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The utility of CT angiography in planning perineal flap reconstruction following radical pelvic surgery

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ABSTRACT

Introduction: Closure of the perineum following radical excision of pelvic tumours can prove to be a complex surgical problem. A number of pedicled flaps have been used for perineal reconstruction in order to reduce post-operative complications such as infection and abscess formation. The aim of this case series was to analyse the use of pre-operative computer tomography (CT) angiography to guide flap selection for perineal reconstruction following radical excision of pelvic tumours.

Methods: We conducted a retrospective review to identify all patients who underwent CT angiography prior to radical excision of pelvic tumours and planned flap reconstruction over an 18 month period. Six patients were identified and are presented in this case series. Patients' medical records, histology reports, pre-operative investigations and CT angiograms, complications and follow-up were reviewed.

Results: The mean patient age was 58.3 years, with a male to female ratio of 1:2. Four out of six patients (66.6%) underwent pre-operative radiotherapy. The deep inferior epigastric arteries (DIEA) were visualised in all six cases (100%) and the pre-operative CT angiography helped guide flap choice in all cases (100%). In one case, narrowing of the DIEA vessels was noted precluding the use of a DIEA-based flap. One patient had a minor superficial wound dehiscence.

Conclusion: Pre-operative CT angiography allows accurate visualisation of the DIEA system including perforator vessels. CT angiography is a useful tool, providing the surgical team with significant additional information to aid pre-operative planning and optimise reconstructive choice and outcome.

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1. Introduction

Extensive surgical resections, such as pelvic exenteration or abdomino-perineal excision of the rectum (APER), are often required to treat certain carcinomas of the anal canal, rectum, bladder, vulva and vagina. Closure of the perineal wound following such radical surgery is frequently complex. Such procedures leave a large deadspace within the perineum and pelvis, and full thickness defect of the skin and subcutaneous tissue. A number of options are available to close the deadspace and skin defect, ranging from primary closure to a wide variety of flap reconstructions. However, primary closure has consistently been shown to be associated with a high rate of wound complications such as

infection and perineal wound dehiscence (25%–60%), particularly following neo-adjuvant radiotherapy.^{1–4} Common complications include prolonged and often painful wound healing, haemorrhage, infection, perineal hernia, pelvic abscess and fistula formation.

Perineal reconstruction using local flaps is being performed more frequently, and as such plastic surgeons have become core members of the colorectal, anal, urological and gynaecological multidisciplinary teams. The most commonly used flaps are the pedicled myocutaneous flaps (vertical rectus abdominis myocutaneous (VRAM) flap and the gracilis myocutaneous flap) and the fasciocutaneous flaps (gluteal fold fasciocutaneous flap). Such flaps are particularly effective in reducing perineal complications and shortening hospital stay.^{2,4–6} In addition, free tissue transfer may also be an option, although it is technically more demanding.

Of the three pedicled flaps above mentioned, the VRAM flap has been shown to result in significantly fewer major complications compared to thigh flaps.^{7,8} However, VRAM flaps are associated

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with a risk of abdominal wall bulge, weakness and hernia formation^{9,10} and may not always be the optimum choice for certain patients. Consideration must also be given to: stoma placement, the possibility of damage to the main pedicle due to previous intra-abdominal and pelvic dissection, and the position of the associated cutaneous surgical scars which could disrupt perforator blood supply to the overlying skin paddle. In cases where a VRAM is contraindicated, gracilis and gluteal fold flaps are useful alternatives. The use of pre-operative computer tomography (CT) angiography for autologous breast reconstruction is considered a routine, non-invasive investigation which provides useful information regarding the location, diameter and anatomic course of the perforator vessels in relation to the abdominal rectus muscles.¹¹ The aim of this study was to analyse the use of CT angiography as a novel strategy in the pre-operative planning of flap selection for perineal reconstruction following radical excision of anorectal and urogynaecological tumours, especially in the presence of previous radical radiotherapy.

2. Methods

A retrospective review of the electronic, password protected databases at Addenbrooke's Hospital, Cambridge (a tertiary referral centre), was conducted in order to identify all consecutive patients who were planned to undergo radical excision of pelvic tumours and flap reconstruction and who underwent pre-operative CT angiography over an 18 month period from May 2010 to November 2011. All reconstructions in this case series were conducted by the same Plastic Surgeon (AD). Patients' medical records, multidisciplinary team meetings, adjuvant therapy, pre-operative investigations including CT angiograms, choice of flap used for the reconstruction, complications and follow-up were evaluated.

