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Paediatric interventional oncology

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Abstract

As is often the case with developments in interventional radiology (IR), widespread adoption of the newer techniques of interventional oncology has taken longer in paediatric than in adult practice. The three main applications of IR techniques in children with cancer are biopsy, regional therapy and supportive care (including the treatment of complications), and these are considered separately.

Keywords: *Paediatric; interventional radiology.*

Introduction

As is often the case with developments in interventional radiology (IR), widespread adoption of the newer techniques of interventional oncology has taken longer in paediatric than in adult practice. The three main applications of IR techniques in children with cancer are biopsy[1–3], regional therapy[1,3] and supportive care (including the treatment of complications), and these are considered separately.

Biopsy

Overall accuracy

The methods of biopsy used to diagnose paediatric cancer vary widely in different countries and even between hospitals in the same country. A good case can be made that biopsies of almost all suspected tumours arising outside the central nervous system (CNS) are best taken using an image-guided needle technique[2], although there are important exceptions.

The tendency in the literature is to review all types of tumours together, and when this is done the diagnostic accuracy of needle biopsy is greater than 90%[2,4]. However, this is a somewhat unsophisticated approach. It makes more sense to look at each clinical presentation separately where possible. For an instructive example, consider a child who presents between the ages of 6 months and 10 years with a unilateral renal tumour, in the absence of any underlying condition (such as Beckwith–Wiedemann syndrome or tuberous sclerosis complex) which might suggest a specific diagnosis. About 90% of patients with this presentation have nephroblastoma (Wilms tumour). One approach here is to resect the tumour immediately, which provides a histological diagnosis, some staging information and is a first step in treatment. The alternative approach, favoured in most of Europe, is to start preoperative chemotherapy without a biopsy, and perform delayed surgery. A third approach involves initial needle biopsy, followed by preoperative chemotherapy, which in this system may be modified according to the result of the biopsy. The accuracy of the biopsy will probably need to be significantly better than 90% to justify this strategy. Although a review of biopsies performed in one clinical trial suggests that this may be possible[5], it is not known whether this level of accuracy can be maintained in regular practice.

Needle biopsy technique

Unlike in adults, biopsies of nearly all masses in children are best taken using ultrasound guidance (Fig. 1). In our centre, less than 5% of biopsies require the use of computed tomography (CT), or more recently cone beam CT in an angiography suite (Fig. 2). Where possible, we use a

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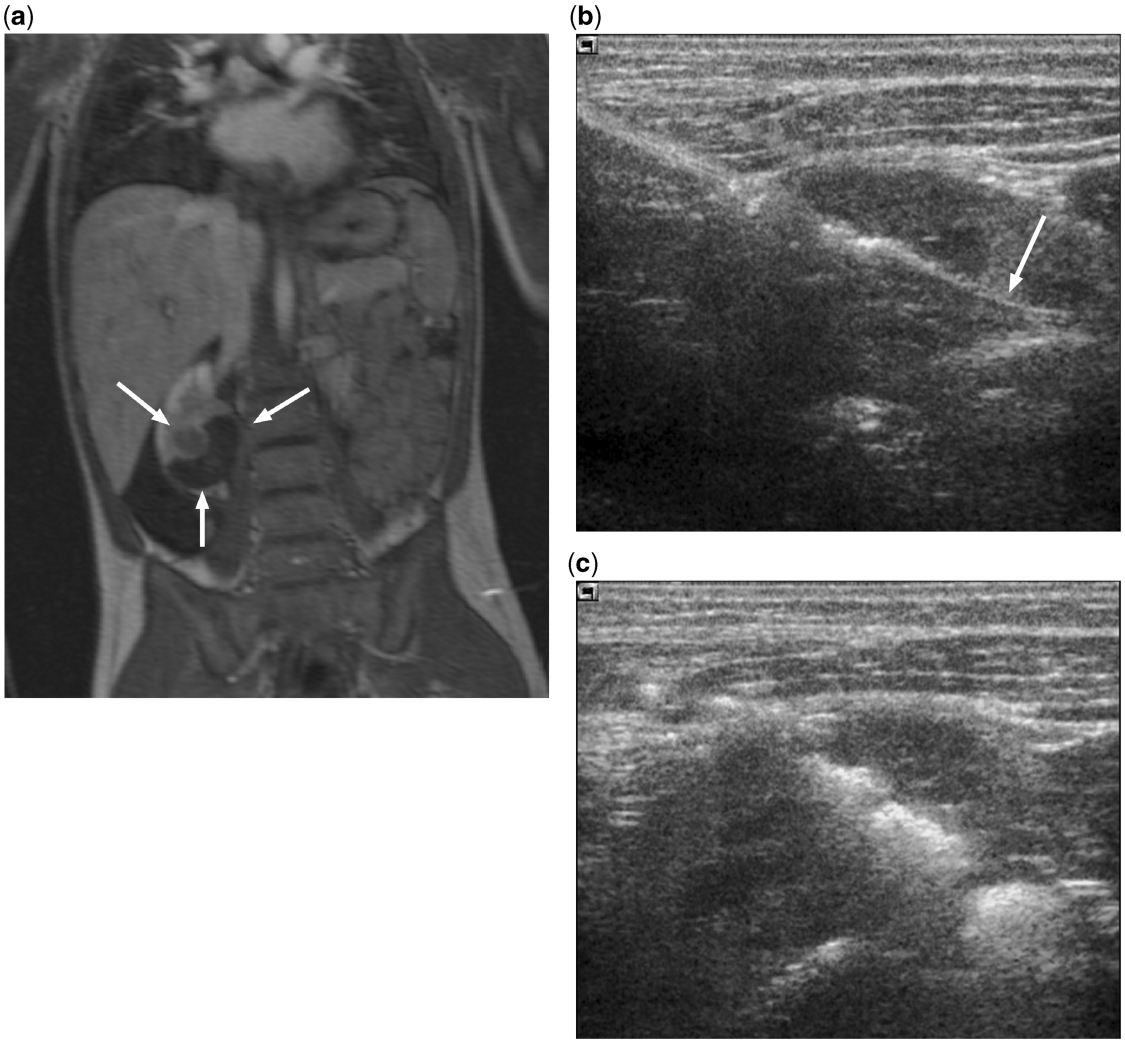

