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ORIGINAL ARTICLE

# Anterior robotic approach in en-bloc sacrectomy: a preliminary experience

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**Abstract**
En-bloc sacrectomy is a highly demanding surgical procedure necessary to obtain wide margin in sacral tumor. The double approach, anterior and posterior approach, is usually preferred for tumors extending proximally to S3 level where iliac internal vessels are at a higher risk for damage during posterior surgery. It can be justified also in selected cases to decrease the risk of posterior approach as in local recurrence or in patients who already underwent laparotomy. Our intent was to apply robotic-assisted techniques for performing anterior preparatory approach for sacrectomy surgery. Between December 2010 and December 2014, three cases of sacrectomies were performed in a previous robotic-assisted preparatory approach to separate the rectum from the tumor. Dissections were successfully performed in all cases close to the pelvic floor. The surgeon was able to position a Gore-Tex spacer between the anterior tumor surface and the rectum in all cases. The anterior dissections were performed with a perfect control of bleeding. No complications related to the anterior approach were reported. Robot-assisted surgery can be considered a valid and minimally invasive technique which allows a safe anterior dissection of the pelvic structures dividing tumors from surrounding tissues. It allows to place a spacer to protect organs during posterior sacral resection performed on the same day or at a later time. Further experiences are advocated to evaluate its efficiency in sacral tumors of greater size.

**Keywords** En-bloc sacrectomy · Robot-assisted surgery · Minimally invasive surgery

## Introduction

En-bloc sacrectomy (EBS) is considered a highly demanding surgical procedure necessary to obtain wide margin in sacral tumor. Several techniques are available and can be classified into different types of resections where in many cases EBS is performed solely by posterior approach. It is preceded by an anterior approach where the tumor mass is separated from the rectum and, when necessary, the internal iliac vessels are identified and bound. The anterior approach makes subsequent posterior approach safer [1].

The double approach is usually the preferred option for tumors extending proximally to S3 level where iliac internal vessels are at higher risk for damage during posterior surgery; nevertheless, this approach can also be carried out for tumors located at lower levels increasing the global safety or in particular cases as shown in our experience [1, 2]. The anterior approach is usually performed by xyphoid–pubic incision and can be associated with a variable morbidity for the patient [1].

The diffusion of minimally invasive techniques also strongly encourages its application in this field. The minimally invasive robotic approach allows to perform a safe anterior because of its magnified vision and its capability to access areas that are not usually accessible through using the traditional approach.

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The aim of this study was to evaluate robotic-assisted techniques in anterior preparatory approach for sacrectomy surgery.

## Materials and methods

### Study design and data collection

Patients with sacral tumors who underwent EBSs [3] with a robot-assisted preparatory anterior approach were included in this study.

All cases were performed at the Department of Experimental Clinical Oncology of the "Regina Elena" National Cancer Institute of Rome, and all the procedures were performed by surgeons with extensive training and experience in surgical oncology and in advanced minimally invasive surgery.

Clinical patient characteristics included age, body mass index (BMI), histopathologic subtype, and tumor grade. Intraoperative assessment parameters comprised complications and blood loss. Blood transfusions were administered if Hb values were ≤ 8 g/L. Postoperative parameters included short-term (within 30 days of the procedure), and long-term complications (more than 30 days after the procedure). Complications were defined according to Common Terminology Criteria for Adverse Events (CTCAE) Version 4.0 [4]. Moreover, length of hospitalization, median follow-up duration, recurrence, and disease-free interval (DFI) were recorded.

Approval to conduct the study was obtained independently from an internal review board. Informed consent, including clinical evaluation and robotic surgery, was obtained from all patients in accordance with national and international regulations (Declaration of Helsinki) [5].

