Interventional oncology

Interventional oncology is the practice of image-guided treatments for cancer care. This review summarizes the diverse range of techniques and specialty teams involved with a focus on the role of interventional radiology.

What is interventional oncology and who practices it?

Cancer services are changing with a growing number of specialties providing cancer treatments in response to a growing population living with cancer. Image-guided cancer treatment is one of these emerging options available to patients.

Numerous specialty doctors are involved in imaging and image-guided cancer treatment including: interventional radiologists, anaesthetists who practice image-guided injections for pain relief and insert vascular lines, oncologists who use imaging to guide radiotherapy and surgeons who use intraoperative imaging to guide cancer resection.

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Interventional radiologists use different imaging modalities to help manipulate needles, catheters and wires into organs, via direct percutaneous puncture or through blood vessels. A subset of interventional radiologists has a specialist interest in cancer treatment and practices minimally invasive techniques to complement the work of cancer surgeons and oncologists. They are involved more directly in patient care than some other radiologists and, in some centres, run multidisciplinary clinics alongside cancer surgeons, organ-specialty doctors and oncologists.

As such, the term ‘interventional oncologist’ is a misnomer. Within each hospital that provides image-guided cancer treatment, there will be a different make up of the interventional oncology team. No single specialty – medicine, surgery, anaesthetics or radiology – provides a defined pathway to train in interventional oncology and clinicians who provide these types of treatment come from a wide range of clinical backgrounds with a special group of postgraduate-acquired skills.

In the UK, doctors typically apply to a radiology training scheme after foundation training or following core medical or surgical training. Three years of core radiological training is then completed in preparation for the Fellowship of the Royal College of Radiologists exam. During a 2- or 3-year subspecialty fellowship in interventional radiology interventional skills are developed and training tailored towards oncological intervention depending on the institution.

The anaesthetics specialist training pathway is geared towards the Fellowship of the Royal College of Anaesthesia. Training in pain management may be undertaken, including image-directed nerve blocks.

Although a research degree is not a prerequisite, interventional oncology remains a cutting-edge discipline heavily reliant on research and evaluation of new technologies, meaning that a research background in a relevant field would likely be considered favourably.

How did interventional oncology develop?

Following Sven Ivan Seldinger’s (Seldinger, 1953) description of a safe technique for vascular access, increasingly complex endovascular procedures were pioneered, most notably by Charles Dotter who is considered the ‘godfather’ of interventional radiology. The use of vascular embolization techniques to deliver local tumour chemotherapy came in the 1970s and since then advances have brought about tumour embolization, chemotherapy-eluting particles and internal radiotherapy.

By the 1990s, minimally invasive thermal tumour ablation using radiofrequency current was gaining widespread acceptance. This technique was developed from the Bovie knife (a surgical tool invented in the early 20th century to cut or cauterize tissue), modified by two independent investigators (McGahan and Rossi) for percutaneous application to achieve deep tissue coagulation necrosis. In the early 1990s, McGahan et al (1990) showed that ultrasound could be used to guide radiofrequency needle electrode placement and monitor tissue changes during ablation. Since then, a number of new minimally invasive techniques for tissue ablation have been developed, including microwave and cryoablation (Chu and Dupuy, 2014).

As many interventional oncology therapies are new, their best use is often uncertain. Therefore, continuing development of such procedures is often required, as is diligently performed research to produce guidelines which define their safety, efficacy and effects on patient outcomes.

What does interventional oncology involve?

The practical aspect of interventional oncology combines fluency with diagnostic imaging modalities with manual dexterity required for interventional procedures. A typical case involves careful planning before the procedure, often using cross-sectional imaging to localize the target and approach. Competency is therefore developed in ultrasound, computed tomography, magnetic resonance imaging and, increasingly, positron emission tomography.

Image-guided needle placement or wire and catheter manipulation under fluoroscopic imaging necessitates manual dexterity to target tumours. Post-procedural follow up and management is required to assess the effectiveness of the treatment and judge whether complications have arisen. Follow-up imaging ranges from simple radiographs, e.g. a plain chest X-ray to look for a pneumothorax, to the complex, e.g. positron emission tomography-magnetic resonance imaging to assess for residual disease.