Figure 1 **Ultrasound-guided percutaneous biopsy in a 4-year-old girl with rhabdoid tumour of the kidney. (a) Contrast-enhanced T1-weighted MR image shows a solid tumour nodule at the periphery of a fluid-filled space in the right kidney (arrows). (b) Transverse ultrasound image shows a 15/16-gauge coaxial biopsy needle (arrow) being advanced to the periphery of the nodule. Old blood was aspirated from the fluid-filled space. Eleven cores of tissue were obtained. (c) The biopsy tract was plugged with absorbable gelatin sponge (Gelfoam, Pharmacia & Upjohn, Kalamazoo, MI, USA) as the outer needle was withdrawn.**

coaxial technique, in which the biopsy tract is occluded using gelatin foam plugs (Fig. 1). This may reduce the risk of haemorrhage and tumour seeding, although this has not been proved[1].

Most paediatric pathologists prefer to be given several large cores of tissue (18- to 14-gauge), as this allows a full range of immunohistochemical and genetic tests to be performed. Fine-needle aspiration cytology is only used in a few paediatric centres.

Other tumour types and locations

Image-guided needle biopsy may be useful in lesions arising in bone (Fig. 2) and soft tissue, lymph nodes, salivary glands[6], lung[7], mediastinum, and the retroperitoneum and abdominal cavity, including the liver, spleen and bowel wall[6]. Needle biopsy provides sufficient tissue for full evaluation of children with suspected neuroblastic tumours[8].

Occasionally, it may be better to undertake a biopsy of a tumour by laparoscopy than by a needle. In addition, some childhood masses, for example most of those arising in an ovary or testis, are best treated surgically[9]. Assessment by a paediatric oncology multidisciplinary team is therefore appropriate before biopsy is performed.

Localization and intraoperative ultrasound

A percutaneous image-guided approach may be used to localize lung lesions prior to resection[1,7]. Intraoperative ultrasound may be used to identify small lesions in the