### Surgical technique

All patients have antibiotic prophylaxis (Augmentin 2.2 g intravenously) and perioperative low molecular weight Enoxaparin (40 mg/24 h subcutaneously). The vaginal cavity was cleansed with povidone iodine solution and a Foley catheter was placed in the bladder. Intraoperative lower extremity sequential compression devices for venous thrombosis prophylaxis were used. All procedures were performed under general endotracheal anesthesia using Si-system Da Vinci® surgical system (Intuitive Surgical Inc®, 1266 Kifer Road, Building 101 Sunnyvale, CA, USA). Our surgical technique was based on a first time anterior and a second posterior approach.

1. *Anterior approach* Patients were placed in the lithotomy position with their arms tucked at each side. After creating a pneumoperitoneum to 12 mmHg, using a transumbilical Verres needle, a 12 mm trocar was placed at 2 cm cranial to the umbilical level; three 8 mm trocars, specific for the Da Vinci robotic systems® were placed (Fig. 1): one (Arm 1) on the right side of the abdominal wall, medial and cranial to the right anterior upper iliac spine, and two on the left side of the abdominal wall, the first (Arm 2) on the left lowest rib and the second (Arm 3) medial and cranial to the left anterior upper iliac spine on the same line of the right trocar, and fastened to the robotic arms. An assistant 10 mm trocar was placed on the right side of the abdominal wall, 7–10 cm lateral from the supra-umbilical trocar. After obtaining the Trendelenburg position (30°), the Da Vinci robotic column was positioned near the operating table between the patient's feet and docked. The following instruments were introduced: a bipolar grasper and a PK grasper on the left robotic trocar (Arms 2 and 3, respectively) and a pair of monopolar scissors on the right robotic trocar (Arm 1). A 30 degree Intuitive Surgical endoscope was used during the whole operation (Fig. 2). A uterine manipulator was used (Cooper Surgical®) to move the uterus more effectively when necessary. Abdominal pressure was maintained at 12 Hg. An abdominal examination was performed and then peritoneal washing samples were collected. Resection of the round ligament and an incision of the retroperitoneum over the iliac external vessels evidently allowed the development of retroperi-

