Tech Coloproctol (2017) 21:445–450
DOI 10.1007/s10151-017-1638-4

ORIGINAL ARTICLE

Pre-emptive triple tributary internal iliac vein ligation reduces catastrophic haemorrhage from sacrectomy during pelvic exenterative surgery

D. J. Coker[1] · K. K. S. Austin[1] · A. A. Eyers[1] · C. J. Young[1]

Received: 11 December 2016 / Accepted: 13 May 2017 / Published online: 26 May 2017

Abstract
Background The risk of significant haemorrhage in pelvic exenterative surgery requiring sacrectomy has been well described. Patients requiring a sacrectomy above S3 are placed in the prone position, posing an increased challenge to gaining control of haemorrhage when it occurs. We describe a technique of pre-emptive control of the internal iliac vein and its three named tributaries to tame the pelvis prior to sacrectomy.
Methods A retrospective, descriptive analysis was performed on a cohort of 25 consecutive patients operated on by one of the authors (AA E) between January 2005 and December 2010; all of whom underwent pre-emptive internal iliac vein triple tributary venous ligation, either unilaterally or bilaterally prior to sacrectomy above the level of S3.
Results The cohort of patients was a heterogenous group ranging in age from 20 to 80 (mean 46.2) years, with primary tumours in 19 (76%), and secondary tumours in 6 (24%). Median operating time was 8.5 h (range 2.32–19.67 h). Median blood loss was 5500 mL (range 1600–18000 mL), with associated median transfusion of packed red blood cells of 9 units (range 0–34 units). Average stay in the intensive care unit was 1 day (range 0–10 days), with a median length of hospital stay of 18 days (range 5–148 days). There was no intraoperative mortality, with one death at 30 days secondary to gram-negative septicaemia. Postoperative morbidity occurred in 17 (68%) patients.
Conclusion Our results show that pre-emptive triple tributary internal iliac vein ligation is feasible for taming the pelvis prior to sacrectomy in the prone position where control of significant haemorrhage can prove challenging. The technique has broader relevance for visceral resections in the pelvis involving the pelvic side walls.

Keywords Pelvic exenteration · Sacrectomy · Haemorrhage · Internal iliac vein

Introduction

Sacrectomy as part of pelvic exenterative surgery, for locally advanced primary or recurrent pelvic malignancy, was first described in 1981 [1]. Despite a 35-year experience, the resection of tumours involving the sacrum remains a surgical challenge, associated with significant morbidity and not insignificant mortality [2, 3]. Following assessment of the patient, and staging via a positron emission tomography (PET) scan, a determination of the resectability of the tumour with magnetic resonance imaging (MRI) is performed. Where sacrectomy above the level of S3 is required, it is performed in the prone position [4]. This poses challenges in gaining control of any haemorrhage that may occur during sacrectomy once the patient has been placed prone and necessitates proactive control of potential bleeding. We describe a technique of pre-emptive dissection and ligation of the internal iliac venous plexus, and the three named venous tributaries are visceral, gluteal and presacral.

✉ C. J. Young
cyoungnsw@aol.com

[1] Department of Colorectal Surgery, Royal Prince Alfred Hospital, University of Sydney, Suite 415, 100 Carillon Ave, Newtown, NSW 2042, Australia

Materials and methods

A retrospective descriptive analysis was performed on 25 patients from January 2005 to December 2010, who underwent internal iliac vein triple tributary venous ligation, either unilaterally or bilaterally as part of a pelvic exenterative surgery and sacrectomy from January 2005 to December 2010 at the Royal Prince Alfred Hospital Sydney, Australia. Information on demographics, operative details, morbidity and mortality was collected.