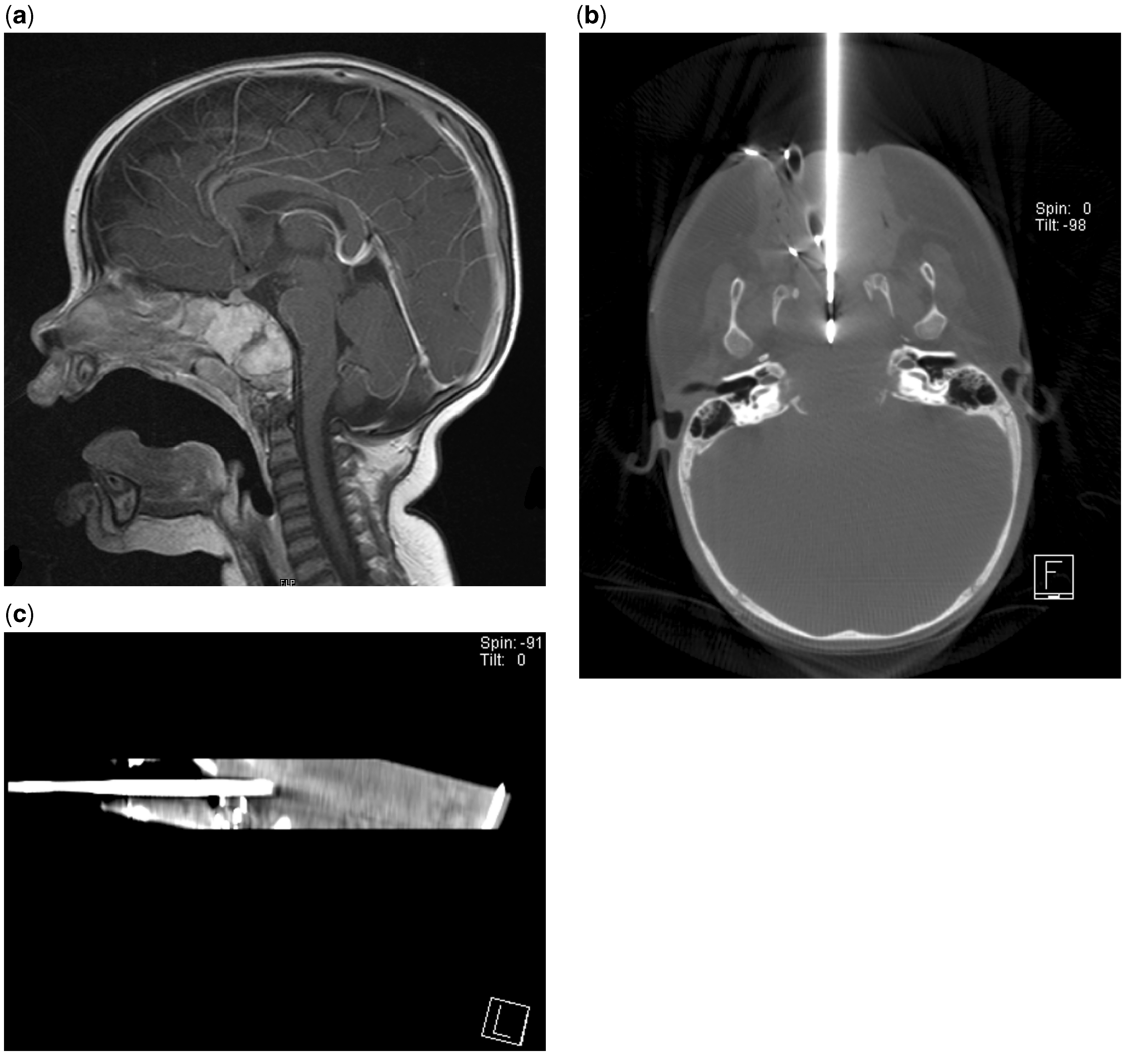

Figure 2 **Needle biopsy using cone beam CT in an angiography suite. (a) Sagittal contrast-enhanced T1-weighted MR image of a 10-month-old boy shows an enhancing lesion in the clivus. (b) A 15/16-gauge coaxial needle is advanced through the mouth. (c) Multiplanar reconstructions are used to confirm the position of the needle during biopsy.**

abdomen or lung when these cannot be palpated by the surgeon (Fig. 3).

Regional therapy

Combination treatment with chemotherapy, surgery and/or radiotherapy has pushed 5-year overall survival rates for certain solid tumours of childhood to well over 80%. Despite this success, there are occasional indications for various regional cancer treatments in paediatrics. Regional therapy may be used to improve effectiveness and/or decrease the complications of treatment with curative intent, or as palliation. The most important techniques are based on transarterial chemotherapy and/or embolization, and percutaneous ablation.