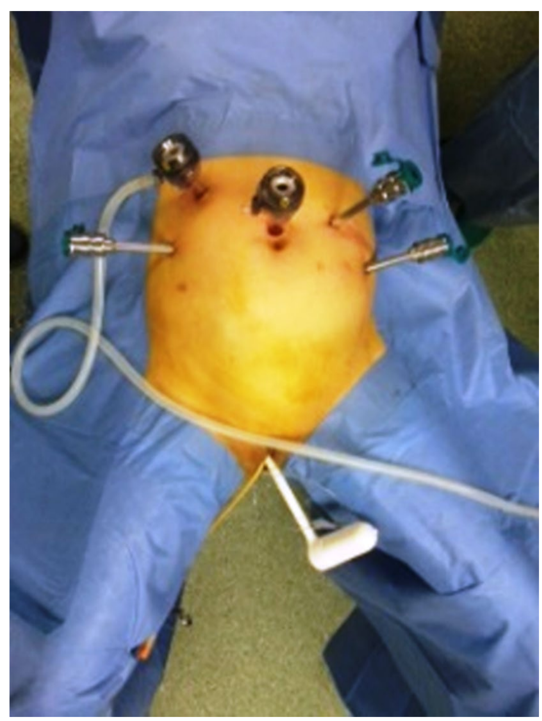

**Fig. 1** Port sites placement

**Fig. 2** Operating field for robotic approach

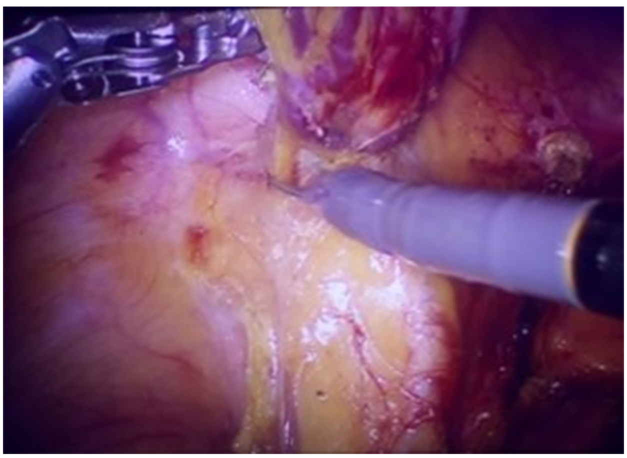

**Fig. 3** Robotic identification of the sacral tumor and its isolation from epogastric vessels

toneal spaces from the right side to the left one. Consequently, paravescical space, Lasko fossa, medial pararectal fossa or "Okabayashi pararectal space" are then bilaterally perfectly detected. We then prepared anatomical landmarks for the lymphadenectomy: lateral to the average obliterated umbilical artery, we found external iliac artery and the psoas muscle deeply below the paravescical and pararectal spaces. Once having detected the obturator nerve, we proceeded to peel off the adventitia over iliac external artery from above. This practice makes it possible to remove the nodal packet "en block" if necessary and let it slide down into the paravescical space. The 12 mm assistant trocar was then used to extract it via endobag. Subsequently, we identified and completely isolated the tumor from the rectum, inferior hypogastric plexus and hypogastric vessels (Fig. 3). At the end of the robotic approach, a Gore-Tex spacer was positioned to divide the structures and reduce the risk of adhesions and of any damage during posterior removal. The pelvis was irrigated with saline solution and accurate control of hemostasis was reassured even "underwater". The Da Vinci robot was disconnected and the port sites were closed with interrupted 2-0 Byosin suture.

2. *Posterior approach* It can be done on the same day or successively. The patient is placed in prone position with hip abducted and gently flexed, knee flexed and foot locked in dedicated supports. Pulse oximetry is bilaterally placed to exclude distal ischemia associated with compression. The incision varies and is based on the tumor characteristics and its size (Fig. 4a). The posterior aspect of the sacrum is isolated and attention must be paid to maintain a wide margin. A one level laminectomy is performed at the first level proximal to the disease; the cauda and depending roots are bound and cut (Fig. 4b). The external rotatory muscles and the pelvic floor muscles are then severed and the affected sacrum removed by transverse osteotomy for distal to S2 tumor and by transverse and sacro-iliac osteotomies for proximal to S2 tumors (Fig. 4c). The spacer placed during the anterior surgery is then removed (Fig. 4d) and the wound is closed directly or previous to the rotation of Gluteus Magnus rotator flap.

## Results

Between December 2010 and December 2014, three cases (Fig. 5) of sacrectomies were performed in a previous robotic-assisted preparatory approach to separate the rectum from the tumor (Table 1). The median age was 60 years (range 45–67), and the median BMI was 23.8 kg/m$^2$ (range 22.3–26.0 kg/m$^2$). In the first case, the extirpative surgery was performed after 7 days from the anterior robotic approach; in the other two cases, both surgical steps were performed in the same day.

### Perioperative parameters

The median docking time was 7 min (range 4–15 min), console time (net surgical time) was 90 min (range 60–120 min), and operation time for anterior approach (skin-to-skin) was 150 min (range 80–180 min). The median operation time for the entire surgery (anterior plus posterior approach) was 435 min (range 340–510 min). The median blood loss for the anterior robotic approach was 50 mL (range 10–250 mL); none of the patients required intraoperative blood transfusion while two out of three patients needed postoperative blood transfusion due to bleeding associated with sacral osteotomy. The median drop of hemoglobin was 2.7 g/L (range 2–3 g/L) before and 24 h after operation. Dissections