3. Results

Pre-operative CT angiography has been used to guide perineal reconstruction in six patients who required radical excision of pelvic tumours in the past 18 months (Table 1). The mean patient age was 58.3 (range 27–80) years, with a male to female ratio of 1:2. Four patients had anorectal malignancy (three anal squamous cell carcinoma (SCC) and one anorectal carcinosarcoma) and two had bladder malignancy (Table 1). All patients were discussed at the multidisciplinary team meeting prior to surgery. Four patients (66.6%) had undergone pre-operative radiotherapy and one patient (16.7%) had undergone pre-operative chemotherapy. One of the patients did not have neo-adjuvant therapy and was found to be suitable for direct closure intra-operatively. Four of the six patients (66.7%) (patients 2, 3, 4, 5) had no evidence of metastatic disease on pre-operative staging. One patient found to have involvement of the inguinal nodes on pre-operative staging underwent synchronous bilateral inguinal node clearance with APER and VRAM flap

reconstruction. One patient was found to have metastatic disease and underwent surgery as palliative treatment for symptom relief. Therefore, five of the six (83.3%) patients were treated with potentially curative intent.

All six patients underwent pre-operative CT angiography in order to aid reconstruction planning pre-operatively and the deep inferior epigastric arteries (DIEA) were visualised in all six (100%) patients. In one case, narrowing of the DIEA vessels was noted (Fig. 2), precluding the use of a DIEA-based flap. Two patients (33.3%) had a VRAM flap reconstruction, two (33.3%) had a gracilis myocutaneous flap, one (16.7%) had bilateral gluteal fold fasciocutaneous flaps, and one (16.7%) was found not to require reconstruction intra-operatively.

One of the six patients had a superficial wound dehiscence affecting the distal aspect of the flap that healed with conservative measures. No other intra- or post-operative complications were noted. Three of the patients (50%) remain disease-free with a mean follow-up period of 11.7 months (range 11–13 months). One patient (16.7%) with bladder leiomyosarcoma developed inoperable liver metastases which were noted on follow-up CT scan 10 months after surgery and is currently receiving palliative treatment. The remaining two patients died; one was a planned palliative resection and died four months following surgery, and the other developed aggressive local recurrence (despite clear resection margins) and died seven months after surgery.

4. Discussion

We describe the use of pre-operative CT angiography in perineal reconstruction in patients with differing pelvic pathologies, namely anal SCC, bladder leiomyosarcoma and the exceedingly rare anorectal carcinosarcoma, of which there have only been three previous cases reported in the literature.^{12–14} All six patients in this case series required radical surgery (either APER or pelvic exenteration). Five patients underwent neo-adjuvant therapy in order to remove the tumours with adequate clear margins, resulting in large dead spaces within the pelvis and perineum. Deciding on the type of flap to reconstruct a particular defect is complex and requires extensive knowledge of individual patient factors.

When planning radical pelvic surgery, a decision must be made as to whether the defect should be closed primarily or whether flap reconstruction would offer a superior outcome. The literature suggests that primary closure is associated with a higher incidence of post-operative complications, particularly when performed after radiotherapy to the region.^{1–4} In fact, the risks of post-operative complications are 2–10 times greater in patients undergoing pre-operative radiotherapy.^{4,15,16} The use of flaps can reduce the

Table 1
Patient demographics, management and outcomes.

	Age	Gender	Histology	Pre-operative radiotherapy	CT angiogram findings	Surgery	Complications	Follow up (months = m)
Patient 1	79	Male	Anorectal carcinosarcoma	Yes	Patent DIEA	APER & VRAM flap (Fig. 1)	None	Disease-free 11 m
Patient 2	59	Male	Anal SCC	Yes	Patent DIEA	APER & gracilis flap	None	Died 7 m
Patient 3	80	Female	Anal SCC	Yes ^a	Patent DIEA	APER & bilateral gluteal fold flaps	Superficial wound dehiscence	Disease-free 13 m
Patient 4	45	Female	Anal SCC	Yes	Patent DIEA	APER & VRAM flap	None	Disease-free 11 m
Patient 5	60	Female	Bladder leiomyosarcoma	No	Patent DIEA	Total cystectomy, ileal conduit, no reconstruction	None	Liver metastases 10 m
Patient 6	27	Female	Bladder TCC	No	Obliterated L EIA, patent R DIEA	Pelvic exenteration & gracilis flap	None	Died 4 m

SCC = squamous cell carcinoma, TCC—transitional cell carcinoma, CT = computer tomography, DIEA = deep inferior epigastric artery, L = left, EIA = external iliac artery, R = right, APER = abdomino-perineal excision of the rectum, VRAM = vertical rectus abdominis myocutaneous.