Our approach to patient assessment is to perform a full clinical assessment, pelvic magnetic resonance imaging (MRI), a positron emission tomogram (PET) scan, and discuss at our multidisciplinary team (MDT) meeting. Patients with an American Society of Anesthesiologists (ASA) score greater than 3 would be deemed unfit for such radical surgery. An examination under anaesthesia (EUA) aids in determining the degree of en bloc visceral resection necessary and allows for further tissue biopsies to be performed, if necessary. MRI imaging in conjunction with EUA determines resectability, whereas PET scan assesses for incurable distant metastatic disease which would be a contraindication to surgery. Presacral fascial involvement or bony infiltration determines the level of sacral transection. Traditionally sacrectomy at S3 and below is performed in the abdomino-lithotomy position, while sacrectomy of S3 and above is performed in the prone position. Two illustrative MRI-road mapping views of patients requiring sacrectomy are shown in Figs. 1 and 2.

Perineal and sacral wound complications are not common but tend to be of higher incidence in patients who have had radiotherapy, ligation of both superior gluteal vessels, a myocutaneous flap reconstruction or a complete soft tissue exenteration with en bloc sacrectomy due to the large empty space. As a result, when possible we try to preserve the rectum, for example, in patients with sacral chordomas or use the omentum to fill the defect to reduce the incidence of postoperative fluid collections, which ultimately discharge via the path of least resistance. Additionally, these patients undergo specialised nursing care until mobile to prevent them from developing pressure sores on their wounds that can result in dehiscence.

Surgical technique

The patient is placed in a modified Lloyd-Davies position, whereupon a thorough abdominal exploration for metastatic disease is performed. After adequate exposure of the operative field is established, a lymph node dissection is performed from the aortic bifurcation down to the origin of the internal iliac vessels.

The technique of triple tributary ligation proper then begins, with the previously described mobilisation and isolation of the common and external iliac vessels to the

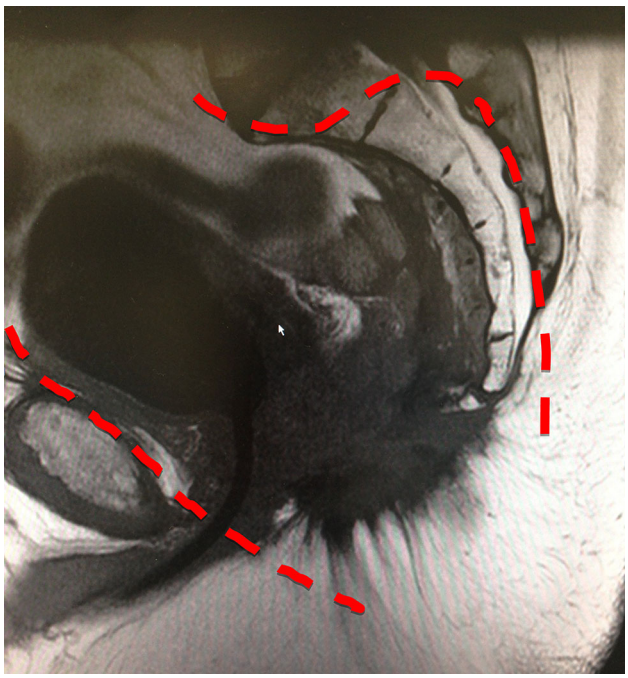

Fig. 1 Illustrates an extensive presacral recurrent rectal cancer abutting the sacrum up to Mid-S1. *The dotted lines* demonstrate the lines of transection required to achieve an R0 margin. This scenario requires bilateral triple ligation of the vessels