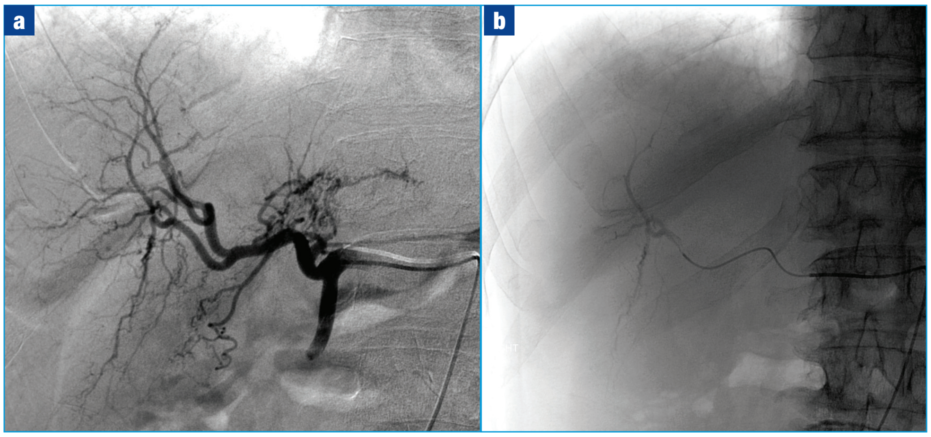
How will my patient benefit from an interventional oncology procedure?

Interventional oncology procedures are often used as an adjunct to invasive surgery or systemic chemotherapy. Interventional oncology can obviate the need for general anaesthesia, reduce or eliminate systemic side effects, prevent pain and allow shorter post-procedure recovery. Tumours may also be treated in locations where surgery is not feasible (e.g. a hostile environment following previous surgery, when tumours are in an unfavourable site or if the patient is a poor surgical candidate).

What can patients undergoing interventional oncology procedures expect?

Many interventional oncology interventions are performed under local anaesthetic and can be performed as a day case or short inpatient admission. Patients will often have intravenous fluids and receive premedication. The patient will be monitored during the procedure and will have to lie still, sometimes for an hour or more. Pain is generally much less than in surgery and there is minimal to no scarring. A 'flu-like' illness following procedure (post embolization or ablation syndrome) is a common experience which is self-limiting, unrelated to infection and passes within a few days (Leung et al, 2001). Careful follow up with imaging is often required following treatment.

Figure 1. **a.** Catheter within the coeliac trunk. **b.** Selective microcatheterisation of the hepatic artery branch feeding a tumour before embolization with chemotherapy beads (DEB-TACE).



What treatment options does interventional oncology offer?

The most common treatment strategies in interventional oncology are embolization and percutaneous ablation procedures, which are outlined below.

Embolization

Neovascularity is a hallmark of cancer. Tumour vessels can be accessed with a wire and catheter inserted into the femoral artery which is manipulated under fluoroscopic guidance. The targeted tissue can be treated using embolic materials alone, or in combination with loco-regional chemotherapy or brachytherapy. These minimally invasive techniques are generally intended to prolong survival rather than offering a cure. However, they can reduce or avoid the systemic effects associated with conventional external beam radiotherapy and systemic chemotherapy and are therefore useful in the palliative setting.

Bland embolization

Bland embolization has multiple aims including the reduction of perioperative blood loss in hypervascular tumour resection, reduction of tumour burden, controlling pain and limitation of 'heat sink' effects before ablation (see later).

Chemoembolization

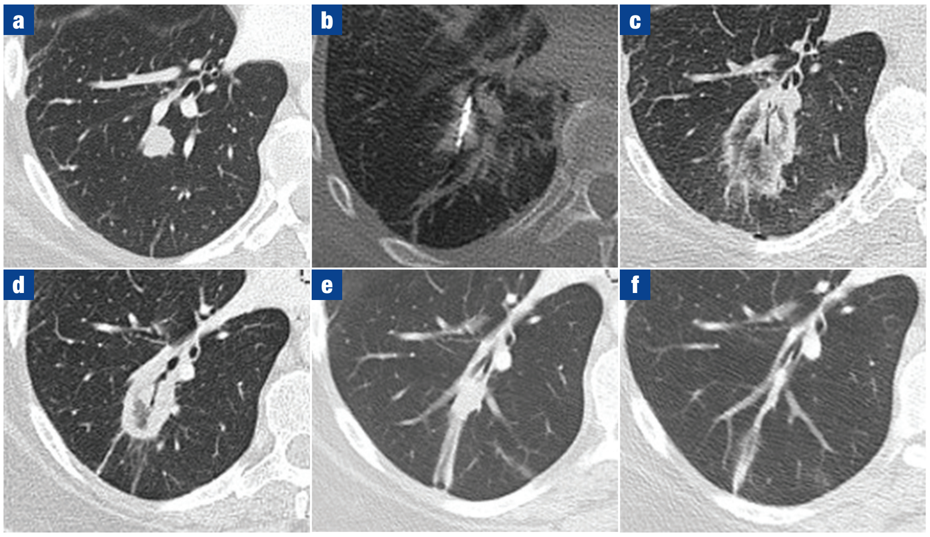
Liver tumours characteristically gain their blood supply preferentially from the hepatic arteries. In transarterial chemoembolization, chemotherapy emulsion is injected into the tumour vasculature via the hepatic arteries followed by injection of embolic material. This creates a pocket of ischaemic liver tumour bathed in chemotherapy, which prevents drug wash out, reduces systemic absorption and induces hypoxia to potentiate drug uptake in tumour cells. Healthy liver tissues, which tend to derive blood supply from the portal venous system, are affected to a lesser extent and therefore survive.

