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INVITED REVIEW

PSMA-PET guided hook-wire localization of nodal metastases in prostate cancer: a targeted approach

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Abstract

Prostate Specific Membrane Antigen Positron Emission Tomography/Computed Tomography (PSMA-PET/CT) has increased the sensitivity and specificity of imaging to identify metastatic prostate cancer in the group of patients with early biochemical recurrence when compared to conventional imaging. In patients who develop biochemical recurrence of prostate cancer following surgical resection, salvage lymph node dissection may reduce prostate specific antigen (PSA) levels and delay the time for commencement of systemic therapies. However, PLND may be an anatomically and technically difficult procedure, particularly with small metastatic diseases which can be problematic for intra-operative identification. We describe the technique using PSMA-PET imaging to pre-operatively localise areas of low-volume nodal metastatic disease with hookwire to allow targeted lymph node dissection with direct visualisation and palpation to ensure adequate clearance of involved nodes.

Keywords Image guided surgery · Hookwire · Prostate cancer · Pelvic lymph node dissection · PET-PSMA scan · Lymph node metastasis

Abbreviation

BCR	Biochemical recurrence
CT	Computed tomography
LND	Lymph node dissection
PET	Positron emission tomography
PSA	Prostate specific antigen
PSMA	Prostate specific membrane antigen

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Introduction

Intra-operative localisation of target pathology for surgical resection has proven itself to be particularly difficult in certain tissue types. Pre-operative identification of target sites with hook-wires and the adoption of intra-operative radioguidance have been a mainstay of sentinel lymph node dissection and breast cancer surgery for some time. There are several single case reports of hook-wire localisation being utilised in the surgical resection of soft tissues such as musculoskeletal, pulmonary and upper abdominal cases. Hookwire localisation of pelvic structures has so far been sparsely described with a significant paucity of material in published scientific literature.

Despite improvements in diagnosis and management of prostate cancer, a significant proportion of men go on to develop biochemical recurrence (BCR) after definitive treatments [1]. The uptake of salvage lymph node dissection (LND) in this patient population has been shown to help reduce prostate specific antigen (PSA) levels and delay the requirement for commencement of systemic therapies [2]. The use of Prostate Specific Membrane Antigen

Positron Emission Tomography/Computed Tomography (PSMA-PET/CT) has been shown to increase sensitivity and specificity in the findings of metastatic prostate cancer in this group when compared to conventional imaging [3, 4]. Although PSMA radio-guided surgery has displayed a benefit in resecting metastatic deposits [5, 6], these avid sites have never been targeted pre-operatively to aid localisation at the time of surgery.

LNDs can be anatomically and technically difficult procedures. They have the potential for significant morbidity as a result of intra-operative complications including ureteral injury, major vascular and obturator nerve injury as well as post-operative complications such as lymphocoele, lymphoedema, ileus, deep vein thrombosis and pulmonary embolism. Complication rates have been quoted between 0.1 and 10.6% [7–15]. However, these studies date back to several decades and include data from both open and laparoscopic procedures. It is generally agreed that today the complication rates associated with pelvic LND are small. Despite this, some have questioned the clinical benefit of such procedures as they are not without risk and also confer significant cost to the patient and the healthcare system. The incidence of node positivity is declining and, therefore, the number of lymphadenectomies required to benefit one patient is increasing. The number needed to treat (NNT) for pelvic LND to prevent 1 clinical event has been estimated to be 667 [16]. However, this drops to 67 in men with a 10% chance of lymph node positivity. In a selected group of node-positive patients, like those with BCR and PSMA-PET/CT avid nodes, salvage pelvic LND can be a curative option. The rate of complications, in particular lymphocoele occurrence, has been directly related to the extent of dissection [7, 8, 12, 17, 18]. Therefore, the ability to pre-operatively localise and target these avid nodes with hook-wire will help to guide the surgeons to occult pathology and allow for more limited dissections, reduce the operative time and minimise the risk of complications.

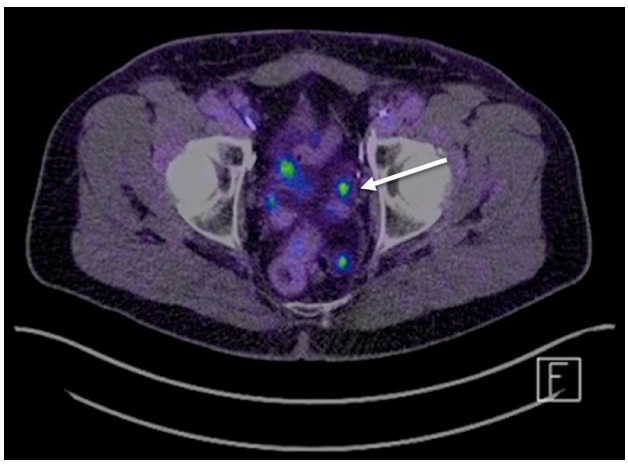

Fig. 1 PSMA-PET/CT identifying nodal metastasis (white arrow) in a patient with biochemical recurrence of prostate cancer following prostatectomy

Technique

PSMA-PET/CT scanning is performed to identify sites of PSMA-PET avidity (Fig. 1). This may be performed either as part of initial staging following diagnosis of high-risk prostate cancer or as re-staging imaging following BCR. On the day of surgery, the patient undergoes CT scan which can be correlated to the previous PSMA-PET to identify the areas of PSMA-PET avidity. Kopans hook-wire needles (COOK Medical) are inserted via a transgluteal approach under CT guidance (Fig. 2). This may be successfully achieved with local anesthetic. The target lymphatic tissue is transfixed with the tip of the needle and the position is confirmed on CT scanning and fused with PSMA-PET images.

