Interventional radiology (IR) is a recognised subspecialty of radiology both within the Union of European Medical Specialties (UEMS) and the European Society of Radiology (ESR). IR is unique and distinct from all other surgical, radiological and medical subspecialties and specialties.

IR is performed by trained IR specialists who have expertise in interpreting diagnostic imaging as well as expertise in image-guided minimally invasive procedures and techniques as applied to various diseases and organs. There are a huge variety of therapeutic procedures performed by IR. They can be divided into broad categories of vascular, non-vascular and oncological interventions. For a more detailed description of IR and what interventional radiologists do, please read the Global Statement on IR.1

TRAINING

Training in IR should be under an accredited training programme and the minimum length of training is 2 years. In several countries there are special training curricula for IR and there is also a European IR training curriculum which can be viewed at <http://www.cirse.org>.

There is a European IR examination which can be taken by every interventional radiologist after the completion of training. This examination is called the European Board of Interventional Radiology (EBIR) and is held under the auspices of an independent European Board. Maintenance of IR skills by performing an adequate number and range of procedures and demonstration of continuous medical education by CME certification is an essential requirement.

CLINICAL INVOLVEMENT

Interventional radiology involves interaction with patients and their families, taking decisions and judging outcome and risks. Most important is the clinical evaluation and management of patients with diseases or conditions amenable to image-guided interventions. The IR as a clinician should keep the following questions in mind when entering into a patient consultation: Is the proposed procedure necessary? Is the patient suitable or fit for the procedure? What is the potential for harm? Are there better alternatives for the patient?

For these reasons an IR should be clinically trained. Clinical involvement may include seeing patients in consultation particularly for complex treatments (see the next section), but this is not always feasible and for more routine work it is often not necessary. It is becoming more common for IRs to have their own clinics and beds. Access to day case and inpatient beds is necessary to optimise provision of an IR service. An on-call service should also be provided on a 24/7 basis, which means having an adequate number of IRs available or providing an on-call service through formation of a network of IRs from adjacent hospitals.

INFORMED CONSENT

Informed consent is an essential requirement in contemporary medicine, especially in cases where there is clinical equipoise, as is sometimes the case in IR treatments. Informed consent should be based on an ethical assessment of the clinical situation, including the invasiveness of the procedure, the clinical indications and not simply on practical issues. Focusing on the whole decision-making process, effective communication and an individualised approach to consent is essential, also because it
will reduce much of the patient’s anxiety for the procedure to follow. A combination of information both written and verbal is often the best approach. Informed consent should ideally be obtained by the operator performing the procedure or, if this is not possible, the task can be delegated to a suitably trained doctor. Informed consent should also be obtained at least 24 h before any procedure so that the patient has time to digest the information and make an informed decision. The risks, intended benefits and alternatives should be discussed with the patient and any follow-up care that is planned should be itemised. Informed consent is a prerequisite for good clinical IR practice as IR is increasingly the first line of treatment and the interventional radiologist is the primary clinician.

**IR CHECKLIST**

In 2009, Haynes et al. published the results of a study which implemented a 19-item surgical safety checklist to determine whether this checklist could reduce complications and deaths associated with surgery. A significant reduction in the rate of death and complications occurred after the introduction of the surgical safety checklist. The death rate fell from 1.5% before the introduction of the checklist to 0.8% afterwards. The complication rate fell from 11 to 7%. Although complications in IR are significantly fewer than with surgery, patient contact before IR procedures is often quite short, and sometimes it is difficult for the interventionalist to gather all the necessary clinical information in a timely manner. This increases the risk of complications. A standardised checklist has the advantage of ensuring that human error, in terms of forgetting key steps in patient preparation, intra-procedural care and postoperative care are not overlooked. This checklist can be downloaded and modified through <http://www.cirse.org/files/files/Profession/IR_Checklist_new.pdf>.

However, the patient safety checklist is only one part of a comprehensive patient safety strategy. Regular morbidity and mortality meetings, reporting of errors, participation in hospital risk management committees and a culture of patient safety are all important items in the overall strategy for patient safety. In an ideal world, competence should match performance but this is not always the case. Performance may be hindered by both system and individual influences. Individual influences on performance can be aided by a lifelong commitment to learning, while system influences may be difficult to deal with and may involve not performing some procedures if the necessary support is not available locally.

