Robot-assisted Placement of Pelvic Tissue Expander for Radiation After Prostatectomy and Cystectomy for Treatment of Prostate Cancer Biochemical Recurrence

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OBJECTIVE To present a robot-assisted surgical technique for overcoming challenges of a patient with prior pelvic surgeries and bowel in the radiation target.

METHODS A 72-year-old male required treatment for biochemically recurrent prostate cancer. In 2006, he presented with Prostate-Specific Antigen (PSA) 5.74 ng/mL, Gleason 3 + 3 prostate cancer. He underwent a robot-assisted radical prostatectomy for pT2aNx adenocarcinoma with negative margins. In 2008, he was found to have muscle-invasive high-grade papillary urothelial carcinoma and underwent robot-assisted radical cystectomy and ileal conduit for pT2bN0 urothelial carcinoma. In 2017, he had prostate cancer biochemical recurrence, with a PSA of 0.27 ng/mL. Pelvic CT showed small bowel in his prostatic bed behind the pubic bone. A robot-assisted lysis of adhesions and placement of a tissue expander in the prostatic fossa was performed. Three robotic ports and 1 assistant port were utilized. The sigmoid and small bowel were displaced during lysis of adhesions. The deflated tissue expander was inserted through the midline trocar site, inflated intra-abdominally, and filled with 330 cc of saline. The tissue expander was secured with proline sutures in a dependent position. The patient subsequently underwent Intensity-modulated radiation therapy of 66 Gy to the prostatic fossa. Eleven days after finishing intensity-modulated radiation therapy, he underwent successful laparoscopic removal of the tissue expander. PSA nadir was <0.02 ng/mL.

RESULTS The patient tolerated intensity-modulated radiation therapy without complications. There were no gastrointestinal complaints following radiation therapy.

CONCLUSION Robotic placement of a tissue expander in patients who have undergone multiple pelvic surgeries is feasible and may reduce radiation morbidity. UROLOGY 124: 292−296, 2019. © 2018 Elsevier Inc.

Prostate cancer, the most commonly diagnosed cancer in men, is frequently treated with radical prostatectomy.[1] Unfortunately, biochemical recurrence (BCR) occurs in 30%-40% of patients who undergo definitive treatment with robot-assisted laparoscopic prostatectomy within 5 years of their surgery.[2,3] Radiation therapy (RT) to the prostatic bed is a standard treatment option for BCR for patients in whom no metastatic focus is found, but it can be complicated by critical tissue(s) falling within the focus of radiation.[4] Examples include the rectum or small bowel falling within the radiation field resulting in radiation proctitis or radiation enteritis, respectively. The dosage of radiation that cause acute radiation enteritis or proctitis is often reached early in salvage RT for BCR prostate cancer, leading to nausea, vomiting, cramping, rectal pain, and rectal bleeding within days to weeks after RT. An estimated 5%-15% of patients treated with RT to the abdomen will also go on to develop chronic radiation enteritis or proctitis, with additional signs and symptoms such as bloody diarrhea, tenesmus, steatorrhea, anorexia, bowel obstruction, fistulas, and perforation that present 6-18 months after RT.[5] Normally, patients with BCR postprostatectomy have the natural radiation spacer of the bladder. However, if a patient has BCR after prostatectomy and cystectomy, there is an increased risk of the small bowel falling within the radiation field, presenting a challenge in radiation planning and a significant risk of causing radiation enteritis.

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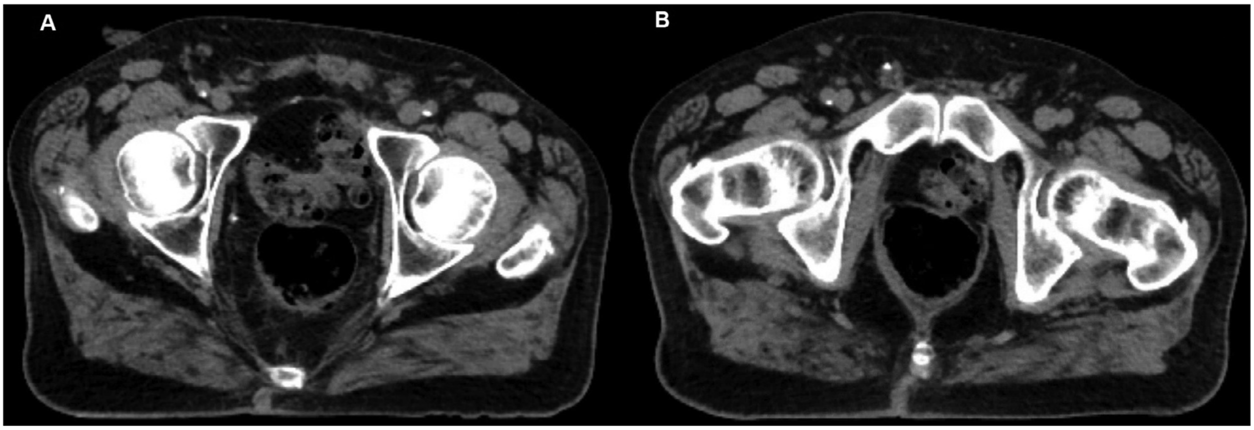