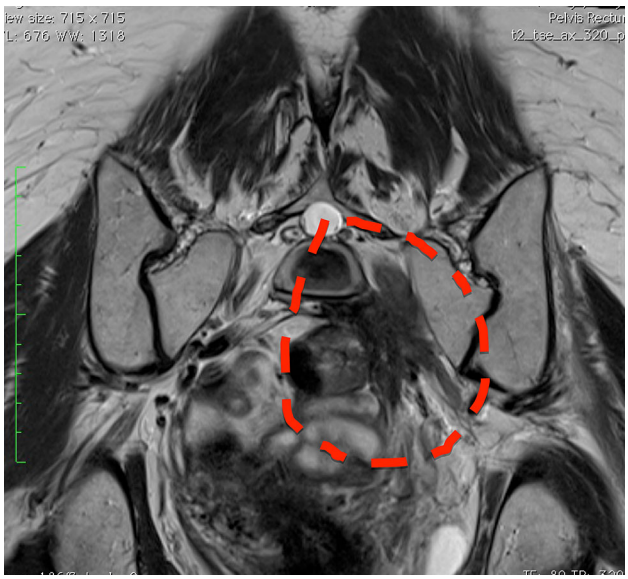

Fig. 2 Illustrates a recurrent rectal cancer mass involving the left sacroiliac joint and lower S1/S2 vertebrae with encasement of the S2 nerve root. *The dotted line* demonstrates the lines of transection to achieve an R0 margin. This scenario required only a left-sided triple ligation of the vessels as a left hemisacrectomy was performed with preservation of the right sacrum

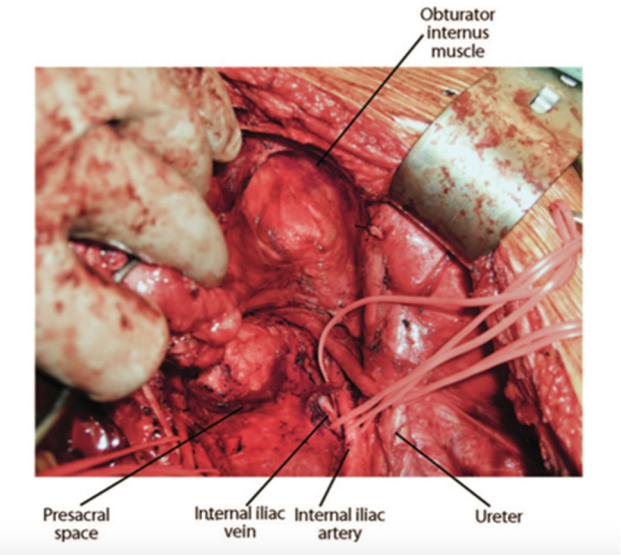

Fig. 3 Anatomical relation of the left internal iliac vein posterior to the artery and the left ureter

inguinal ligament [3]. The relationship or involvement of these vessels to the tumour is assessed, and a decision is made on whether a partial or complete vascular resection, with patch or bypass, is necessary. Vessel loops are placed at proximal and distal ends of the external iliac vessels, to enable vascular control during further dissection. As highlighted in a paper by Austin and Solomon [3], critical in the exposure of the internal iliac vein (IIV) is the identification and prior ligation of the internal iliac artery (IIA) (Fig. 3).

Once the IIV is exposed, it is ligated 0.5–1.0 cm from its junction with the external iliac vein (EIV). Dissection is then followed along the course of the IIV medially and inferiorly into the pelvis for approximately 5 cm. Three groups of veins are encountered during this step: gluteal, visceral and sacral. Large S1 and S2 foraminal veins are a feature of this dissection. Each of these groups of veins is ligated in situ (Fig. 4). With each branch ligated, the IIV collapses and can be safely divided (Fig. 5). If sacrectomy is required from the mid-body of S1–S3, it is necessary to further ligate distal branches or tributaries of the IIV to the anatomical level of transection. This may require two or three ligations of the visceral, gluteal and sacral foraminal tributaries. All vessels passing posteriorly are suture-ligated using 5/0 prolene. Additional gluteal tributaries in the plane of dissection when encountered are divided and suture-ligated. It is important to note that the most delicate part of this technique is taking the posterior and lateral veins off the posterior aspect of the IIV as they pierce the posterior muscle, enter the sacral foramina and enter the lesser sciatic foramina.