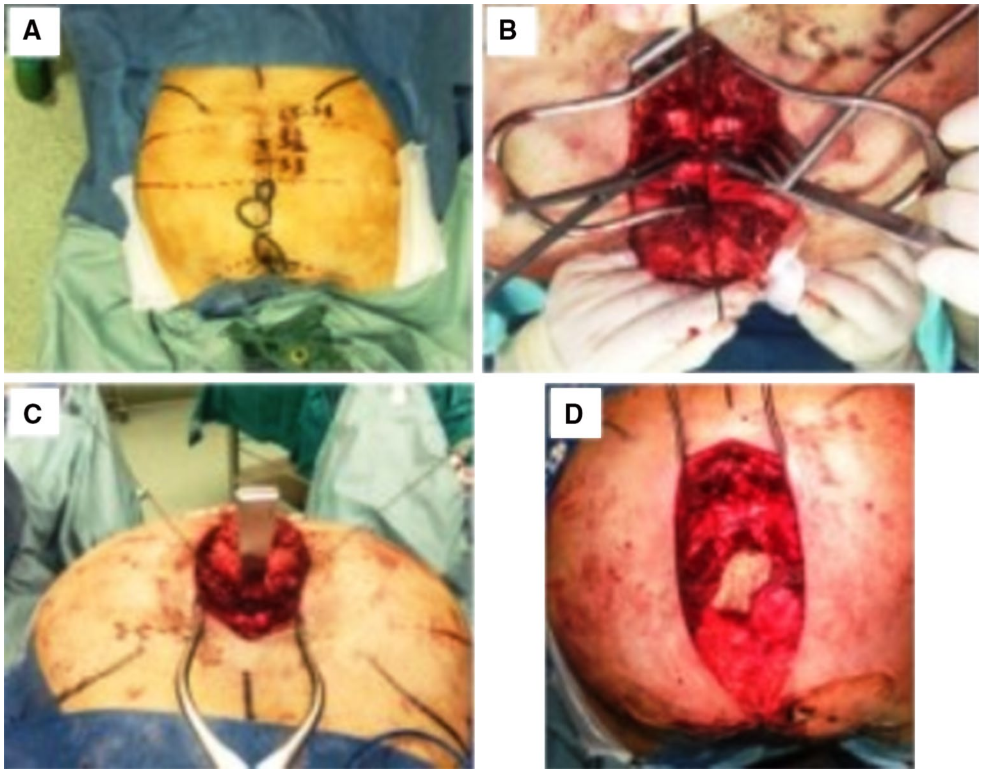


**Fig. 4** **a** In the preoperative draw, it is possible to see the sacral levels and the skin projection of the disease; **b** cephalic view: the laminectomy is performed at the level proximal to the tumor and the dural sac bound; **c** cephalic view: proximal osteotomy is then performed using osteotomes, a Gigli saw or a high speed burr in accordance with the surgeon preferences; **d** the surgical field after sacral resection: it is possible to see the Gore-Tex spacer placed during the first surgery