Figure 1. (A and B) Prepelvic spacer implantation CT scan with small bowel in radiation planning zone.

One approach to prevent these adverse outcomes is to insert a spacer to bolster the bowel out of the focus of radiation. This approach has been described in a number of case series and studies, which describe the use of rectal spacers in prostate cancer prior to RT and mesh spacers to displace the small bowel out of the path of RT for unresectable liver tumors.[6,7] In these studies and series, radiation doses to critical structures are often reduced compared to the initially calculated area of collateral radiation, and radiation toxicity is minimized. Almost all of the literature on the use of spacers describes open surgical approaches, with a single case report of a laparoscopic placement.[8]

To date, there are no reports of robotic placement of a pelvic spacer or tissue expander to prevent RT-induced damage to critical structures. We present a robot-assisted surgical technique for overcoming the challenges of a patient with a history of 2 prior pelvic surgeries whose small bowel lies in the radiation target.

METHODS

A 72-year-old male with a history of robot-assisted radical prostatectomy (RARP) and subsequent robot-assisted radical cystectomy with ileal conduit required treatment for BCR prostate cancer.

In 2006, the patient presented with a Prostate-Specific Antigen (PSA) of 5.74 ng/mL and a biopsy that revealed Gleason 3 + 3 prostatic adenocarcinoma. He was diagnosed with stage T1c prostate cancer and underwent a RARP. He tolerated the procedure well and had an uneventful recovery. His final pathology was pT2aNX Gleason 3 + 3 prostatic adenocarcinoma with negative margins. He achieved a postoperative PSA nadir in the undetectable range (<0.02 ng/mL) within 3 months of his RARP.

However, in 2008, he developed episodic, painless gross hematuria. A transurethral resection of bladder tumor revealed high-grade muscle-invasive urothelial carcinoma with sarcomatoid features. He underwent a robot-assisted radical cystectomy a month later with intracorporeal ileal conduit. The final pathology revealed pT2bN0MX high-grade muscle-invasive papillary urothelial carcinoma with negative margins, no lymphovascular invasion identified, and without prostatic adenocarcinoma or prostatic tissue identified.

A PSA drawn in October 2013 was 0.07 ng/mL, increased from a nadir of <0.02 ng/mL. By May 2017, his PSA of 0.27 ng/mL was above the threshold for BCR. After evaluation by a radiation oncologist and medical oncologist, and a bone scan that did not reveal any metastatic foci, it was recommended by medical oncology that he be treated with daily bicalutamide 150 mg for 24 months as well as with 60-68 Gy of salvage radiation to the prostate bed for BCR. However, a treatment planning/simulation CT scan of his abdomen and pelvis revealed that loops of small bowel had descended into the space previously occupied by his bladder and prostate, deep behind the pubic bone, and squarely within the planned treatment volume (Fig. 1A and B).

In July 2017, he underwent robot-assisted laparoscopic lysis of adhesions and placement of a pelvic tissue expander. The da Vinci SI robot system (Intuitive Surgical, Sunnyvale, CA) was used with a camera port in the midline supraumbilically, 2 robot arms placed to the right and to the left of the camera port, and one 8-mm assistant port was placed in the left lower quadrant (Fig. 2A). Lysis of adhesions was performed to create enough space to place the tissue expander (Fig. 2B). The camera port was then expanded to 2.5 cm, and a wound protector placed. A 450 cc Integra tissue expander (PMT Corporation, Chanhassen, MN), bathed in an antibiotic solution was inserted into the patient's abdomen through the wound protector; a gel-port was used to dock the camera port. The tissue expander fit deeply and snugly within the pelvis after 330 cc of saline was injected into the injection port. The tissue expander was secured with 0 Prolene sutures through the peritoneum and 5-mm Hem-o-lok clips, creating a loose net to maintain the tissue expander in the pelvic position (Fig. 2C). Care was taken to inflate the tissue expander to a level that would not compress the iliac vessels and cause potential deep vein thrombosis. The injection port was then robotically inserted into the left lower quadrant area above the transversalis fascia (Fig. 2D). The injection port was palpable through left lower quadrant skin. This injection port was utilized to facilitate potential modifications of the size of the spacer based on patient

