

RADIOLOGY TODAY

Paediatric interventional radiology: it's not child's play

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Abstract Pediatric interventional radiology is a dynamic and growing subspecialty. The new training pathways in interventional radiology, the maintenance of skills with a small volume of cases or complex procedures, the limited availability of specific pediatric equipment and materials pose significant challenges and opportunities.

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PALABRAS CLAVE

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Radiología intervencionista en pediatría: no es un juego de niños

Resumen La radiología intervencionista pediátrica es una subespecialidad dinámica y en crecimiento. Las nuevas vías de formación en radiología intervencionista, el mantenimiento de las competencias con pequeño volumen de casos o procedimientos complejos, la disponibilidad limitada de equipos y material pediátrico específico, los efectos de la sedación o anestesia sobre el neurodesarrollo o la protección radiológica suponen importantes retos y oportunidades.

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Introduction. The origins of vascular and interventional radiology in paediatrics

Vascular and interventional radiology (VIR) is a relatively young subspecialty. It can be traced back to 1953, the year Sven Seldinger described the Seldinger technique,¹ considered the basis for the majority of vascular interventional radiology procedures. This new needle-guide-catheter technique allowed radiologists, more specifically angiologists, to delve into the world of angiography. Until then, vascular surgeons had the monopoly on therapies for vascular pathologies. This new technique opened the door to develop new endovascular techniques and procedures. The first antegrade aortography was described in 1960, in which a catheter was inserted into the right atrium via the basilic vein.² In the same decade, the first injectors and x-ray machines able to produce angiographic series came onto the market.³

However, Charles Dotter was the pioneer when it came to demonstrating that VIR could be a therapeutic as well as a diagnostic tool. Dotter first performed an angioplasty by accident in 1963. He was conducting a diagnostic aortogram on a patient with renal stenosis when he introduced the catheter in a retrograde fashion through an occluded right iliac artery. The following year, Dotter performed the first balloon angioplasty on an 82-year-old patient with chronic stenosis in the superficial femoral artery who had refused amputation. The patient lived for a further three years with no further symptoms, at which point she died of other causes.^{4,5}

These advances by Seldinger and Dotter paved the way for interventional radiology, with a host of innovations to this day. These breakthroughs include the accidental discovery in 1964 that it was possible to link the hepatic vein and the portal vein during an attempt to drain the bile duct into the hepatic veins⁶; the first embolisations were performed in 1972 to treat gastrointestinal bleeding⁷; and in 1973 to treat pelvic trauma⁸; the first coils were used to treat aneurysms and intracranial vascular malformations in 1974⁹; and also in 1974, the first angioplasty balloons created by Andreas Gruentzig were used.¹⁰

Children were not overlooked. In 1981, the first percutaneous closure of a patent ductus arteriosus was described.¹¹ Similarly, the first splenoportographies in paediatric patients for the diagnosis of portal obstructions were performed by Charles Dotter himself in 1971.¹² One of the pioneers of paediatric VIR is Philip Stanley, author of the first book on paediatric angiography,¹³ who described the diagnosis and treatment of renal hypertension,^{14,15} the first arterial embolisations¹⁶ and the first image-guided percutaneous drains.¹⁷ The first text dedicated exclusively to paediatric radiology was published in 2014 by Michael Temple and Francis E. Marshall, in which they describe paediatric interventional procedures in great detail.¹⁸ It is our aim with this article to discuss the challenges and opportunities facing paediatric VIR today and to raise awareness of the usefulness of these minimally invasive procedures in the paediatric population.

Challenges and opportunities

Training

To acquire the specific skills and competencies necessary to practise interventional radiology in paediatrics, specialisation in general radiology as well as further training in paediatric radiology and VIR is necessary.¹⁹

Specific training in this field has arrived to Spain relatively recently, with fellowship programmes in VIR for adult patients endorsed by the Spanish Society of Vascular and Interventional Radiology (SERVEI, Spanish acronym).²⁰ At present, there is no specific fellowship programme for paediatric VIR in Spain. However, there are more than a dozen fellowship programmes in the United States and Canada, in large tertiary paediatric centres (Boston Children's Hospital, Children's Hospital of Philadelphia, The Hospital For Sick Children, among others). In contrast, there is only one programme in Europe (Great Ormond Street Hospital, London). There are also significant differences in the number, type and complexity of cases performed depending on the centre. This is an obstacle to the standardisation and homogenisation of paediatric VIR training.²¹

Volume and complexity of cases

The characteristics of paediatric VIR procedures vary widely between hospitals fundamentally due to variations in the availability of equipment and personnel. This results in large differences when acquiring proper training.

