, by overcoming some of the kinematic limitations of manual laparoscopic surgery, brought some advantages in several situations where fine and precise maneuvers are required. To date no data are available in literature about the application of robot-assisted surgery for T2E repair. We herein describe a full robotic approach in T2E treatment using the da Vinci Xi surgical system.

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Materials and methods

We recorded medical and operative data of patients with a diagnose of T2E who underwent robot-assisted repair using the da Vinci Xi by Intuitive Surgical (Sunnyvale, CA, USA) in our institution in December 2018. All patients had been pre-operatively evaluated with an Uutrasound examination (US) and a contrast computed axial tomography (CTA) of the abdominal aorta to diagnose the endoleak from inferior mesenteric artery plus lumbar arteries and to identify the precise target of vascular ligation.

Surgical technique

The procedure can be divided into two phases. The first phase consisted of inferior mesenteric artery (IMA) ligation, left colon mobilization and infra-renal exposure of the anterior longitudinal ligament of the column and of the left side of the sac. The second phase entailed the posterior aneurysm mobilization and the selective clipping of lumbar arteries (LA) responsible of the T2E, as identified by the pre-operative CTA.

The patients were placed in a 60° right flank position. Once established pneumoperitoneum to 12 mmHg, the first 8 mm robotic trocar was placed on the left pararectal line above the umbilicus. The other robotic trocars were placed under vision as shown in Fig. 1a. The surgical cart, coming from the left side, was driven to position the green laser crosshairs on the initial endoscope port. After docking, the scope was pointed to sigmoid colon and the "targeting" function was performed. During the first phase, we used only three trocars positioned on the left pararectal line (Fig. 1b). For the right-handed instrument, we alternatively used the monopolar scissors and the robotic clip applier (Hem-o-lok® Ligation System), whereas for the left-handed instrument, we used a Maryland bipolar forceps. The IMA was first approached and clipped at its origin just below the Treitz ligament and the left colon was fully mobilized along the Toldt's fascia till the aortic plane. Then the infra-renal plane was gained to expose the right side of the aorta and of the column. Once prepared the described operative field, the