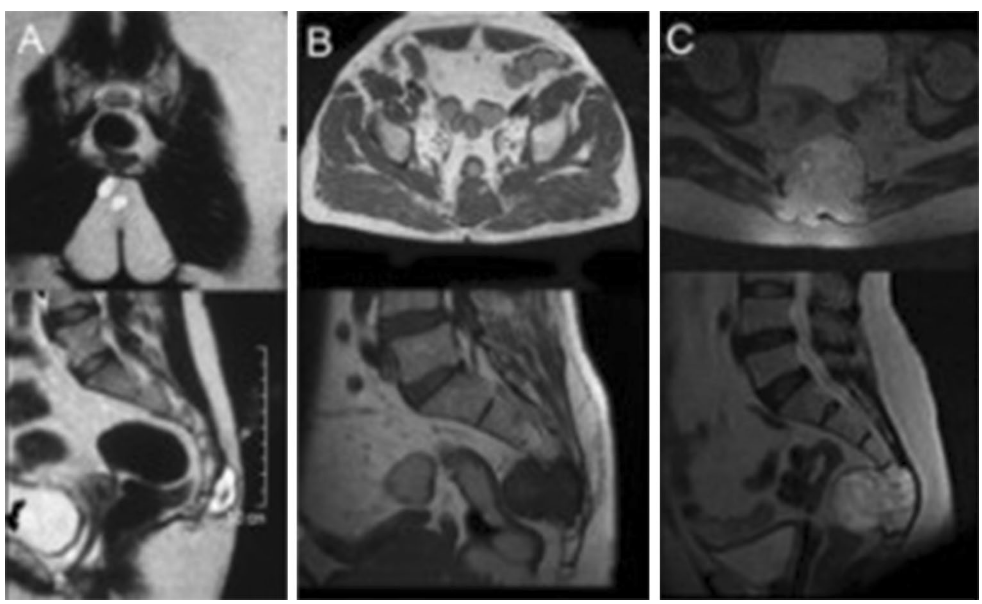


**Fig. 5** **a** A 45-year-old female affected by multiple exostoses, underwent curettage of a posterior sacral mass, after having been diagnosed with low grade chondrosarcoma, in another hospital. MRI showed local recurrence; **b** a 67-year-old male affected by chordoma; the MRI showed the mass located distally to S2; **c** a 60-year-old Asian female affected by chordoma with differentiation in spindle cell sarcoma; the MRI showed a mass located distally to S3

were successfully performed in all cases close to the pelvic floor. The surgeon was able to position a Gore-Tex spacer between the anterior tumor surface and the rectum in all cases.

## Postoperative parameters

No complications related to the anterior approach were reported. The posterior resections were considered less

**Table 1** Patients characteristics and surgical outcome

| Patients/characteristics | Age (years) | BMI | Hystology | OT (min) | EBL (mL) | HS (days) | Complications | | CV | Transfusions (number) | Status (months) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Intra-op | Post-op | | | |
| 1. Figure 5a | 45 | 26.0 | Chondrosarcoma | 510 | 500 | 20 | 0 | 1 | No | 2 | NED (60) |
| 2. Figure 5b | 67 | 22.1 | Chordoma | 340 | 200 | 12 | 0 | 1 | No | 0 | NED (24) |
| 3. Figure 5c | 60 | 23.1 | G3 spindle cell sarcoma | 435 | 550 | 15 | 0 | 0 | No | 2 | NED (18) |

*OT* operative time, *EBL* hematic blood loss, *HS* hospital stay, *CV* conversion, *NED* no evidence of disease

challenging because the Gore-Tex spacers were positioned anteriorly to protect anterior viscera from cutting instruments.

The anterior wounds healed completely and the stitches removed after 2 weeks in all cases; orthostatic standing was allowed after 4 days; drains were removed after wounds healed. The posterior wound healed in two cases after 20 days. In the remaining case, a little fistula of about 2 mm of diameter was present draining minimal quantity of serum. Cultural tests were negative and wound completely healed after 3 months from surgery.

At median time of follow-up of 24 months (range 18–60 months), all patients are apparently free of disease and able to walk without support even if the first patient (case 1) presents low back pain associated with vertebrectomy (grade 2 according to CTCAE v4.04).

## Discussion

The benefits of minimal invasive surgery are less wound related problems, increased comfort in patients, better visualization, less blood loss, shorter recovery time, decreased analgesic requirements, shorter hospital stay and earlier recovery, in comparison with the traditional open approach [6]. Indeed, the application of robotic surgery is widespread in urologic surgery where, thanks to the magnified visualization and controlled motion, it is possible to perform nerve-sparing prostatectomy and cystectomy with a high success rate consequently decreasing the complication rate of the extensive approach [7]. In recent years, robotic surgery has become popular also in the field of gynecology. Robotic radical hysterectomy with lymphadenectomy (RRH) was described and published for the first time in 2006 by Sert and Abeler [8]. The use of robotic surgery has been associated with faster performance times, increased accuracy, enhanced dexterity, faster suturing, and reduced number of errors when compared to conventional laparoscopic surgery [9]. In a recent study, surgical outcome of RRH was compared to laparoscopic radical hysterectomy (LRH) for the treatment of locally advanced cervical cancer (LACC) after neoadjuvant chemotherapy (NACT). RRH resulted in being an appropriate alternative to LRH for the treatment of women, not only with ECC, but also with LACC treated with NACT. In fact, RRH group was able to take advantage of less blood loss and shorter hospitalization times compared to conventional LRH [10].