Intra-operatively, the target tissues are easily localised by direct visualisation and palpation of each Kopans needle and removed (Fig. 3). After the target sites have been resected, the operator may then continue with the pelvic and

Fig. 2 CT guided insertion of Kopans hook-wire (COOK Medical) into target nodal metastasis pre-operatively

Fig. 3 Resected nodal metastasis pre-operatively identified with hookwire localization

low-retroperitoneal dissection of lymph node tissue for completion of the extended lymph node dissection.

Example case

We herein describe a case of a male patient who underwent pre-operative hook-wire localisation of PSMA-PET/CT positive target lymph node tissue with subsequent successful identification and resection.

A 59-year-old male underwent robot-assisted laparoscopic radical prostatectomy with lymph node dissection for Gleason 4 + 5=9 disease. His initial specimen revealed multiple foci of extra-prostatic extension at the apex, posteriorly and to the left side of the gland. There was no seminal vesicle involvement and surgical margins were negative. None of the resected lymph nodes were positive for the presence of cancer. Given the aggressive nature of the primary pathology, the patient went on to have radiotherapy.

The patient developed BCR at 3 months with a PSA level of 0.43 µg/L. This was monitored throughout the period of radiotherapy and remained stable. Serial review of the patient continued to display increasing elevations in his PSA. At 4 years post-operative, with a PSA of 2.4 µg/L, a PSMA-PET/CT was performed. This revealed a 5 mm avid node on the left lower lateral pelvic wall and an additional site of increased uptake to the left of the mid-rectum (Fig. 1). No further sites of PSMA avidity were noted. The decision was made to proceed with salvage pelvic LND. Hook-wire localisation of target nodal tissue was performed as described above, followed by open lymph node dissection of hook-wire localised tissue and completion of the extended template.

Histopathological analysis of the resected specimens yielded 34 lymph nodes. Of the two areas of target lymph node tissue, one displayed metastatic prostatic adenocarcinoma involving a 7 mm node without the evidence of extra-nodal extension and Gleason pattern 4 + 4=8; the other revealed a 5-mm centrally necrotic lymph node with a fibrous rim of tissue, but no identifiable features of viable malignancy. The patient had an uncomplicated postoperative course and was discharged on day 4 post-operatively.

Discussion

Advances in radiology supply clinicians with a great range of options in the identification of pathology. Nuclear medicine now allows for targeted imaging and can unmask diseases that may have otherwise remained occult. The recent advent and swift uptake of PSMA-PET/CT is a prime example of this phenomenon. However, findings on imaging are not always appreciable in the anatomy as seen in the operating theatre [6]. Surgeons must be able to increase the precision and accuracy of dissection to mirror the benefits afforded to us by diagnostic imaging.

Pre-operative localisation of target pathology with hook-wire has long been utilised in breast surgery [19] and more recently in the field of thoracic surgery for the resection of pulmonary nodules. This helpful adjunct guides the operating surgeon in an effort to marry radiology to the surgical field at times of anatomical ambiguity. This is especially important in technically demanding situations such as sites of previous operations, non-palpable lesions or areas previously treated with radiation therapy.

In the setting of salvage LND for recurrent prostate cancer, PSMA-PET/CT can be used to localise the disease and plan surgical dissection [20]. The use of pre-operative hook-wire localisation of sites of interest is a novel concept and can be helpful in overcoming issues encountered with salvage LND such as identification of lymph nodes in irradiated or fibrotic tissues and avoidance of injury to vital structures. Other techniques to overcome this difficulty are being developed, including PSMA-radioguided surgery represent promising options, however, these alternatives are not yet widely available [6].

Our discussion of technique and the reported case of PSMA-PET/CT guided hook-wire localisation represents the first of its kind in the literature. This approach depicts a novel concept in the resection of prostate cancer nodal metastasis. Having previously undergone radical prostatectomy with nodal dissection and pelvic radiotherapy, the patient in our reported case had a number of factors that would contribute to a difficult salvage LND. Further to this, localisation of the site of pathology as identified on PSMA-PET/CT would have added an extra level of difficulty to lymph node resection. The use of externally applied hook-wire localisation has displayed an ease of use in our case and improved the operating surgeon's ability to identify target nodal tissue in a difficult operating field. This translates to a reduction in the need for tissue disruption, thereby lowering the risk of complications associated with more extensive dissection. This calculated approach allows the surgeon to minimise unnecessary dissection of tissues in proximity to vital structures and, therefore, possible damage to these structures.

In appropriate patients, pre-operative hook-wire localisation has definite potential advantages to patients not only in terms of improved oncological outcomes from complete resection of pathology, but also by helping to avoid complications associated with pelvic LND.

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Compliance with ethical standards

Conflict of interest All of the authors declare that they have no conflict of interest.

Informed consent The individual re-identifiable data included in this article were included with the informed consent of the patient.

Human and animal rights This article does not contain any experimental studies with human participants or animals performed by any of the authors.

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