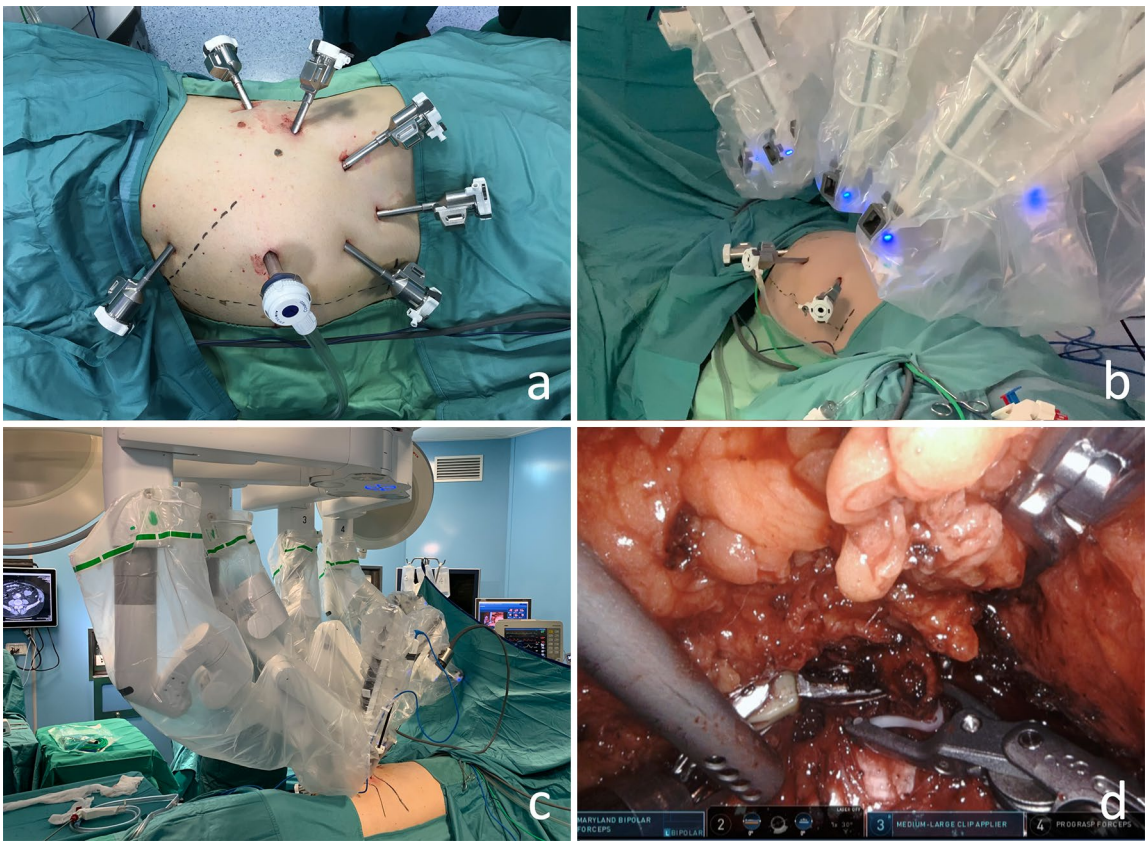

Fig. 1 **a** Trocars disposition. **b** First docking with trocars positioned on the left pararectal line for inferior mesenteric artery ligation and left colon mobilization. **c** Second docking after boom rotation and trocars used for the second phase. **d** Selective clipping of lumbar feeding with the sac pulled to the right side using the fourth arm

robot was undocked and the boom was rotated in a clockwise direction to ensure an optimal left-side visualization. During this second phase four trocars were disposed in an oblique fashion, with the endoscope coming from the left flank trocar, to obtain the best vision and ability for the retro-aortic plane dissection (Fig. 1c). The instruments remained the same with addition of a Cadiere grasper inserted for countertraction on the fourth arm docked at the left posterior site. The assistant provided suction through the other trocars used for the first phase. The dissection was continued close to the anterior longitudinal ligament of the column until it reached the lumbar arteries responsible for the endoleak that were isolated and clipped. (Fig. 1d). The sac was pulled to the right side using the fourth arm and the LA were approached along the plane of the anterior longitudinal ligament. We did not systematically isolate the neck of the aneurism and we did not perform the systematic ligation of all the aortic collaterals, focusing only on the lumbar arteries responsible for the endoleak, as identified by the pre-operative CTA. After clipping the IMA and the LAs, we used a dedicated ultrasound probe (12–5 MHz, curved linear array, BK Medical APS, Peabody MA, USA), inserted throughout the assistant port, to verify the absence of backflow inside the sac. US and color Doppler (CD) signals were displayed by the surgeon at the console in a real-time manner as a picture-in-picture image, using the TilePro function. Finally, a retroperitoneal drain was inserted.

In the first post-operative day, patients underwent contrast-enhanced ultrasound (CEUS) to assess the immediate surgical result.

Results

The procedure was performed in two patients. Informed consent for each procedure was obtained. Consent for participation in the study was waived due to the retrospective nature of the study.

Case #1

The first case was a 72-year-old man with chronic pulmonary obstructive disease (grade C by GOLD) and atrial fibrillation underwent EVAR with Gore Escluder C3 endograft (W.L. Gore & Associates, Flagstaff, Ariz) in 2017 for a 65 mm infra-renal aortic aneurysm. During the follow up, the CTA revealed an increasing sac diameter till 75 mm due to T2E from IMA and LA at L5 level. An attempt of endovascular sealing was performed in November 2018 but it was unsuccessful due to the endothelization of the prothesis and to the impossibility to advance the microcatheter throughout the mesocolon vessel arch. After a multidisciplinary evaluation of general and vascular surgeons and anesthesiologists, the decision turned to an abdominal approach. Hence, we considered a minimally invasive management using the da Vinci Xi. The surgical procedure was successfully completed in 185 min, without intra-operative complications. The patient was discharged 3 days after surgery and the post-operative CEUS revealed no refilling of the sac.

Case #2

The second case was an 80-year-old man with arterial hypertension. Previous surgical intervention included inferior left lobectomy for squamous lung carcinoma in 2014 and EVAR with Cook Zenith Alpha endograft, (Cook Medical, Bloomington, Ind) in 2015 for a 60 mm infra-renal aortic aneurysm. A T2E was already diagnosed in 2017, but the CTA performed in November 2018 demonstrated a sac expansion up to 70 mm. After a multidisciplinary evaluation of general and vascular surgeons and anesthesiologists, we decided to first perform the robotic trans-abdominal approach. The procedure was completed in 180 min and no intra- or post-operative complications were recorded. The patient was discharged 2 days after surgery and also in this case the post-operative CEUS revealed the success of the operation.