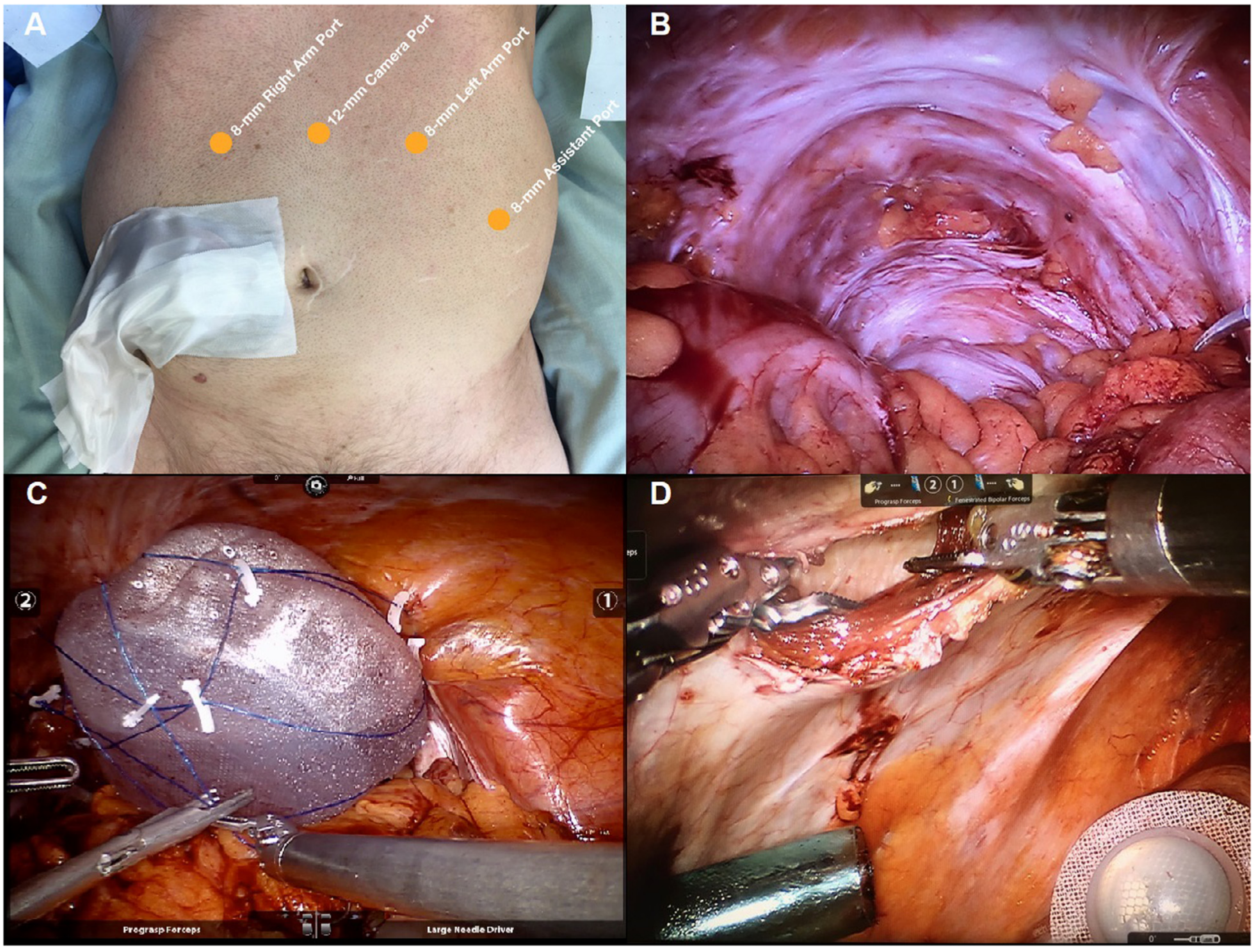

Figure 2. (**A**) The da Vinci trocar sites, (**B**) view of the empty pelvis after lysis of adhesions, (**C**) tissue expander in pelvic position with Prolene sutures and Hem-o-lok clips creating a loose mesh retention barrier, and (**D**) placement of the tissue expander injection port in the left lower quadrant above the transversalis fascia. (Color version available online.)

comfort and radiation planning modifications from the subsequent postoperative radiation planning CT scan. The patient tolerated the entire procedure without complications and was discharged home on postoperative day 1.