Bland embolization

The simplest transarterial approach is embolization with liquid or particulate agents, or occasionally with coils. Bland embolization may be used to control symptoms (e.g. in benign tumours such as haemangioma or kaposiform haemangioendothelioma), before resection in order to reduce blood loss (e.g. in choroid plexus tumours, Fig. 4), or occasionally in malignant tumours (e.g. neuroblastoma metastases[10]).

Intra-arterial chemotherapy

Intra-arterial (IA) delivery of chemotherapeutic agents has the obvious effect of increasing local dose and reducing systemic levels. The former may be helpful where there is an appropriate relationship between dose and

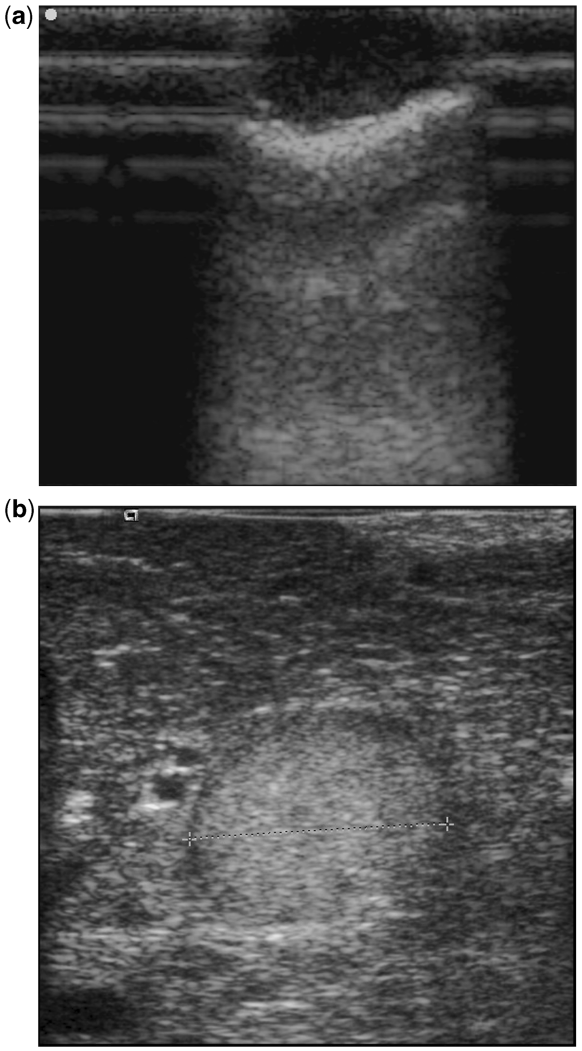

Figure 3 **Intraoperative ultrasound with a high-frequency transducer may be used to find lesions that are difficult to palpate. (a) A lung metastasis in a 16-month-old girl with hepatoblastoma. (b) A small insulinoma in the head of the pancreas in a 13-year-old girl.**