^a Patient 3 had a past medical history of vulval SCC which had been treated with wide local excision and left gluteal fold V-Y advancement flap followed by radiotherapy to the perineum.

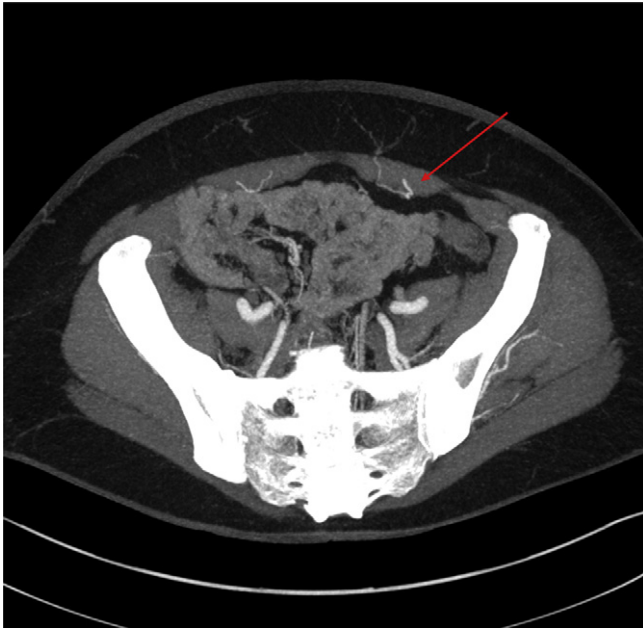


Fig. 1. CT angiography (patient 1) showing a large, patent, left-sided deep inferior epigastric artery perforator.

incidence of wound complications significantly,^{2,4–6} particularly following radiotherapy, and consideration of perineal wound closure with a flap is standard in this setting. Furthermore, the muscle in a myocutaneous flap, such as a VRAM flap, appears to increase oxygen tension and improve leukocyte delivery and function in perineal wounds.³

All six patients in this case series underwent pre-operative CT angiography to assess the DIEA vessels. There is significant variation amongst individuals in the DIEA anatomy and in particular there is variation in the position and diameter of perforators. The

aim of using pre-operative CT angiography of the DIEA system is to visualise the vascular anatomy and to assess the position and patency of the DIEA perforators and their relation to the VRAM flap skin paddle for each individual patient.^{17,18} It can thus optimise the position and the reliability of the perforator within the skin paddle. Furthermore, it allows for preservation of the anterior rectus sheath thus reducing the risk of abdominal wall bulge, weakness and hernia formation. Although doppler ultrasonography may be used peri-operatively to locate and even aid choosing the perforator(s), we suggest using CT angiography as it allows accurate visualisation of each individual perforator pre-operatively. In addition, in cases where a VRAM flap is not the first choice for reconstruction, a pre-operative CT angiogram may still prove to be a useful tool. If a problem arises whilst raising the chosen flap or the defect is larger than expected, a VRAM flap could still be raised if the CT angiogram findings are satisfactory.

The benefits of imaging the vascular anatomy by conducting pre-operative CT angiography are especially highlighted by patient 6 in this case series. The malignancy had extended anteriorly into the deep rectus muscles and also laterally on the left side narrowing the external iliac vessels with a resultant lack of perforators from the DIEA, thus precluding use of a left-sided VRAM flap, which was the initial reconstructive choice (Fig. 2). Due to the presence of a left-sided hemiparesis, the patient opted not to have her unaffected right abdomen used as a donor site as she depended greatly on her right rectus abdominis muscle for mobilisation and core stability. A gracilis myocutaneous flap was used to reconstruct her vaginal defect.

Although all six patients in this case series were considered for a VRAM flap pre-operatively only two patients actually had a VRAM flap reconstruction. Two patients, an 80 year old mobile, independent woman and a 27 year old woman with a history of a right sided cerebrovascular accident and residual left-sided hemiparesis were deemed unsuitable for a VRAM flap as their core stability following such reconstruction would have been significantly impaired. The 80 year old woman (patient 3) had lax gluteal fold tissue bilaterally which provided sufficient tissue bulk to be used as stacked flaps with the right-sided flap de-epithelialised and inset first into the pelvic deadspace. This reconstruction therefore avoided abdominal wall weakness which would have resulted from using a VRAM flap. A further patient was considered unsuitable for a VRAM pre-operatively due to his large body habitus, as abdominal closure following raising of the flap would have been extremely challenging, requiring a combination of techniques to achieve closure such as component separation with or without biological or prosthetic mesh. In this case, a right-sided gracilis flap was performed which provided enough bulk to obliterate the deadspace within the perineum and closed the skin defect. In addition, a 60 year old female who had not undergone neo-adjuvant therapy was planned to undergo a VRAM flap. However, intra-operatively the defect was closed primarily without the need for flap reconstruction. The patients discussed in this case series strongly highlight the importance of choosing the type of flap reconstruction to match patients' individual circumstances.

