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Interventional radiology in infancy

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ABSTRACT

Interventional radiology (IR) is an emerging sub-speciality within paediatric medicine. In adult care, IR is largely centred on the management of vascular disease but in paediatric practice, IR applications are varied and increasingly innovative, making this an exciting field to be a part of. IR has a central role both in the day to day care of sick children, from long term IV access provision to feeding tube insertions, and in the acute management of critically ill infants, such as those with overwhelming liver disease, neonatal tumours and vascular malformations. Paediatric IR faces a unique set of challenges, developing or modifying techniques and equipment for use in very small patients, training professionals to take the speciality forward and, most importantly, convincing paediatricians and healthcare institutions to create opportunities for IR to make a difference.

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1. Introduction

Interventional radiology (IR) is well established in adult medical practice but has been slow to develop in paediatric care. The reasons for this can be debated but include the challenges of adapting already-complex techniques for use in small patients, the lack of industry-led innovation on paediatric-specific IR devices, a relative low number of interventionalists from traditional adult vascular surgery backgrounds willing to consider a career involving paediatric medical expertise and interaction with small children and their families, as well as a frustratingly widespread lack of vision by medical institutions in embracing the speciality. But it can no longer be denied that IR brings a wide range of new approaches to many aspects of neonatal and paediatric care, offering not only quicker, less painful minimally invasive options for many procedures but also emergency interventions for very sick children unable to tolerate complex surgery. Not only does IR offer alternatives to more traditional surgical approaches, it is also developing new treatments previously unavailable for many conditions and changing the future for many children and families.

2. Intravenous access

Provision of medium to long term intravenous access devices for children, for many decades the responsibility of paediatric surgeons, is fast becoming the remit of IR. It has been clearly demonstrated that image guidance increases the safety and efficiency of central venous catheter (CVC) placement [1]. The UK National Institute for Health and Care Excellence (NICE) stated as long ago as 2002 that ultrasound imaging guidance should be the preferred method for CVC placement in adults and children in elective situations and should be considered

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in most clinical situations where CVC insertion is necessary, whether the situation is elective or an emergency [2]. The particular strengths of an IR-led image-guided technique are that a suitable route of access can be planned before any incision or surgical exploration is undertaken and that the vein is usually preserved for future access. In the early days of IR, many long-term patients presented after multiple previous surgical access procedures. The majority of central veins would be lost and increasingly heroic IR options were required to place a CVC, including transhepatic, transrenal or translumbar routes. Patients managed in an institution with ready access to an IR-led vascular access service present with this scenario increasingly rarely and central venous access should now be straightforward in the majority of cases. In instances where children have lost access routes due to previous procedures, IR techniques originally developed for peripheral arterial work in adults are modified to negotiate small collateral venous channels, stent venous stenoses and recanalise central vessels.

Any paediatric healthcare institution should have a robust central venous access policy which details the decision-making process when choosing a suitable central venous access device for a child and formalises the progression from ward or intensive care-based cannulation procedures for short-term lines to surgical or IR-led procedures in a dedicated operating suite for long term access. The majority of institutions agree that the remit of IR is solely for the placement of medium to long-term devices. The most common indications for central venous access referral in infants include extended intravenous antibiotic or antiviral courses, parenteral nutrition, dialysis and chemotherapy. Specialised centres will also require reliable access for children with haemophilia, enzyme replacement therapy and metabolic conditions such as hyperinsulinism. Recently there has been a move towards IR involvement in cannulation for extracorporeal membrane oxygenation (ECMO) programs. In paediatric practice, there is of course also a drive for intravenous access solutions for children with needle phobia and difficult peripheral venous access.

Device options vary from 2-5Fr peripherally inserted CVCs (PICCs) to 11Fr dual lumen cuffed tunnelled CVCs, the details of which are beyond the scope of this review but are well documented elsewhere [3]. Decisions need to be made about whether a device should be peripherally inserted, tunnelled or totally implanted and whether the procedure can be performed with the child awake. Consideration should also be given to whether a local team can manage the child's device after discharge from hospital and whether general anaesthesia is required for device removal. Clinical teams looking after complex inpatients will often be tempted to request a device with the greatest number of lumens but this needs to be balanced with other considerations such as the size of the catheter relative to the child (large catheters in small children can be associated with acute superior vena cava obstruction or long term central vessel occlusion) and the need for reliable withdrawal rates (catheters with multiple lumens tend to have smaller calibre individual lumens which may not aspirate well).