A number of chemotherapeutic agents may be used including doxirubicin, irinotecan and mitomycin. Transarterial chemoembolization has shown promising results in treatment of primary and metastatic liver deposits and more recently metastatic lung cancer (Takayasu et al, 2006; Vogl et al, 2009; Liapi and Geschwind, 2011). Delivery of chemotherapeutics with drug-eluting beads is a recent development, which involves injecting the liver tumour with thousands of tiny beads (in the order of microns) impregnated with a chemotherapeutic agent (*Figure 1*). This allows slow drug release with more predictable dosing and fewer systemic effects (Martin et al, 2011).

Radioembolization

Radioembolization, also known as selective internal radiation therapy, also involves the selective catheterization of hepatic arteries, which are injected with millions of micron-sized glass or resin microspheres loaded with the radioisotope yttrium-90. This creates a localized internal radiotherapy field of high dose pure β radiation in the order of 150 Gy (by comparison external beam radiotherapy is around 30 Gy). While radioembolization is an effective treatment in its own right, further trials are required to determine best use as it is more expensive than chemoembolization and requires more expertise from the

Figure 2. Computed tomography images show **(a)** right lower lobe metastasis (sarcoma) pre-ablation; **(b)** during ablation with microwave ablation antenna in situ; **(c)** 1 day post ablation with visible needle tract through lesion; and **(d)** 1 month, **(e)** 4 months and **(f)** 8 months post ablation, when only a fibrotic band remains.



multidisciplinary team with complex nuclear medicine investigations (Kennedy et al, 2007; Salem et al, 2010).

Percutaneous local therapies: tumour ablation

Tumour ablation is the percutaneous placement of probes in and around a tumour, in order to deposit lethal energy. Different forms of ablative energy may be used depending on the tumour biology and lesion position, and a range of tumour types may be treated including lung, liver and renal (Chu and Dupuy, 2014). Ablative treatment is generally performed on fewer lesions than arterial therapies and in the case of limited local disease can potentially offer cure. In order to achieve successful treatment, the ablation zone must encompass the entire tumour and a rim of surrounding healthy tissue. Percutaneous ablation broadly leads to reduced physiological stress compared with open surgery and can be an option for those patients deemed medically unsuitable for surgery.

Radiofrequency ablation

Radiofrequency ablation is the longest established ablative technique. This works by emitting alternating current, which causes local ionic agitation, heat dissipation to the surrounding tissues leading to temperatures of 60°C and cell death by coagulation necrosis. However, blood flowing in nearby vessels produces a heat sink effect, which conducts heat away from the target, thereby reducing procedural efficacy. Radiofrequency ablation is used predominantly in primary and secondary liver cancer, and thoracic tumours (Huang et al, 2011), and is equally effective as surgical resection in small (less than 3 cm) hepatocellular carcinomas (Lau and Lai, 2009).

Microwave ablation

Microwave energy is of higher frequency (0.9–2.5 GHz) than radiofrequency waves and creates an oscillating electromagnetic field that rapidly realigns water molecules causing direct frictional heating. This creates faster thermal tissue destruction over a larger volume, minimizes heat sink and confers more predictable energy dosimetry than radiofrequency ablation (Martin et al, 2011) (*Figure 2*).