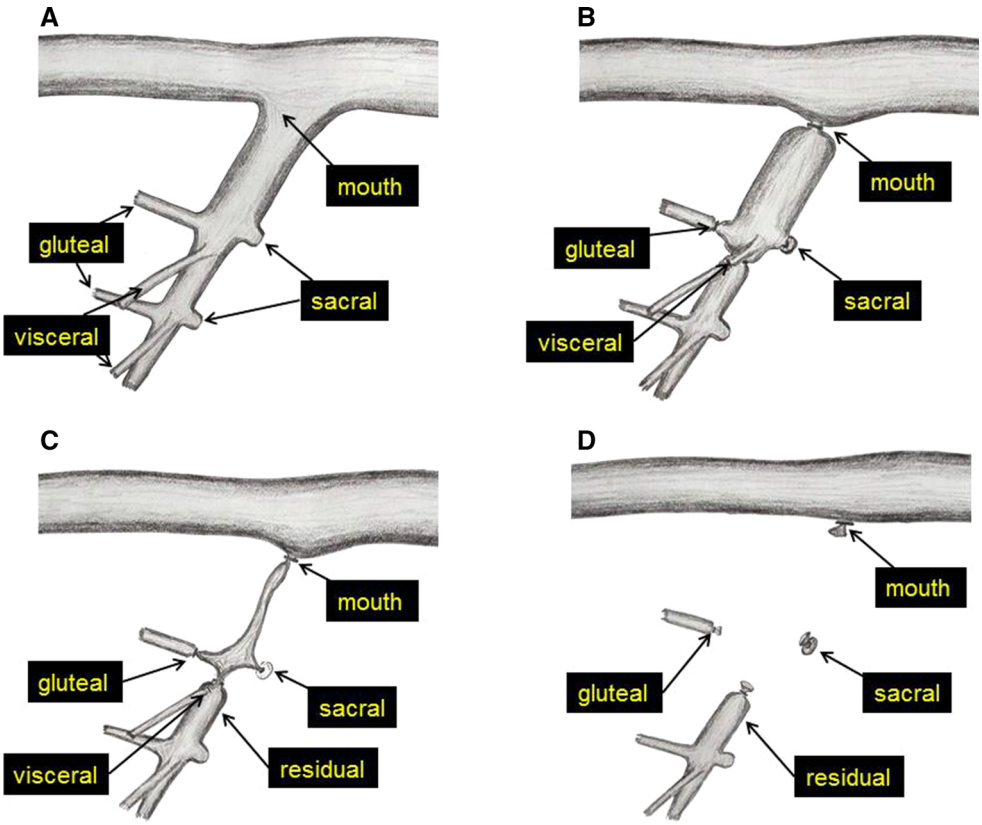

Fig. 4 Schematic illustration demonstrating the three named branches of the internal iliac venous plexus and the triple tributary ligation performed

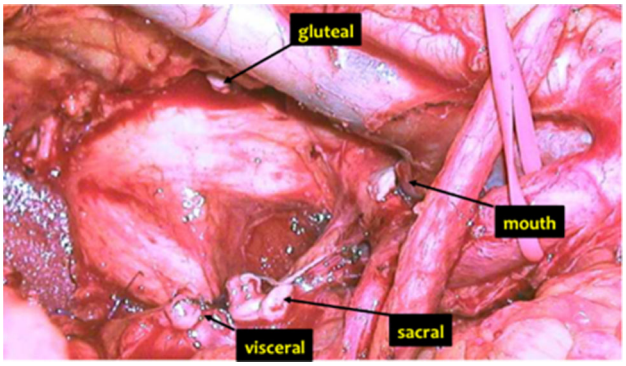

Fig. 5 Three named branches of the internal iliac vein following ligation

Table 1 Cancer Pathology in 25 patients undergoing triple tributary ligation during sacrectomy

Type of cancer	No. of patients (%)
Chordoma	7 (28)
Recurrent colorectal cancer*	5 (20)
Schwannoma	3 (12)
Chondrosarcoma	2 (8)
Giant cell tumour	2 (8)
Ewing's sarcoma	2 (8)
Squamous cell carcinoma	1 (4)
Malignant fibrous histiocytoma	1 (4)
Duplication cyst	1 (4)
Metastatic melanoma*	1 (4)

* Secondary tumours

Results

Triple tributary ligation during sacrectomy was performed in 25 patients (12 male, 13 female) by a single surgeon (AA E). The ages ranged from 20 to 80 years, with a mean age of 46.2 years. ASA grades for the cohort were: ASA 1 ($n = 9$), ASA 2 ($n = 15$) and ASA 3 ($n = 1$). The cancers resected included 19 (76%) primary tumours and 6 (24%) secondary tumours. The origins of the cancer included chordoma in 7 patients (28%) and recurrent colorectal cancer in 5 (20%). The remaining 52% of the cancers were a heterogenous group of predominantly primary cancers, with 1 case of metastatic melanoma (Table 1).