This is the first description of the use of pre-operative CT angiography to aid planning of perineal reconstruction. However, it has been shown to be useful in autologous breast reconstruction, where DIEA perforator flaps are used.^{19,20} A potential disadvantage of using CT angiography is the exposure of patients to ionizing radiation, which is reported as 5.3 mSv per CT abdomen in the United Kingdom.²¹ However, it must be noted that patients undergoing radical surgery for malignancy commonly undergo numerous pre-operative and follow-up CT scans and the incremental dose in radiation from CT angiography is therefore relatively small. In

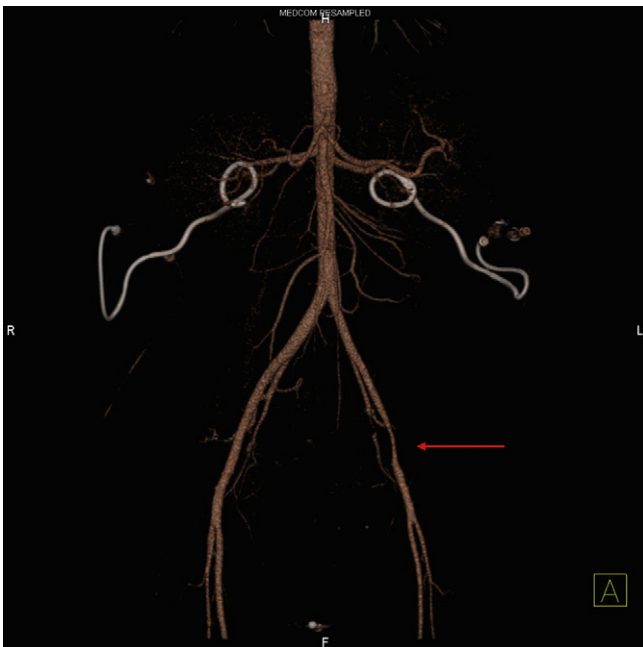


Fig. 2. CT angiography reconstruction (patient 6) showing narrowing of the left external iliac artery caused by the tumour (arrow).

addition, the appropriate images could be obtained at the time of pre-operative staging, thus reducing the need for repeated scans and excess radiation exposure. Furthermore, several studies have shown that this technique significantly reduces operative time and the rate of total and partial flap necrosis.^{17,18}

Five of the six patients in this case series were treated with potentially curative intent. This type of surgery is a very major undertaking, and the risks must always be countered against the potential benefits. Although two patients died within a year of surgery, we feel the relative lack of complications, combined with the potential for cure, makes such major resection and reconstruction a feasible treatment option in this challenging patient group.

Overall, pre-operative CT angiography appears to have a role in aiding perineal reconstruction following radical pelvic surgery. Further studies are warranted at this stage to compare surgical outcomes of perineal reconstruction with and without the use of CT angiography to image the perforating arteries.

5. Conclusion

This study has described our initial experience in the use of pre-operative CT angiography for guiding perineal reconstruction following radical excision of different pelvic malignancies. Although the VRAM flap is recommended as first-line choice for perineal reconstruction, it is essential to consider each individual's circumstances and relative contraindications to such a procedure. We believe that pre-operative CT angiography has a valuable role in peri-operative planning for perineal reconstruction.

Conflict of interest

None.

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Not applicable.

Trial registry number

Not applicable.

Author contribution

Miss A. Rosich-Medina – data collection, data analysis, writing.

Dr J. Ariyaratnam – data collection, data analysis, writing.

Dr B. Koo – data collection, editing.

Mr William Turner – data collection, editing.

Miss N Fearnhead – data collection, editing.

Mr A. Durrani – concept, study design, data collection, data analysis, revising the article.

Mr J. Davies – concept, study design, data collection, data analysis, revising the article.