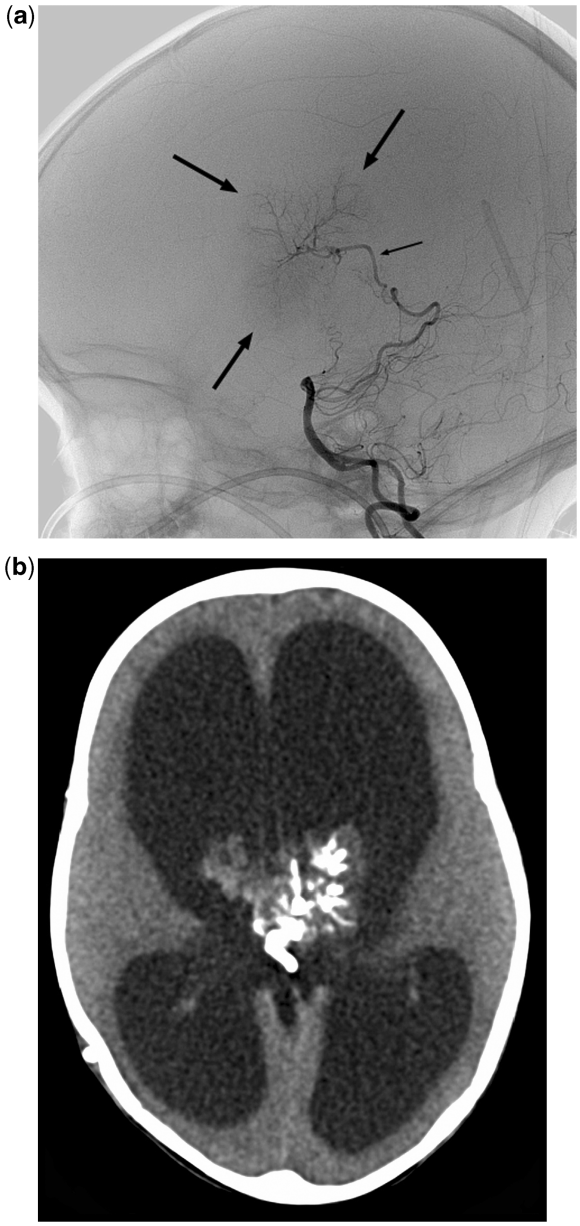

Figure 4 **Preoperative embolization of a choroid plexus tumour in a 22-month-old girl. (a) Lateral image from a vertebral angiogram shows that the tumour (large arrows) is supplied mainly by an enlarged posteromedial choroidal artery (small arrow). (b) Following embolization with cyanoacrylate adhesive (Glubran 2, GEM S.r.l., Viareggio, Italy) via a flow-directed microcatheter (MAGIC1.2F, Balt Extrusion, Montmorency, France) there is extensive glue cast in the tumour.**

response; the latter may reduce adverse systemic effects at the price of decreasing efficacy of treatment of known or potential metastases. IA therapy with melphalan has recently been introduced to treat retinoblastoma, a characteristically paediatric tumour of the eye, in which distant (extraneural) metastases are rare (Fig. 5)[11]. It may also be used in other CNS tumours, with or without disruption of the blood–brain barrier[12,13]. Potential applications for IA chemotherapy outside the CNS include osteosarcoma[14,15].

Other IA techniques

In general, tumours derive most of their blood supply from branches of the hepatic artery, but normal tissue is supplied mainly by the portal vein. This dual blood supply of the liver makes hepatic artery chemoembolization (HACE) an attractive idea for the treatment of unresectable liver tumours. In practice, HACE has been used in children for the treatment of malignant lesions of several histological types, principally hepatocellular carcinoma and hepatoblastoma (Fig. 6)[16]. Preoperative

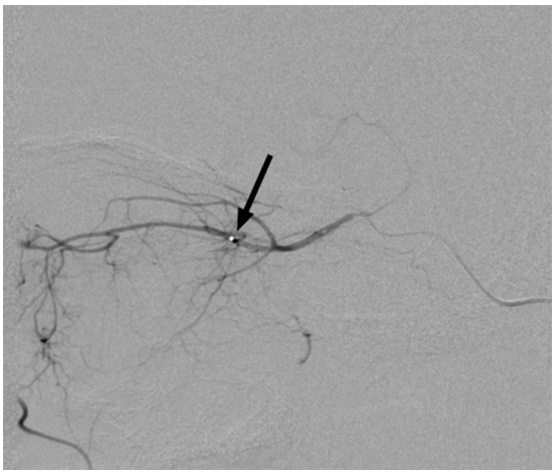

Figure 5 **IA treatment of retinoblastoma. Lateral projection of an ophthalmic artery angiogram shows the tip of the microcatheter (arrow) positioned to prevent reflux of the chemotherapeutic agent into the internal carotid artery. Melphalan (5 mg) was given by slow IA infusion.**

portal vein embolization, a technique used to increase the future liver remnant following partial hepatectomy, may also be performed in children[16].

Selective internal radiation (radioembolization)

An alternative to HACE is transarterial radioembolization with yttrium-90 microspheres. This technique allows very high radiation doses to be delivered to the tumour, but protects the normal liver from radiation injury[17]. Unfortunately, selective internal radiation requires special equipment, which is rarely available in children's hospitals, and has only been used in a few children[16].

Radiofrequency ablation and other ablative techniques

The first local ablative technique used in hepatocellular carcinoma in adults was percutaneous ethanol injection (PEI). More recently, radiofrequency ablation (RFA)

