ORIGINAL ARTICLE

Successful use of tissue expander and pelvic sling to exclude small bowel for high-dose pelvic irradiation

Dedrick Kok Hong Chan[1,2] · Timothy Cheo[3] · Wai Kit Cheong[1]

Abstract

Objective Our study seeks to describe our surgical technique of the use of a tissue expander and a pelvic sling in order to perform high-dose pelvic irradiation without incurring radiation toxicity to the small bowel.

Summary background data High-dose radiation therapy for pelvic tumours comes at a risk of radiation toxicity to the small bowel. Our study discusses our novel surgical technique of compartmentalising the abdomen and the pelvis through the use of a tissue expander and pelvic sling to avoid small bowel radiation toxicity.

Methods We present a patient with an unresectable sacral chordoma. We describe our surgical technique incorporating both a tissue expander and an absorbable pelvic mesh sling to successfully compartmentalise the abdomen from the pelvis.

Results The patient underwent an uneventful surgical procedure to place the tissue expander within the pelvis and deploy the pelvic mesh sling. Following surgery, a separation of at least 8 cm was achieved between bowel loops and the tumour. A dose of 70 Gy delivered over 35 fractions using intensity modulated radiotherapy (IMRT) was administered to the sacral chordoma, whilst managing to constrain the maximum bowel dose to 35.7 Gy. Surgery to remove the tissue expander was uneventful. The patient has not suffered any small bowel irradiation toxicity.

Conclusions Our technique to exclude small bowel from the pelvis is effective and safe. This technique not only can be applied in the setting of unresectable sacral chordomas but also may be applicable to other pelvic cancers which require radiation therapy.

Keywords Tissue expander · Pelvic sling · High-dose radiation therapy · Pelvic sarcoma

Introduction

Chordomas are tumours which arise through malignant transformation of benign notochordal cells [1]. They have an incidence of 0.08 per 100,000 persons per year [2]. The most common site in 30% of cases is at the sacrum [3]. The treatment for chordomas is surgical resection with negative histologic margins. However, owing to its indolent, slow-growing, and locally

destructive nature, many patients present when the tumour may have invaded into surrounding structures, rendering surgical resection not possible [4]. In patients with unresectable disease, the key to achieving local control is radiation therapy. One of the main concerns of providing high-dose radiation therapy to the lower abdomen and pelvis is injury to the small and large intestines within the pelvis, resulting in complications such as fibrosis and adhesions, gastrointestinal bleeding, as well as gastrointestinal perforation [5, 6].

In order to mitigate against these complications, we performed a surgical procedure to exclude the small bowel from entering the pelvis by compartmentalising the abdominal and pelvic cavities through the placement of a tissue expander and a biologic mesh. We describe our experience managing this patient as well as our surgical technique.

Patient and methods

The patient was a 67-year-old lady who presented with progressively worsening lower back pain with radiation to the

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✉ Dedrick Kok Hong Chan
dedrick_kh_chan@nuhs.edu.sg

1   Division of Colorectal Surgery, University Surgical Cluster, National University Health System, 1E Kent Ridge Road, Singapore 119228, Singapore

2   Department of Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore

3   Department of Radiation Oncology, National University Cancer Institute, Singapore, Singapore

right foot. She presented with a limp, due to weakness of her right lower limb. Initial imaging showed a large solid-cystic mass arising from the sacrum and extending into the pre-sacral plane and displacing the rectum. The mass also involved the sacral foramina bilaterally, the sacral spinal canal and the S1 nerve root, the right sacroiliac joint, and the right iliac bone. This lesion was deemed to be unresectable and the patient was counselled for radiotherapy. In view of the high doses of radiotherapy required, and concerns regarding toxicity to bowel, the patient was counselled and consented to undergo a procedure to compartmentalise the abdominal cavity from the pelvis, and therefore, to minimise inadvertent irradiation of high doses of radiation therapy to small bowel.