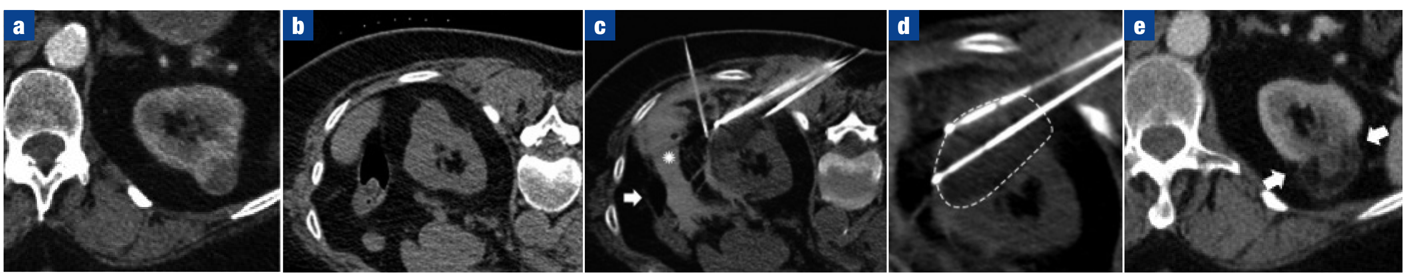
Cryotherapy

Cryoablation uses the supercooling effect of rapidly expanding argon gas to freeze target tissue into an iceball that is clearly visible on imaging – a key advantage of cryotherapy over radiofrequency and microwave ablation. Below -40°C extracellular water freezes leading to tissue destruction by osmotic effects and microvascular thrombosis. Cycling between freezing and thawing creates a well-defined ablation zone, which with multiple cryoprobe placements can be shaped to encompass the target lesion (*Figure 3*). Cryotherapy is of particularly value in the treatment of renal tumours (Breen and Railton, 2010) where vascular coagulation reduces the risk of significant haemorrhage.

Where is interventional oncology going in the future?

No individual specialty providing interventional oncology services – surgery, medicine, anaesthetics or radiology – owns

Figure 3. A 69-year-old woman with left-sided clear cell renal cell carcinoma. **a.** Initial computed tomography scan with intravenous contrast, arterial phase, demonstrating a 30 mm tumour arising from the posterior of the left kidney. **b.** Pre-procedure unenhanced planning computed tomography – note the skin markers (white arrow). **c.** Peri-procedure scan showing two Icerods (Galil Medical, Arden Hills, Minneapolis, USA) within the tumour (right side), and hydrodissection needle (vertical needle) with approximately 30 ml of dilute Omnipaque 300/0.9% saline mixture (white asterisk) separating the iceball from the neighbouring bowel (solid arrow). **d.** Zoomed in view demonstrating the Icerods and surrounding elliptical iceball (dashed line). **e.** 2-year follow-up scan with a non-enhancing central nodule, peripheral halo of scar tissue and fat encroachment (solid arrows) – the typical appearances of a successfully ablated tumour.



interventional oncology. Each provides a different skill set that complements the other specialties. For instance traditionally interventional radiologists did not have clinical responsibilities but as interventional procedures in cancer provide new challenges in patient management, many radiologists are beginning to carry out clinics and admit patients directly for their treatments, and this trend is likely to increase.

While clinical radiology and clinical (radiation) oncology separated decades ago, they still share the same Royal College affiliation. As interventional oncology develops recognition it is becoming similar again to clinical oncology in terms of its goals which include clinical involvement and image-directed therapy. In the USA, many physicians who perform interventional oncology are now dual accredited in both radiation oncology and clinical radiology, which may signify the future for interventional oncology in the UK. The British Society of Interventional Radiology has an interventional oncology specialist interest group, which held its inaugural meeting in June 2015 with the aim of promoting interventional oncology in the UK. **BJHM**

FURTHER READING

- British Society of Interventional Radiology: http://bsir.org
- Society of Interventional Radiology: www.sirweb.org
- European Conference on Interventional Oncology: www.ecio.org

Conflict of interest: none.

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KEY POINTS

- Interventional oncology is a new and rapidly developing field which applies image-guided intervention to cancer care.
- Interventional oncology teams are multidisciplinary, comprising interventional radiologists, anaesthetists, oncologists and surgeons.
- Techniques may be used to support patients undergoing cancer treatment and treat tumours themselves.
- Strategies are broadly categorized into vascular and non-vascular.
- Future challenges include gaining a solid evidence base for use of new therapies and establishing a clear role for interventional oncology techniques alongside existing treatments.