### COAGULATION

Management of coagulation status and haemostasis risk in percutaneous image-guided interventions is very important. Haemorrhage is a major complication of IR procedures and guidelines for the management of coagulation status and haemostasis risk are available. IR procedures can be divided into two categories: those with low and those with moderate risk of bleeding. For each category special attention should be given to the clotting status of the patient. In elective treatments, the coagulation status should be optimised unless there are other important contraindications to stopping anticoagulation. General rules for haemostasis management are given in Table 1-1.

<table>
<thead>
<tr>
<th>TABLE 1-1</th>
<th>IR Procedure Categories: Haemorrhagic Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Risk of Haemorrhage</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **Vascular** | • Dialysis access interventions  
| | • Venography  
| | • Central line removal  
| | • IVC filter placement  
| | • PICC line placement |
| **Non-Vascular** | • Drainage catheter exchange  
| | • Superficial abscess drainage |
| **Moderate Risk of Haemorrhage** |
| **Vascular** | • Angiography, arterial and venous intervention with access size up to 7Fr |
| **Non-Vascular** | • Intra-abdominal, chest wall or retroperitoneal abscess drainage or biopsy  
| | • Lung biopsy  
| | • Transabdominal liver biopsy (core needle)  
| | • Percutaneous cholecystostomy  
| | • Gastrostomy tube: initial placement  
| | • Radiofrequency ablation: straightforward  
| | • Spine procedures (vertebroplasty, kyphoplasty, lumbar puncture, epidural injection, facet block) |
| **High Risk of Haemorrhage** |
| **Vascular** | • INR: Routinely recommended for patients receiving warfarin anticoagulation or with known or suspected liver disease  
| | • Activated PTT: Routinely recommended for patients receiving intravenous unfractionated heparin  
| | • INR > 2.0: Threshold for treatment (i.e., FFP, vitamin K)  
| | • PTT: No consensus  
| | • Platelets: Transfusion recommended for counts < 50,000/μL |
| **Non-Vascular** | • INR: Correct above 1.5.  
| | • Activated PTT: No consensus (trend toward correcting for values 1.5 times control, 73%)  
| | • Platelets: Transfusion recommended for counts > 50,000/μL  
| | • Hematocrit: No recommended threshold for transfusion  
| | • Plavix (clopidogrel): Withhold for 5 days before procedure  
| | • Aspirin: Do not withhold  
| | • Low-molecular-weight heparin (therapeutic dose): Withhold one dose before procedure |
CONTRAST MEDIUM ALLERGY

Contrast medium carries a risk for allergic reactions, but this has been reduced to a very low level since the advent of low-osmolar contrast media. A treatment protocol for anaphylaxis and allergy should be available in the interventional suite. Patients with known previous allergic reactions to contrast medium should be pretreated with steroids. An oral regimen often used is dose 1, prednisone 50 mg 13 h prior; dose 2, prednisone 50 mg 7 h prior; and dose 3 (final dose), prednisone 50 mg 1 h prior to the intervention. If oral prednisone is not an option for the patient one of the following equivalent alternatives should be considered: 8 mg Decadron (dexamethasone) IV × 3 doses starting 13 h prior to intervention or 200 mg Solu-Cortef (hydrocortisone) × 3 doses starting 13 h prior to the procedure.

KIDNEY FUNCTION

Low-osmolar contrast medium has a small but definite benefit over high-osmolar contrast media for patients with pre-existing renal impairment. Pre-procedural hydration may have a protective effect in high-risk patients and some newer drugs may also have a role in protection from contrast medium-induced nephrotoxicity (CIN). For the purposes of this standard, CIN as a major complication is clinically defined as an elevation of serum creatinine requiring care which delays discharge or results in unexpected admission, readmission or permanent impairment of renal function. This definition focuses on the outcome of renal impairment, which is the central issue in any monitoring programme. The threshold chosen is 0.2% and is based on consensus and a review of the pertinent literature. Three factors have been associated with an increased risk of contrast-induced nephropathy: pre-existing renal insufficiency (such as creatinine clearance <60 mL/min (1.00 mL/s)), pre-existing diabetes and reduced intravascular volume.