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References

1. Khoo AKM, Skibber JM, Nabawi AS, Gurlek A, Youssef AA, Wang B, et al. Indications for immediate tissue transfer for soft tissue reconstruction in visceral pelvic surgery. *Surgery* 2001;**130**:463–9.
2. Buchel EW, Finical S, Johnson C. Pelvic reconstruction using vertical rectus abdominis musculocutaneous flaps. *Ann Plast Surg* 2004;**52**:22–6.
3. Chessin DB, Hartley J, Cohen AM, Mazumdar M, Cordeiro P, Disa J, et al. Rectus flap reconstruction decreases pelvic wound complications after pelvic chemoradiation: a cohort study. *Ann Surg Oncol* 2005;**12**:104–10.
4. Bullard KM, Trudel JL, Baxter NN, Rothenberger DA. Primary perineal wound closure after preoperative radiotherapy and abdominoperineal resection has a high incidence of wound failure. *Dis Colon Rectum* 2005;**48**:438–43.
5. Nisar PJ, Scott HJ. Myocutaneous flap reconstruction of the pelvis after abdominoperineal excision. *Colorectal Dis* 2009;**11**:806–16.
6. Chan S, Miller M, Ng R, Ross D, Roblin P, Carapeti E, et al. Use of myocutaneous flaps for perineal closure following abdominoperineal excision of the rectum for adenocarcinoma. *Colorectal Dis* 2010;**12**:555–60.
7. Nelson RA, Butler CE. Surgical outcomes of VRAM versus thigh flaps for immediate reconstruction of pelvic and perineal cancer resection defects. *Plast Reconstr Surg* 2009;**123**:175–83.
8. Shibata D, Hyland W, Busse P, Kim HK, Sentovich SM, Steele Jr G, et al. Immediate reconstruction of the perineal wound with gracilis muscle flaps following abdominoperineal resection and intraoperative radiation therapy for recurrent carcinoma of the rectum. *Ann Surg Oncol* 1999;**6**:33–7.
9. Tei TM, Stolzenburg T, Buntzen S, Laurberg S, Kjeldsen H. Use of transpelvic rectus abdominis musculocutaneous flap for anal cancer salvage surgery. *Br J Surg* 2003;**90**:575–80.
10. Lejour M, Dome M. Abdominal wall function after rectus abdominis transfer. *Plast Reconstr Surg* 1991;**87**:1054–68.
11. Rozen W, Phillips T, Ashton M, Stella D, Gibson R, Taylor I. Preoperative imaging for DIEA perforator flaps: a comparative study of computed tomographic angiography and doppler ultrasound. *Plast Reconstr Surg* 2008;**121**(1):9–16.
12. Takeyoshi I, Yoshida M, Ohwada S, Yamada T, Yanagisawa A, Morishita Y. Skin metastasis from the spindle cell component in rectal carcinosarcoma. *Hepato-gastroenterology* 2000;**47**:1611–4.
13. Roncaroli F, Montironi R, Feliciotti F, Losi L, Eusebi V. Sarcomatoid carcinoma of the anorectal junction with neuroendocrine and rhabdomyoblastic features. *Am J Surg Pathol* 1995;**19**:217–23.
14. Tsekouras DK, Katsaragakis S, Theodorou D, Kafiri G, Archontovasilis F, Giannopoulos P, et al. Rectal carcinosarcoma: a case report and review of literature. *World J Gastroenterol* 2006;**12**(9):1481–4.
15. Chadwick MA, Vieten D, Pettitt E, Dixon AR, Roe AM. Short course preoperative radiotherapy is the single most important risk factor for perineal wound complications after abdominoperineal excision of the rectum. *Colorectal Dis* 2006;**8**:756–61.
16. Nissan A, Guillem JG, Paty PB, Douglas Wong W, Minsky B, Saltz L, et al. Abdominoperineal resection for rectal cancer at a specialty center. *Dis Colon Rectum* 2001;**44**:27–35.
17. Phillips TJ, Stella DL, Rozen WM, Ashton M, Taylor GI. Abdominal wall CT angiography: a detailed account of a newly established preoperative imaging technique. *Radiology* 2008;**249**:32–44.
18. Masia J, Clavero JA, Larranaga JR, Alomar X, Pons G, Serret P. Multidetector-row computed tomography in the planning of abdominal perforator flaps. *J Plast Reconstr Aesthet Surg* 2006;**119**:18–27.
19. Moon HK, Taylor GI. The vascular anatomy of rectus abdominis musculocutaneous flaps based on the deep superior epigastric system. *Plast Reconstr Surg* 1988;**82**:815–32.
20. Lindsey JT. Integrating the DIEP and muscle-sparing (MS-2) free TRAM techniques optimises surgical outcomes: presentation of an algorithm for microsurgical breast reconstruction based on perforator anatomy. *Plast Reconstr Surg* 2007;**119**:18–27.
21. Shrimpton PC, Miller HC, Lewis MA, Dunn M. *Doses from computed tomography (CT) examinations in the UK*. Review. National Radiological Protection Board (NRPB); 2003.