Discussion

Current guidelines recommend the treatment of T2E when aneurysmal sac grows up during the follow-up because the sac enlargement is an indication of elevated pressure with a consequent increased risk of rupture [6]. Nowadays the endovascular embolization is considered the first-line treatment option but it presents some limitations, as the feeding lumbar arteries can be difficult to embolize by conventional trans-arterial, or trans-lumbar approaches, mainly because of their location and trajectory [7]. Furthermore, rates of T2E persistence or recurrence, or both, remain considerably high with these techniques [3].

Laparoscopic T2E repair has been described as a minimally invasive surgical alternative [5]. This approach permits a definitive ligation of aortic collaterals responsible for endoleak inflow and outflow. Although encouraging results have been described, it remains a technically demanding procedure applied. So far, it has only been performed by very highly experienced laparoscopic vascular surgeons. Furthermore, published series are limited in size and somewhat controversial [8, 9]. The difficulty lies in the peri-aneurysmal dissection, related to the inflammatory tissue surrounding the aorta and the consistent risk of LA damage during the posterior mobilization, with consequent uncontrolled bleeding.

Robot-assisted surgery provides a number of technical advantages capable of overcoming the kinematics

limitations of laparoscopy and resulting in a potential higher level of precision and control during surgery, and in a shorter learning curve. However, while with laparoscopy the surgeon can easily change the operative field, the previous da Vinci versions presented reduced skill to perform a multi-target operation (IMA plus LA) because bulky, prone to arms collisions and obliged to a fixed patient's position after docking, thus limiting its application in this field.

Conversely, the latest da Vinci Xi combines the functionality of a boom-mounted system with the flexibility of a mobile platform allowing the operating surgeon to quickly scan over a wider operative field. In addition, the scope can be placed on any of the 8-mm robotic trocar, thus enabling different surgical views and improving versatility [10–13].

In T2E repair, robotic assistance can be useful during the entire operation. In the first phase the IMA is easily recognized and dissected thanks to the wristed instruments (wristed monopolar scissors, Maryland bipolar forceps, and robotic clip applier) and to the 3-D stable camera, despite the unfavorable angle due to the 60° right flank position. In the same phase, by continuing the dissection from the right side of the patient, the left colon and the infra-renal space are better mobilized if compared with a simple posterior approach. Then, the boom rotation of da Vinci Xi in a clockwise direction allows an optimal left-side visualization, enabling the posterior retro-aortic approach from the left side of the patients, avoiding a time consuming double docking technique. Again, the articulated instruments with motion scaling and tremor filtering facilitate a gently retro-aneurysmal dissection and an easy LA identification, dissection, and ligation.

Finally, the Tilepro function permits the operator to directly control from the console with intra-operative US, CD or CEUS the absence of residual endoleak after selective IMA and LA ligation, thus avoiding the need of a systematic ligation of all the aortic collaterals.

We acknowledge that although encouraging, our experience is very preliminary and, because of the high costs related to the robotic procedure, the widest application of this technique needs caution. However, recent articles have suggested an economic gain with increasing surgeon's experience and with the use of da Vinci Xi [14, 15]. Therefore, we suggest an assessment on costs, in comparison with the previous economic analyses, as well as the exploration of new applications of robotic technology.

To the best of our knowledge this is the first manuscript that describes the technical aspects of a full robotic T2E repair with the da Vinci Xi. The main aim of this study was to report our preliminary experience on the feasibility of this new robotic approach for the treatment of T2E. Robot-assisted ligation of feeding vessels represents a potential alternative treatment after a failed standard endovascular embolization, but further studies are recommended to define its medium and long-term efficacy and its cost-effectiveness.

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Compliance with ethical standards

Conflict of interest Luca Morelli, Simone Guadagni, Gregorio Di Franco, Matteo Palmeri, Niccolò Furbetta, Desirée Gianardi, Matteo Bianchini, Andrea Moglia, Giulio Di Candio, Mauro Ferrari and Raffaella Berchiolli declare that they have no conflict of interest.

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