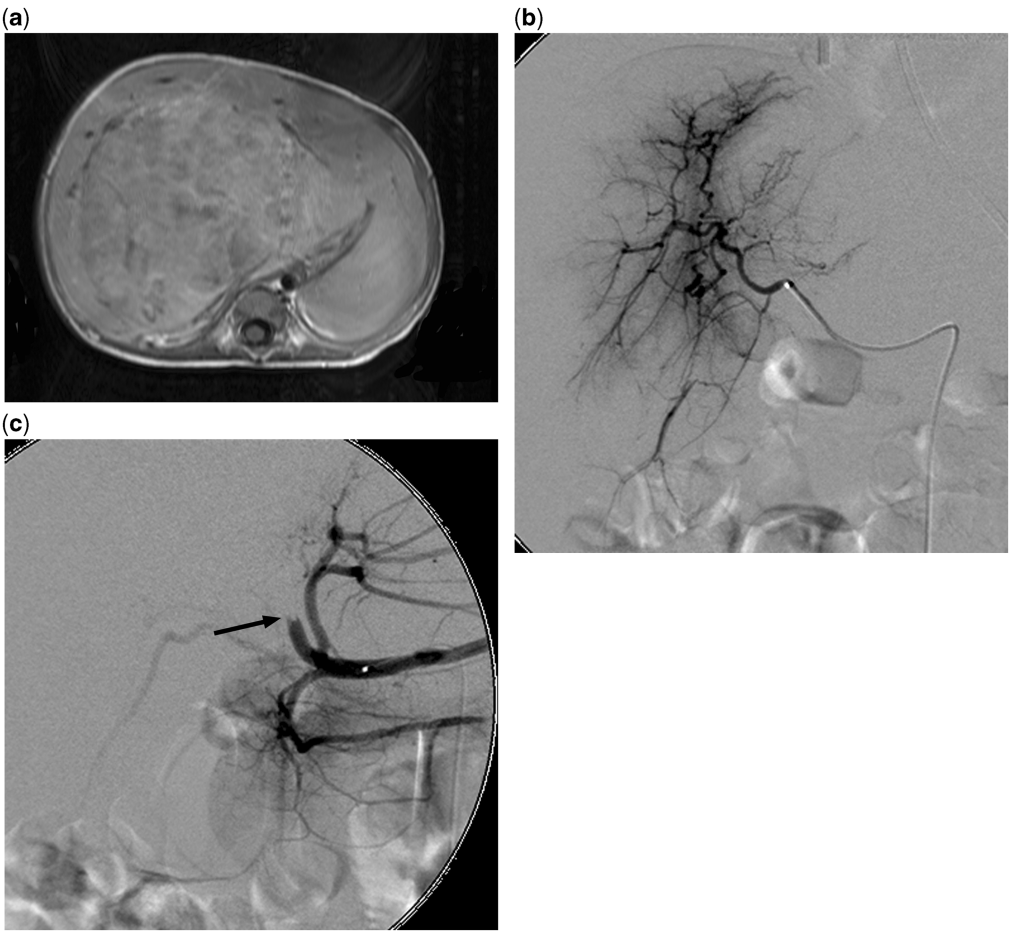

Figure 6 **Hepatic artery chemoembolization (HACE) in a 15-month-old girl with hepatoblastoma. (a) Transverse contrast-enhanced T1-weighted MR image shows an unresectable liver tumour. (b) Right hepatic angiography using a microcatheter technique shows abnormal vascularity in the right lobe of the liver. (c) Following HACE with doxorubicin and cisplatin, the right hepatic artery (arrow) has been occluded with a temporary embolic agent.**