Many paediatric centres with well-established IR practices advocate the development of an IR-led vascular access team. This service can be nurse-led and should coordinate the decision-making process when a child first requires long term access, family education, monitoring of indwelling lines, troubleshooting of faulty devices on the wards and liaison with the community upon patient discharge. Currently, IR has limited involvement with patients once devices are placed and this must be detrimental to the patient and the process, under-using IR's skills in diagnosing and managing malfunctioning catheters and limiting data collection on long term line outcomes [4].

3. Biopsy

The commonest indications for biopsy in infants are suspected malignancy, hepatic disease, renal disease, infection and the investigation of some soft tissue masses [5]. Liver biopsy may also be indicated in infants with suspected biliary atresia [5]. Soft tissue masses and suspected malignancies should be carefully imaged with ultrasound in the first instance, as the diagnosis can often be reached on imaging features alone. Complex masses with deep extension should then be assessed with detailed cross-sectional imaging, ideally MRI, to document the anatomical relations of the tumour, its vascular supply and its tissue viability. It makes a significant difference to biopsy planning, for instance, to know that a lesion is within, rather than adjacent to, the liver, and biopsy should be targeted at the most viable tissue within the mass to optimise the quality of the samples obtained. Infants with abdominal malignancies often present with very large tumours and the organ of origin can sometimes be difficult to determine on initial imaging. Much of the tumour is often necrotic at presentation, having outgrown its blood supply, so biopsy must be directed towards the well-perfused, viable parts of the mass. It is also critical to look for secondary masses during imaging work-up, as there may be satellite or secondary lesions that are more easily accessed than the primary tumour.

Because neonatal and infant tumours are usually large and because the child is small, most lesions are relatively superficial and can be accessed percutaneously using ultrasound guidance alone [5]. It is rare to need cross sectional imaging guidance but occasionally CT proves invaluable. Many modern IR suites have inbuilt cone-beam CT technology which allows for a single 200 degree rotation of the X-ray C-arm, generating a volumetric dataset which can be reconstructed into cross sectional images. This significant technical advance allows for real-time CT imaging during an IR procedure and affords the radiologist an opportunity to confirm, for instance, biopsy needle position for small or relatively inaccessible lesions.

Abdominal and chest mass biopsies can be performed using a coaxial biopsy needle system, which allows for only one breach of the tumour capsule. Multiple cores can then be obtained using the inner needle. This reduces the risks of bleeding and inadvertent damage to other structures compared to multiple biopsy needle passes and provides an opportunity to embolise or plug the biopsy track as the outer needle is finally withdrawn. This is likely to reduce the risk of tumour spill, so is of particular importance in hepatoblastoma and renal tumour biopsy.

4. Gastrointestinal intervention

Indications for feeding tube placement in infants are rare but do occur. Gastrostomy tube insertion may be indicated in children unable to take oral feeds due to an unsafe swallow secondary to neurological impairment, those with specific nutrition or medication demands (renal failure, cystic fibrosis, certain metabolic conditions) and those with severe oesophageal disease such as caustic strictures. Gastrostomy devices are placed by IR, gastroenterology or paediatric surgery, using a range of techniques. In infants, gastrostomy tube insertion is often combined with fundoplication in patients with severe reflux and therefore a combined surgical approach is indicated. However, image-guided percutaneous gastrostomy tube placement by IR is well described and this quick, minimally invasive technique can be advantageous in small children [6]. There is still conflicting evidence as to whether surgical or IR techniques are safer or more successful [6,7].

IR-guided balloon dilatation has a central role in the management of oesophageal strictures. A proportion of strictures are secondary to foreign body obstruction, caustic ingestion or epidermolysis bullosa (EB), but in infancy, the commonest indication for dilatation is anastamotic stricture secondary to oesophageal atresia (EA) repair. Anastamotic strictures occur in 18–55% of patients following surgical repair of EA but respond well to serial balloon dilatation [8,9]. An image-guided technique allows accurate visualisation of the entire length of the stricture and for both safe crossing of the stricture with a hydrophilic guidewire and controlled balloon dilatation under real-time fluoroscopic control. Complication rates are very low, with oesophageal rupture rates of $<1\%$ [9].