Table 2 outlines the procedural details of the sacrectomies performed. There were 13 unilateral and 12 bilateral sacrectomies. Nineteen operations were completed in a single stage, with 6 requiring two-stage procedures. Only 1 of the two-stage procedures was planned at the outset as two stages.

Table 2 Procedural details in 25 patients undergoing triple tributary ligation during sacrectomy

Procedure type	No. of patients (%)
Sacrectomy	
Unilateral	13 (52)
Bilateral	12 (48)
Staged	
Single	19 (76)
Planned two stage	1 (4)
Unplanned two stage	5 (20)

Median operating time was 8.5 h (range of 2.32–19.67 h). Median blood loss in the cohort was 5500 mL (range of 1600–18000 mL). It should be noted that estimated blood loss for 4 patients was not recorded. Median transfusion of packed red blood cells was 9 units (range of 0–34 units). The average number of days in the intensive care unit was 1 day (range 0–10 days), with a median length of stay in hospital of 18 days (range 5–148 days) (Table 3).

There was no intraoperative mortality in the cohort. There was one death at 30 days secondary to gram-negative septicaemia. Postoperative morbidity occurred in 17 (68%) patients (Table 4).

Discussion

Significant haemorrhage is a well-recognised problem in pelvic exenterative surgery requiring sacrectomy [2, 3], with increasing blood loss associated with more rostral sacrectomy [5]. It is well established that massive blood transfusion is independently associated with adverse outcomes, including death [6]. Thus, in pelvic exenterative surgery requiring sacrectomy at S3 or above, it is essential to take pre-emptive measures to minimise blood loss prior to positioning the patient prone for sacrectomy, whereupon haemorrhage control is compromised.

The connection between the internal iliac veins and the epidural venous plexus was described by Batson in the 1940s [7, 8]. Crucially in the context of haemostasis, this communication between the presacral plexus and the paravertebral plexus is valveless [9]. Experimental studies have demonstrated that blood loss from presacral veins can reach 1000 mL/min, with an increase in the vein diameter of only 1 mm leading to a threefold increase in blood loss [10]. Therefore, unlike arterial bleeding which is readily controlled in most circumstances by suture ligation or electrocauterisation, venous bleeding can be both torrential and endless [11].

Table 3 Operative and admission details in 25 patients undergoing triple tributary ligation during sacrectomy

Median operative time	8.5 h (range 2.32–19.67 h)
Median blood loss*	5500 mL (range 1600–18,000 mL)
Median blood transfusion volume	9 units of packed red blood cells (range 0–34 units)
Median blood transfusion in staged procedures	22 units of packed red blood cells (range 8–34 units)
Median number of days in ICU	1 day (range 0–10 days)
Median length of stay in hospital	18 days (range 5–148 days)

* Blood loss data were not recorded for 4 patients

Table 4 Triple tributary ligation with sacrectomy in pelvic exenteration: morbidity and mortality details

Type of morbidity and mortality	No. of patients (%)
Mortality	
Gram-negative septicaemia	1 (4)
Morbidity	
Unplanned conversion to two-stage procedure	5 (20)
Neuropathic pain	4 (16)
Faecal incontinence	3 (12)
Urinary incontinence	3 (12)
Faecal and urinary incontinence	1 (4)
Wound infection	2 (8)
Lower respiratory tract infection	
Urinary tract infection	2 (8)
Atrial fibrillation	2 (8)
Deep vein thrombosis	1 (4)

Some authors have advocated preoperative embolization as an alternative pre-emptive modality, as is seen in the emergency setting for pelvic haemorrhage related to trauma. However, its use in sacral resection during pelvic exenteration may lead to more haemorrhage with the formation of pelvic collaterals [12]. Similarly, isolated ligation of the internal iliac vein without ligation of the tributaries has been demonstrated to increase pressure in the paravertebral venous plexus in an animal model and postulated as a significant factor in major haemorrhage during sacrectomy [13]. Our technique differs in that each tributary is ligated separately to minimise significant pressure shunts within the pelvic venous plexus.