In orthopedics, robotic surgery can be helpful to perform anterior approach to spine, sacrum and pelvis. In our experience, the surgical robot allows to safely dissect the anterior surface of sacral tumors from the rectum respecting wide margin. This technology provides a high definition-3-D vision system and instruments which allow surgeons to increase accuracy by mimicking the complex movement of the human hand, enhance the dexterity with tremor abolition, and faster suturing. Indeed, three-dimensional vision, tremor filtration and the precision and manoeuvrability of robotic instruments are advantages that assist in easier dissection, particularly in the case of fibrosis or tissue retraction after chemotherapy. Indications for an anterior robotic approach could be for any case where an anterior release and isolation and binding of the internal iliac vessels are advocated regarding sacral or sacrum-iliac resection. Tumors proximal to S2 levels are where robotic surgery gives major advantage, but the low morbidity associated with the procedure and the simplification of the posterior approach extend indications also in more distal tumors like in our first and third presented case. In the first case, the patient had already undergone a previous erroneous posterior approach where intralesional surgery was performed. The anterior release allowed the posterior approach with the scar removal decrease the risk of anterior vessels damage. In the third case, the patient several years before underwent a hysterectomy and, thus, a previous anterior approach was suggested considering the possible presence of adherences.

The three tumors that we treated were small; therefore, it was rather simple to extend the dissection distally. Indeed, the dissection level could depend on the dimension of the tumor. When a large mass, originating from the sacrum, completely occludes the small pelvis, dissection is extremely difficult also in open surgery. More experience is needed to verify the effectiveness of robotic surgery also in giant sacral tumors.

Disadvantages are possibly related exclusively to the high cost of the procedure and to the learning curve associated with robotic surgery; therefore, only specialized centers where robotic surgery is routine should robotic-assisted sacrectomy be performed. For robotic surgery, surgeons must first become proficient in port placement, set-up, and docking. Then, surgeons must gain proficiency in performing individual procedures. A study comparing the first 10 and last 10 cases in a cohort of 100 patients undergoing robotic staging for endometrial cancer revealed a shorter operative time, a higher number of lymph nodes retrieved, and a lower rate of operative complications in the later cases [11]. Others have demonstrated that proficiency in robotic hysterectomy with pelvic–aortic lymphadenectomy is achieved upon completion of approximately 20 cases and that efficiency continues to improve over time [12]. In addition to the acquisition of surgical skills, an important factor in the successful implementation of a robotic surgical program is the creation of a robotic surgical team, including surgical scrub and circulating nurses as well as bedside surgical assistants who are familiar with the robotic equipment. In the adoption of a hospital robotics program, training of bedside assistants is essential, and the effect of such training on reducing total operative time and surgical errors has been documented [13].

In an era of dwindling reimbursements and added financial pressures on both hospitals and insurance providers, medical surgical technology has emerged as a major driving force in increasing health-care costs. Wright et al. [14] found robotic hysterectomy to be $1291 more costly than laparoscopic approaches (95% CI $985, $1597). However, after calculating for societal/productivity losses, robotic approaches demonstrate to be cost effective over open approaches, with mean costs of $8212 versus $12.943 ($P=0.0001$), respectively [15]. Moreover, Lau et al. showed that the overall hospital costs were significantly lower for robotics compared with laparotomy or laparoscopic procedures even when acquisition and maintenance costs were included (Can$8.370 compared with Can$10.368; $P$ = 0.001) [16].

In conclusion, to our knowledge, this is the first report where robot-assisted surgery was applied to assist sacrectomy for bone tumors. Robot-assisted surgery can be considered a valid and minimally invasive technique which allows a safe anterior dissection of the pelvic structures dividing tumors from surrounding tissues. It allows to place spacers to protect organs during posterior sacral resections performed on the same day or at a later time. Further experiences are warranted to assess its efficiency in sacral tumors of major size.

## Compliance with ethical standards

**Conflict of interest** The authors declare no conflict of interest; no funding was received for the present study.

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