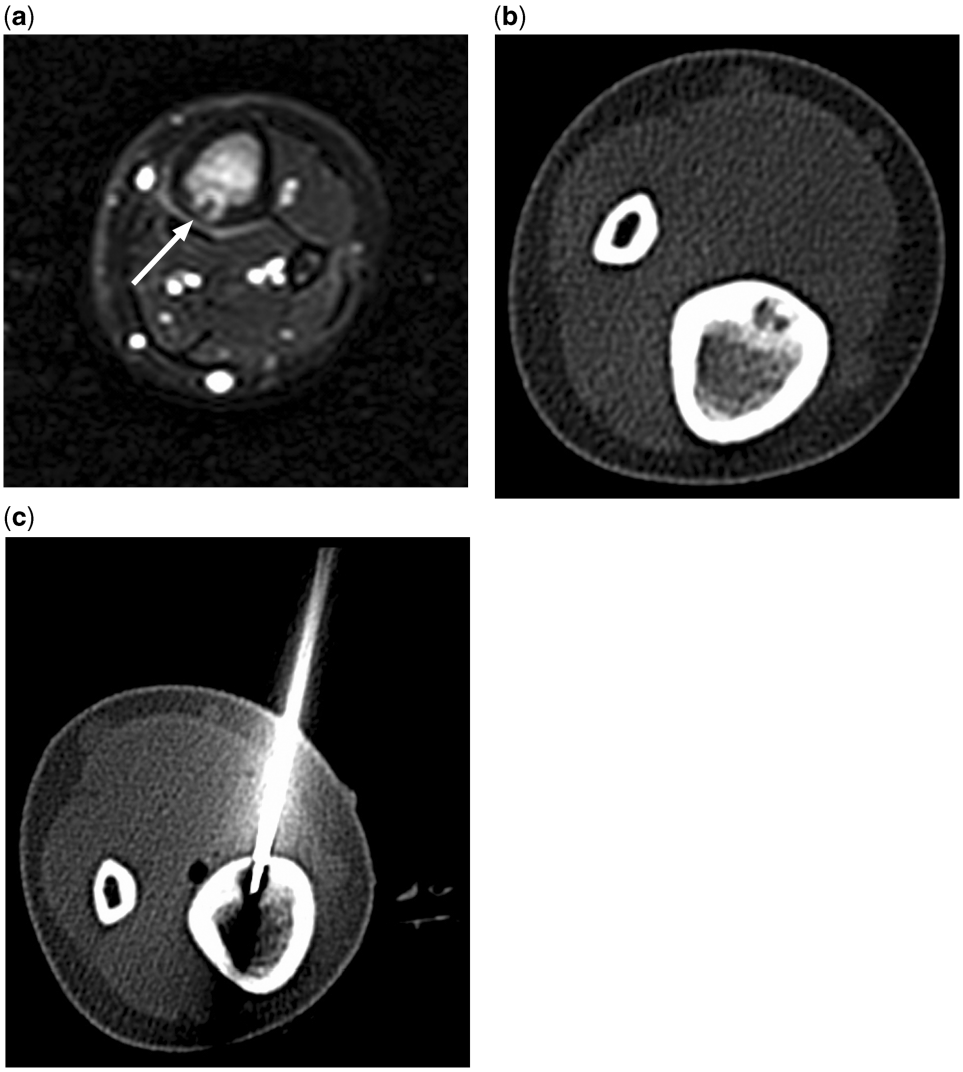

Figure 7 **Radiofrequency ablation of an osteoid osteoma in an 11-year-old boy. (a) Transverse T2-weighted MR image shows very high signal in the marrow of the distal left tibia, with a nidus (arrow) in the posterior cortex. (b) CT (prone position) confirms the diagnosis of osteoid osteoma. (c) Following access with a Bonopty penetration set (Apriomed AB, Uppsala, Sweden), a radiofrequency ablation probe (Cosman Medical, Burlington, MA, USA) was used to treat the lesion, with complete resolution of symptoms.**

has become more popular, because it appears to offer improved long-term survival at the price of more immediate complications[18]. RFA has been used in the treatment of hepatoblastoma[19,20], fibrolamellar carcinoma[21] and liver metastases[1,22] in children.

PEI is rarely used in the liver in children, but may have a role in the treatment of hyperfunctioning thyroid nodules in teenagers[23].

Outside the liver, RFA has been used to treat malignant tumours in lung, soft tissue and bone[21]. It may also have a role in the treatment of renal tumours, particularly small Wilms tumours arising in a solitary kidney[24,25]. The best-established use of RFA in childhood, however, is for treatment of osteoid osteoma (Fig. 7)[26].

Supportive care

Central venous access

Most children with a diagnosis of cancer will need some form of central venous (CV) access, usually a Hickman catheter or central venous port device. It is widely accepted, although not proved, that image-guided percutaneous insertion techniques are safest and best in children.

Gastrostomy

Many children with leukaemia or solid tumours will require gastrostomy feeding, even if their nutritional

status at the start of treatment is normal. The results of radiological (non-endoscopic) gastrostomy in these patients are good[27].

Treatment of complications

As in adults, numerous IR techniques are available in the management of complications of tumours and their treatment. These include drainage of fluid collections including ascites and abscesses, pleurodesis[28], airway stenting[29], nephrostomy[30], biliary drainage and stenting[6,31,32], vertebroplasty[33] and the insertion of epidural ports for pain relief[34].

Conclusions

Although the benefits of interventional oncology (the fourth pillar of cancer treatment) have only been adopted gradually in children, there are clear indications that image-guided biopsy, regional therapy and various other IR techniques will become more important in future years.

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