Conclusions

It is not possible to draw statistically significant conclusions from this small, heterogenous cohort of a single institution, and further investigation is required. We have, however, demonstrated the technical feasibility of triple tributary ligation. Its use has not been associated with any appreciable increase in adverse sequelae or consequences. This technique has broader relevance for visceral resections where the pelvic side wall fascia, obturator internus or piriformis muscles are also involved.

Authors' contribution David J. Coker was involved in the conception and design of the article, analysis and interpretation of data, drafting the article and revising the article critically for important intellectual content. Kirk KS. Austin was involved in the conception and design of the article, acquisition, analysis and interpretation of data, revising the article critically for important intellectual content and final approval of the version to be published. Anthony A. Eyers was involved in the conception and design of the article, acquisition of the data and revising the article critically for important intellectual content. Christopher J. Young was involved in the conception and design of the article, acquisition, analysis and interpretation of the data, revising the article critically for important intellectual content and final approval of the version to be published.

Compliance with ethical standards

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

Ethical approval All procedures reviewed were in accordance with the local ethics committee.

Informed consent Informed consent from each patient was obtained.

References

1. Wanebo HJ, Marcove RC (1981) Abdominal sacral resection of locally recurrent rectal cancer. Ann Surg 194:458–471
2. Moriya Y, Akasu T, Fujita S, Yamamoto S (2004) Total pelvic exenteration with distal sacrectomy for fixed recurrent rectal cancer in the pelvis. Dis Colon Rectum 47:2047–2052
3. Austin KK, Solomon MJ (2009) Pelvic exenteration with en bloc iliac vessel resection for lateral pelvic wall involvement. Dis Colon Rectum 52:1223–1233
4. Fourney DR, Rhines LD, Hentschel SJ et al (2005) En bloc resection of primary sacral tumors: classification of surgical approaches and outcome. J Neurosurg Spine 3:111–122
5. Clarke MJ, Dasenbrock H, Brydon A et al (2012) Posterior-only approach for en bloc sacrectomy: clinical outcomes in 36 consecutive patients. Neurosurgery 71:357–364
6. Acheson AG, Brookes MJ, Spahn DR (2012) Effects of allogenic red blood cell transfusions on clinical outcomes in patients undergoing colorectal cancer surgery: a systematic review and meta-analysis. Ann Surg 256:235–244

7. Batson OV (1940) The function of the vertebral veins and their role in the spread of metastases. Ann Surg 112:138–149
8. Batson OV (1942) The role of the vertebral veins in metastatic processes. Ann Intern Med 16:38–45
9. Heriot AG, Byrne CM, Lee P, Dobbs B, Tilney H, Solomon MJ et al (2008) Extended radical resection: the choice for locally recurrent rectal cancer. Dis Colon Rectum 51:284–291
10. Baque P, Karimdjee B, Ianelli A et al (2004) Anatomy of the presacral venous plexus: implications for rectal surgery. Surg Radiol Anat 26:355–358
11. Hill AD, Menzies-Gow N, Darzi A (1994) Methods of controlling presacral bleeding. J Am Coll Surg 178:183–184
12. Melich G, Weber M, Stein B, Minutolo V, Arena M, Arena GO (2014) Total sacrectomy for recurrent rectal cancer—a case report featuring technical details and potential pitfalls. Int J Surg Case Rep 5:403–407
13. Hata M, Kawahara N, Tomita K (1998) Influence of ligation of the internal iliac veins on the venous plexuses around the sacrum. J Orthop Sci 3:264–271