In centres which handle a low number of procedures, and ones of a lower complexity, it may be difficult to find paediatrics-trained staff with access to the best equipment. To overcome these difficulties, close collaboration and integration with adult VIR may be a viable alternative.²¹

On the other hand, there is also a growing demand for professionals who are able to perform procedures in the paediatric population due to the diagnostic and therapeutic possibilities offered by VIR in paediatrics. This is already a reality in large tertiary centres. It is true, however, that this subspecialty is still relatively unknown.

Specific material

Materials initially designed for adults do not meet all paediatric needs, and their utility, performance and safety have yet to be validated.²² In general, innovation in paediatrics seems to move more slowly. There also seems to be less availability of paediatric-specific materials. Although some devices have been specifically designed for paediatric patients, such as guidewires, vascular catheters, dialysis catheters, port-a-caths or enteral feeding devices, this is an unattractive market on the whole due to the lower demand and the high costs involved in redesigning devices that have already been extensively validated for adults.

Needs of paediatric patients and their families

Paediatric patients and the people around them have different needs to those of adult patients. Depending on their age, children do not always understand the importance of a diagnostic or therapeutic procedure. Also, the impact on each of the two population groups differs greatly.

With regard to anaesthesia techniques, there is, in general, a greater need for sedation and anaesthesia to perform a procedure safely in the paediatric population. This often leads to a higher risk of complications. Less complex procedures can in some cases be performed without the aid of sedation, especially in neonates or infants, who can be calmed during minimally invasive procedures. Examples would be peripherally inserted central catheters or ultrasound-guided lumbar punctures in patients under one year of age. However, these patients require differentiated care, such as body temperature management during the procedure, minimising blood loss, as well as minimising the volumes of fluid or contrast administered. For older paediatric patients, or for longer and more complex procedures where collaboration is not an option, most require anaesthesia or sedation under the supervision of an anaesthetist. Exposure to prolonged sedation or general anaesthesia should be minimised because of potential adverse neurodevelopmental effects,²³ and strategies to combine all these procedures under one single anaesthetic are useful.²⁴

Besides the welfare of the patient, that of the patient's family must also be ensured.²⁵ Illness is a source of concern and anxiety for the parents, often a greater one for them than for the actual patient. The need for the procedure and its short, medium or long-term outcomes must be explained, as must the procedure's risks and complications and post-procedural care. Continuity of care before, during and after the procedure by the same team of professionals is key to addressing the patient's problems and reassuring their relatives.²⁶

Radiation protection and safety in contrast administration

While the benefits of these radiological interventions are well recognised, there are also risks associated with exposure to ionising radiation. This is especially important in the paediatric population as these patients are more sensitive to the effects of radiation. The primary goal of radiation management in VIR is to minimise unnecessary radiation use in accordance with the ALARA (As Low as Reasonably Achievable) principles.^{27,28}

For all fluoroscopically guided interventional procedures, the radiation dose during the procedure must be monitored and recorded in the patient's medical record. Patients who have received a clinically significant radiation dose should receive follow-up after the procedure to check for possible side effects. In addition, low-dose protocols must be created that allow procedures to be performed safely.²⁹

Regarding radiological contrasts, low-osmolality contrast media are preferred with maximum volumes of 4–5 ml/kg in

neonates and 6–8 ml/kg for other paediatric patients. Diluting contrast or avoiding the use of contrast injectors may be useful strategies to reduce the amount of contrast used and avoid unwanted adverse effects due to allergic reactions (generally less frequent than in adults) or contrast nephrotoxicity (rare in patients with adequate glomerular filtration rate or almost always associated with other comorbidities).^{30,31}

Present and future

The number of paediatric interventional radiologists who define themselves as such has grown in recent decades, from 110 professionals and 38 hospitals mainly in the United States and Canada in 2007³² to 177 professionals and 88 hospitals in 2017.³³ There are only five European paediatric interventional radiology centres.

The first Society for Paediatric Interventional Radiology (SPIR) was created in 2009, with the aim to "support and promote the health of the paediatric population through minimally invasive image-guided procedures". The society now has more than 300 members in 24 countries.³³

Paediatric VIR is a promising subspecialty with incredible potential for innovation and development. The challenges it faces are similar to those faced by adult VIR in its early days, some of which still exist today. These include the need for specific and structured training, greater recognition by healthcare institutions of the need for interventional services, and collaboration in the development of appropriate paediatric teams. Overcoming these challenges is essential to ensure that all paediatric patients have access to the minimally invasive VIR procedures which are available to adults.

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- Alonso Sánchez, Jaime: Study design. Data collection. Analysis and drafting. Approval of the final manuscript.

- Parra, Dimitri A: Study design. Critical content review. Approval of the final manuscript.
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Conflict of interests

The authors declare that they have no conflicts of interest.

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