Adenosine antagonists such as the methylxanthines theophylline and aminophylline may help, although studies have produced conflicting results. Administration of sodium bicarbonate 3 mL/kg/h for 1 h before, followed by 1 mL/kg/h for 6 h after administration of contrast medium was found superior to plain saline in one randomised controlled trial of patients with a creatinine level of at least 1.1 mg/dL (97.2 μmol/L). A randomised controlled trial involving patients with a creatinine over 1.6 mg/dL (140 μmol/L) or creatinine clearance below 60 mL/min studied the use of 1 mL/kg of 0.45% saline per hour for 6–12 h before and after the administration of contrast medium and suggested that N-acetylcysteine (NAC) 600 mg orally twice a day, on the day before the procedure, may reduce nephropathy, but the results are inconclusive.

SEDATION AND PAIN MANAGEMENT

Sedation and pain management during IR procedures are becoming more important as many complex percutaneous procedures are performed without general anaesthesia. Sedation should, however, only be performed in those circumstances when adequate resuscitative equipment and organisational support are available. For more complex cases in ill patients and in instances where deep sedation is desired, the assistance of a dedicated anaesthetist is mandatory. Conscious sedation is often used in interventional procedures to minimise discomfort. There are three main categories: benzodiazepines, opioids and intravenous anaesthetics. The most common side effects of conscious sedation are described in Table 1-2.

Benzodiazepines

These drugs are reasonably safe to use during IR procedures, as their cardiorespiratory suppressive effects are minimal. However, even commonly used doses of benzodiazepines can cause apnoea. Therefore, it is important to adequately monitor patients receiving benzodiazepines. The most commonly used benzodiazepines include midazolam and lorazepam. Midazolam has a rapid onset and short duration of action, which makes it an ideal drug for most interventional procedures.

In patients where a benzodiazepine overdose occurs, flumazenil (0.2 mg IV every 60 s, usually up to 1 mg) should be administered.

Opioids

For most interventional radiological procedures, and especially for elderly patients, shorter-acting narcotics like fentanyl and alfentanil are preferred. The regular dose for fentanyl is 25–50 μg IV. Duration of effect becomes longer with higher doses/infusions.

In case of opioid overdose, naloxone (0.1–0.3 mg IV every 30–60 s, with no specific maximum dose) should be administered.

Intravenous Anaesthetics

Ketamine and propofol can be used for conscious sedation in IR procedures. These drugs should, however,
only be reserved for situations in which all necessary provisions for administration of general anaesthesia are available, which includes the participation of an anaesthetist.

**COMPLICATIONS REGISTER**

The periprocedural management of patients undergoing image-guided interventional procedures is continually evolving. Local factors such as procedure types and patient selection will influence management. In addition, advances in technology and image guidance may have a significant effect on periprocedural management. The use of arterial closure devices, smaller-gauge catheters and biopsy devices, adjunctive haemostatic measures such as postbiopsy tract plugging/embolisation and colour flow ultrasonography or computed tomographic fluoroscopy can affect the incidence of periprocedural haemorrhagic complications. One of the most effective methods of improving the safety of IR procedures is to maintain a local complication register and to hold a regular complication meeting. This should lead to improved local procedural guidelines, protocols for interventional radiological procedures and training.

**THE INTERVENTIONAL RADIOLOGY SUITE**

Common medications used during arterial interventions and their doses are indicated in Table 1-3.

**INVENTORY**

An inventory of interventional radiological devices, catheters and guidewires should be available. Also the essential materials to deal with complications, such as covered stents, in case of an arterial rupture after angioplasty, should be part of the inventory. In general it is recommended to keep the stock small, as technology changes rapidly and most devices have a limited period of sterility. No specific recommendations can be given here and local practice will dictate how sufficient stock and stock control is achieved. In many European countries separate storage of interventional equipment outside the interventional room is required by hospital infection committees.8

**REFERENCES**


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**TABLE 1-3 Doses of Common Medications Used during Arterial Interventions**

<table>
<thead>
<tr>
<th>Medication</th>
<th>Dose</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyceryl trinitrate</td>
<td>0.1 mg/mL/dose IA, repeated up to 3 times</td>
<td>Treatment of vasospasm</td>
</tr>
<tr>
<td>(nitroglycerin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heparin</td>
<td>75–100 IU/kg IV</td>
<td>Prevent arterial thrombosis</td>
</tr>
<tr>
<td>Protamine</td>
<td>10 mg IV per 1000 IU heparin</td>
<td>Heparin reversal</td>
</tr>
<tr>
<td>Papaverine</td>
<td>1 mg/kg IA</td>
<td>Treatment of vasospasm</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>0.5 mL/kg (5 mg/kg) 1% (without adrenaline)</td>
<td>Local anaesthesia</td>
</tr>
</tbody>
</table>

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