The procedure was performed under general anaesthesia with the patient in the supine position. Prophylactic broad-spectrum antibiotics, ceftriaxone and metronidazole, were administered to the patient. A 10-cm midline laparotomy incision was created for access into the abdominal cavity. In order to anchor the absorbable mesh, the ascending colon as well as the sigmoid colon was mobilised lateral to medial off the retroperitoneum. We fashioned three pieces of 26 × 30-cm VICRYL Mesh Bag (Ethicon, USA) to compartmentalise the abdomen from the pelvis. The mesh was anchored to the L5 region just distal to the bifurcation of the aorta at the midline, proceeding laterally across the iliac vessels and the ureter, and then to the abdominal side wall up to the level of the umbilicus (Fig. 1a). Particular care was taken to identify the iliac vessels as well as the ureter and to avoid both anchoring the mesh to these vital structures, or strangulating these vessels as they came through the mesh. Compartmentalisation allowed for a clear space in the pelvis (Fig. 1b). In order to prevent any slippage of small bowel, and concerns regarding the weight of the small bowel either sagging into the pelvis or tearing the mesh, we placed a 13.7 × 7.1 × 7.7-cm rectangular tissue expander (Mentor, USA) into the space created by the mesh and infiltrated 450 ml of normal saline. As the tissue expander was intended for breast reconstruction, we obtained institutional consent for the off-label use of the tissue expander. Full informed consent was also obtained from the patient prior to the surgery.

The patient commenced radiotherapy 4 weeks after surgery and completed 35 cycles of 70 Gy in total of radiation therapy. Two weeks after completion of radiation therapy, the patient was brought into the operating theatre for removal of the tissue expander. This procedure was performed under general anaesthesia. A 5-cm incision through the previous scar at the lower abdomen was created. Minimal adhesions were encountered in the pelvic space between the expander at the abdominal wall. The VICRYL mesh and small bowel were completely incorporated together and there was no residual mesh. The tissue expander was deflated and removed uneventfully (Fig. 1c).The patient did not suffer any major complications following the initial surgery to compartmentalise the abdominal and

pelvic cavities. Length of stay was 2 weeks. The patient had some ileus which resolved on post-operative day three.

CT simulation datasets before and after surgery were compared. Before the surgical procedure, small intestinal loops extended into the pelvic cavity and were abutting tumour. After the surgical procedure, a separation of at least 8 cm was achieved between the bowel loops and the tumour. (Fig. 1d). The planning target volume (PTV) of the sacral chordoma was treated to a dose of 70 Gy delivered over 35 fractions using intensity modulated radiotherapy (IMRT), whilst managing to constrain the maximum bowel dose to 35.7 Gy. Daily radiotherapy setup was assessed by cone beam CT and found to be highly reproducible.

Radiation therapy was interrupted due to a fall and fracture of her right neck of the femur. This was likely due to muscle weakness resulting from tumour which had been present prior to surgery. The patient therefore had the tissue expander within her pelvis longer than was intended to. She reported no discomfort or symptoms relating to the tissue expander. Her bowel movements were normal and there was no abdominal fullness or distension felt.

The patient had an uneventful surgery for the removal of the tissue expander. Length of stay was 1 day, and the patient was able to tolerate diet immediately post-operatively. She has since been followed up for 4 months since the second surgery, and she does not suffer from any abdominal complications related to the surgery nor does she have any features of radiation toxicity to the bowel such as abdominal pain, intestinal obstruction, or gastrointestinal bleeding.

Discussion

High-dose pelvic irradiation can result in long-term morbidity for the patient. In one series, extended AP-PA treatment of 45–50 Gy in 5 weeks to the pelvis was enough to result in severe small bowel complications in 37% of patients [7]. These complications are related both to the volume of irradiation, as well as the dose of irradiation given. One study suggested that measures should be undertaken to reduce the exposure of irradiation in terms of both volume and dose to small bowel to not more than 150 cc and 15 Gy, respectively, in order to minimise the incidence of small bowel complications [8]. In chordomas, radiation therapy is used not only as adjuvant therapy following surgical resection but also in high doses as definitive treatment [9]. These high-therapeutic doses will require novel methods in order to minimise morbidity.