The patient underwent a treatment planning/simulation CT scan 3 weeks after his surgery that revealed a well-placed tissue expander with no small bowel in the prostatic fossa (Fig. 3A and B). He was started on 150 mg of bicalutamide daily and received his full course 66 Gy of intensity-modulated RT (IMRT) to the prostatic bed over the course of 51 days and 37 fractions. He tolerated the RT well, had minimal discomfort from the tissue expander during treatment, and reported no significant gastrointestinal side effects.

Three weeks after his final dose of radiation, the pelvic spacer was removed laparoscopically through the same incisions that had been made in the previous surgery. The patient tolerated this procedure without any complications, and was discharged home on postoperative day 1.

His PSA nadir following salvage RT was in the undetectable range (<0.02 ng/mL). With 1-year follow-up since finishing RT, he reports no signs and symptoms of acute or chronic radiation enteritis or proctitis.

DISCUSSION

Prevention of radiation enteritis and proctitis is a key method to reduce morbidity for RT of abdominal and pelvic cancers. Many methods of preventing radiation injury to the bowel have been proposed, including different forms of external beam RT, local treatment, patient positioning, organ distention, and introduction of non-native gas or fluid into the abdominal cavity.[6-12]

External beam RT today has progressed to the point where 3-dimensional planning to shape the radiation beam to the target is possible using multifield conformal RT. IMRT is a feasible method to prevent injury because the doses delivered are rapidly adjusted and shaped to the planned treatment volume. However, these methods are unable to fully prevent collateral damage to bowel that is in the path of radiation.[13] Volumetric modulated arc therapy is another RT used to deliver highly conformed doses to a target volume while sparing normal tissue; while its utility has been shown in head and neck cancers, its effectiveness in prostate cancer is uncertain.[14] Finally, external

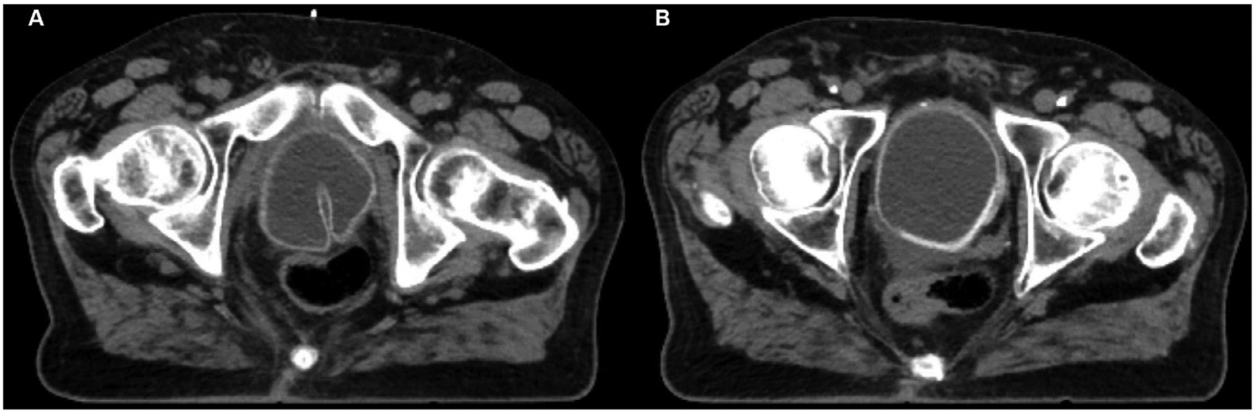

Figure 3. (A and B) Postpelvic space implantation CT scan showing displacement of the small bowel outside the radiation treatment zone by the pelvic spacer.

beam RT with heavier particles such as protons or carbon ions has been shown to release only low doses to collateral tissue while delivering maximal energy at the target. One study looked at carbon ion radiotherapy in conjunction with surgical spacer placement in order to treat sacral chordomas. While this study shows the effectiveness of placing the spacer and improving carbon ion RT safety, heavier particle RT is an uncommon and expensive tool unavailable at most institutions.[9]

Other methods include physical adjustments to the patient. Patent positioning, such as placing the patient in reverse Trendelenburg position, is a technique frequently used in surgical operations to assist in moving the bowel out of the way of the operation. Unfortunately, this positioning is less reproducible in RT because there is no instrument to sweep the bowel out of the way. Additionally, prior pelvic or abdominal surgery, as in this case, often causes adhesions, decreasing the ability of positioning to move bowel out of the treatment field. Distension of organs, such as the bladder, is another possible method of moving the bowels out of the path of radiation, yet it is difficult to reproduce the same level of distension required for RT consistency. Finally, the instillation of gas, fluid, or gel into the abdomen is another possible solution.[11,12] However, the iatrogenic creation of pneumoperitoneum or ascites is most likely uncomfortable for the patient, difficult to replicate consistently, and may not move the bowels out of the path of radiation.

The literature on the use of surgical procedures to keep the bowel out of the path of RT to the pelvis or abdomen extends back to the late 1970s. Early approaches to this solution involved using a patient's own tissue or prosthetic material to separate the abdominal contents from the pelvis. These techniques were plagued with problems such as tissue inadequacy, infection, and creation of adhesions or fistulas. Further, imperfect surgical technique could result in the creation of internal hernias with the potential for strangulation or small bowel obstruction.[8]

An early report of an open surgical placement of a pelvic spacer involved the insertion of a saline-filled breast implant into the pelvis, which was then covered with a mesh and sutured to the peritoneum to create an abdominal-pelvic barrier.[12] While this was an effective initial approach, mesh was later associated with increased risk of adhesions, obstructions, and fistulas. Later cases involved suturing expanders directly to the peritoneum. These earlier tissue expanders were often left in place, compressing blood vessels and the rectum, and potentially leading to the formation of blood clots and obstructive constipation. In 2011, a case report of the laparoscopic insertion of a tissue expander was published, demonstrating that an open approach was not necessary.[8] Later studies compared the efficacy of different types of spacers in preventing collateral RT damage. One such study comparing the use of a hydrogel vs a biodegradable balloon in the prevention of radiation proctitis during external beam RT for the treatment of prostate cancer showed that both methods reduced the dose of radiation to the rectum; however, the study authors noted that both materials had a decline in volume, and thus, rectal-sparing ability, over the course of radiation treatment.[6] A 2015 cost analysis on the use of spacers to reduce toxicity in IMRT for prostate cancer demonstrated their cost effectiveness, providing compelling evidence for their use.[15] These biodegradable approaches have innate size limitations and as of yet have only been utilized reduce rectal involvement and not small bowel interposition from an absent bladder and prostate.

Our approach is the first report of a robot-assist laparoscopic insertion of a pelvic spacer prior to RT to the prostatic bed for BCR of prostate cancer, and the subsequent laparoscopic removal of the pelvic spacer following RT. The case we present is unique not only in its original robotic approach, but also because this patient had already undergone 2 prior pelvic surgeries before this procedure, resulting in a distortion of the patient's original pelvic anatomy.

The robotic approach allows for easier access to the pelvis than is possible with a laparoscopic approach, especially in manipulating behind the public bone where some loops of small bowel had descended. All port sites in our patient were outside the radiation field, decreasing potential complications from wound healing as compared to an open approach. Because the patient presented with prior robot-assisted pelvic surgeries, this facilitated future pelvic surgeries due to less dense adhesions compared to nonrobotic surgeries.[16] Given the now-common use of robot assistance in minimally invasive pelvic surgery as well as the ubiquity of radiation treatment to the pelvis or abdomen, it is likely that this approach will be adopted in future practice to bolster vital organs from the path of radiation and thus prevent radiation exposure complications such as radiation enteritis and proctitis.

A future application of this approach may involve the robot-assisted placement of a hydrogel or biodegradable spacer prior to radiation to the abdomen or pelvis in conjunction with shorter courses of RT. This combination of approaches would allow for safe and effective delivery of a radiation dose while preventing collateral radiation damage or the need for subsequent surgery to remove the spacer.

This case demonstrates feasibility of a new surgical technique rather than demonstrating oncologic superiority or generalizable results. Other limitations include a narrow patient selection criterion for the procedure and the requirement to undergo 2 additional procedures to facilitate safe radiation delivery.

CONCLUSION

Robot-assisted placement of a tissue expander to prevent RT-induced damage to the bowel is feasible even in patients who have had multiple prior pelvic surgeries. The patient population with surgically removed pelvic organs is most likely to benefit from this technique, especially as lifespans and likelihoods of cancer recurrence increase. We present a novel, robot-assisted surgical technique for overcoming the challenges of a patient with a history of 2 prior pelvic surgeries and small bowel in the radiation target.

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