Our technique of combining a surgical sling using the VICYRL bag mesh to compartmentalise the abdomen and pelvis and a tissue expander to support the sling and fill up the space within the pelvis, represents a novel technique which may be used to exclude small bowel from the pelvic cavity. The use of the VICYRL sling and tissue expander is
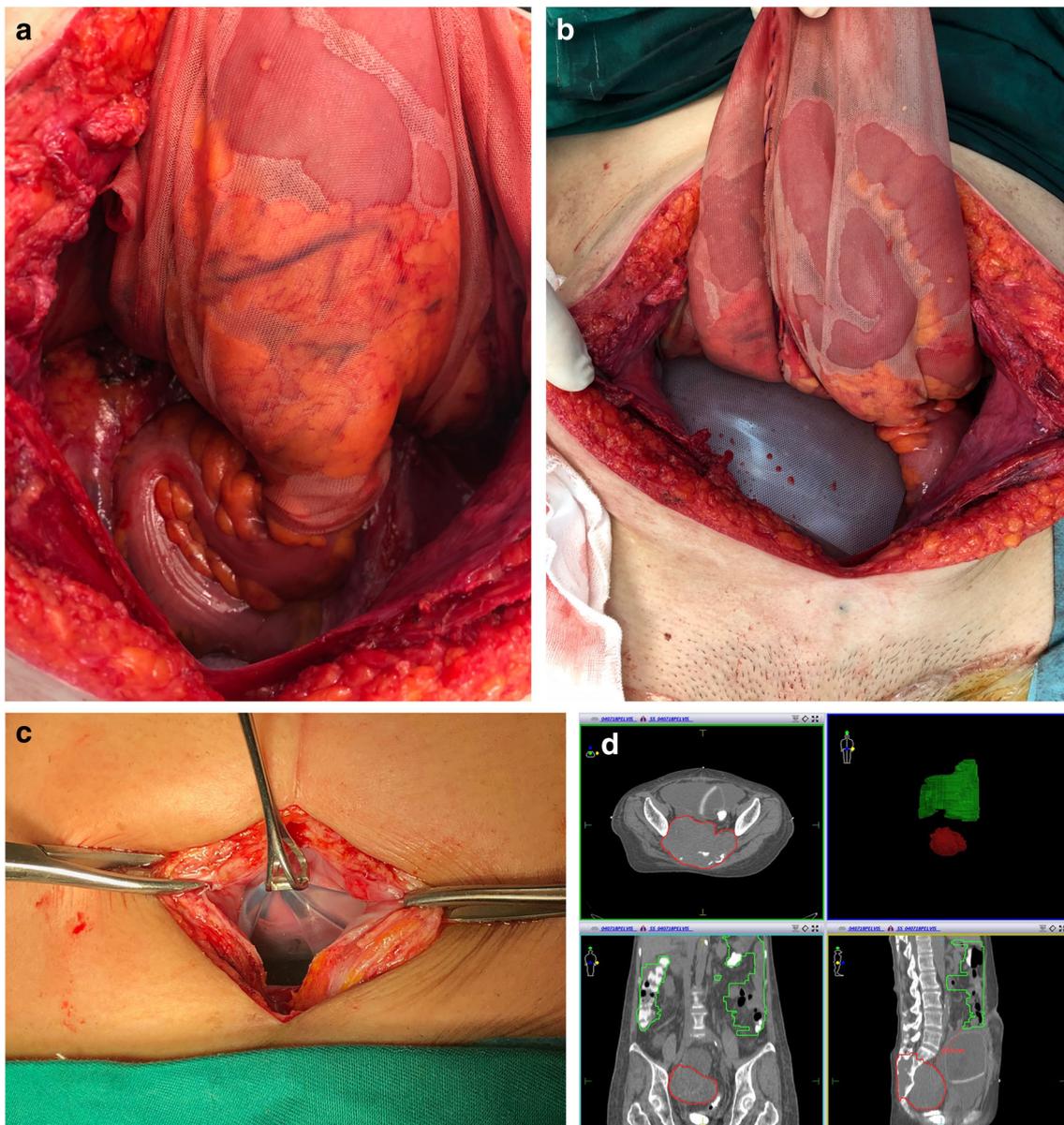
Fig. 1 a Absorbable mesh used to sling the small bowel contents. b The tissue expander is then placed into the pelvis. c No adhesions between the tissue expander and surrounding structures, allowing for easy removal. d CT simulation images after surgical procedure showing more than 8-cm separation between small bowels (green line) and tumour (red line)

complementary. This VICYRL sling ensures that the small bowel does not inadvertently slip around the tissue expander and fall into the pelvis, whilst the tissue expander prevents excessive weight on the sling which may result in it tearing when the patient is in a standing position. Our procedure is feasible and safe. The patient recovered well from both surgeries and suffered no serious complications. Minimal adhesions were encountered during the second surgery to remove the tissue expander, allowing for safe access into the pelvis. Our patient was able to complete a high-radiation dose of 70 Gy over 7 weeks without any complications thus far. A laparoscopic approach may be considered in future; however,

the profile of the tissue expander may limit the extent of the incision size.

Some authors have advocated for the use of particle therapy like protons and carbon ions over traditional photon therapy because of the favourable depth dose profile conferred by the Bragg peak of particle therapy [10]. This allows high doses of radiotherapy to be delivered to the tumour whilst sparing critical organs like the small bowels in close proximity. However, particle therapy facilities are uncommon and the costs associated are prohibitive. Our experience with this patient suggests that we can achieve the same high-radiotherapy doses to tumour whilst sparing the small bowels with a simple, well

tolerated surgical intervention without the need for costly particle therapy.

One limitation of the use of this technique is the repeated surgery required for the removal of the tissue expander. Patients may not be fit enough to undergo a second general anaesthesia, or may develop new morbidities related to cancer and therapy. The long-term feasibility of leaving the tissue expander within the pelvis has not been studied.

Nonetheless, new techniques will need to be developed in order to facilitate better radiation therapy to the pelvis and reduce associated morbidity. The use of our technique may not be confined to surgical chordomas alone. Radiation of the pelvis may be required for other sarcomas and also be required for other solid organs tumours located within the pelvis such as gynaecological or genitourinary cancers.

Conclusions

The use of an absorbable mesh and a tissue expander in the pelvis to compartmentalise the abdomen and pelvis was safe and effective in excluding the small bowel from the pelvis, allowing for high doses of radiation therapy. Further studies in a greater number of patients will need to be performed.

Author's contribution All authors are in agreement with this paper.

Dedrick Kok Hong Chan contributed to the data collection and analysis, revision of manuscript, and final approval of the manuscript.

Timothy Cheo contributed to the data interpretation, drafting and revision of manuscript, and final approval of the manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Informed consent statement Written consent was obtained from the patient for publication of this report and any accompanying images.

References

1. Chambers KJ, Lin DT, Meier J, Remenschneider A, Herr M, Gray ST (2014) Incidence and survival patterns of cranial chordoma in the United States. Laryngoscope. 124(5):1097–1102
2. McMaster ML, Goldstein AM, Bromley CM, Ishibe N, Parry DM (2001) Chordoma: incidence and survival patterns in the United States, 1973–1995. Cancer Causes Control 12(1):1–11
3. Sciubba DM, Chi JH, Rhines LD, Gokaslan ZL (2008) Chordoma of the spinal column. Neurosurg Clin N Am 19(1):5–15
4. Walcott BP, Nahed BV, Mohyeldin A, Coumans JV, Kahle KT, Ferreira MJ (2012) Chordoma: current concepts, management, and future directions. Lancet Oncol 13(2):e69–e76
5. Tobias CA, Lyman JT, Chatterjee A, Howard J, Maccabee HD, Raju MR, Smith AR, Sperinde JM, Welch GP (1971) Radiological physics characteristics of the extracted heavy ion beams of the bevatron. Science. 174(4014):1131–1134
6. Coia LR, Myerson RJ, Tepper JE (1995) Late effects of radiation therapy on the gastrointestinal tract. Int J Radiat Oncol Biol Phys 31(5):1213–1236
7. Letschert JG, Lebesque JV, de Boer RW, Hart AA, Bartelink H (1990) Dose-volume correlation in radiation-related late small-bowel complications: a clinical study. Radiother Oncol 18(4):307–320
8. Gunnlaugsson A, Kjellén E, Nilsson P, Bendahl PO, Willner J, Johnsson A (2007) Dose-volume relationships between enteritis and irradiated bowel volumes during 5-fluorouracil and oxaliplatin based chemoradiotherapy in locally advanced rectal cancer. Acta Oncol 46(7):937–944
9. Stacchiotti S, Sommer J (2015) Chordoma Global Consensus Group. Building a global consensus approach to chordoma: a position paper from the medical and patient community. Lancet Oncol 16(2):e71–e83
10. Mima M, Demizu Y, Jin D, Hashimoto N, Takagi M, Terashima K, Fujii O, Niwa Y, Akagi T, Daimon T, Hishikawa Y, Abe M, Murakami M, Sasaki R, Fuwa N (2014) Particle therapy using carbon ions or protons as a definitive therapy for patients with primary sacral chordoma. Br J Radiol 87(1033):20130512