



# European Curriculum and Syllabus for Interventional Radiology

UEMS – European Training Requirements  
for Interventional Radiology

Third Edition



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### **The European Curriculum and Syllabus for Interventional Radiology**

This is a living document that is subject  
to continuous review every 5 years  
by representatives of CIRSE and the  
UEMS Division of Interventional Radiology.

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# The European Curriculum and Syllabus for Interventional Radiology

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ÖGIR – Austrian Society of Interventional Radiology  
BSR – IR Section of the Belgian Society of Radiology  
BSIR – British Society of Interventional Radiology  
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DFIR – Danish Society of Interventional Radiology  
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IESIR – Italian European Society of Interventional Radiology  
SIRM-ICIR – Italian Society of Medical and Interventional Radiology - Italian College of Interventional Radiology  
LAIR – Latvian Association of Interventional Radiology  
SIRNM – Society of Interventional Radiology of North Macedonia  
NFIR – Norwegian Society of Interventional Radiology  
PLTR – Polish Society of Interventional Radiology  
APRI – Portuguese Society of Interventional Radiology  
SNRIR – Romanian Neuroradiology and Interventional Radiology Society  
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SIRS – Serbian Society of Interventional Radiology  
SKVIR – Slovakian Society of Vascular and Interventional Radiology  
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SOBRICE – Brazilian Society of Interventional Radiology and Endovascular Surgery  
CAIR – Canadian Association for Interventional Radiology  
GACIR – Georgian Association of Cardiovascular and Interventional Radiology  
HKSIR – Hong Kong Society of Interventional Radiology  
ISVIR – Indian Society of Vascular and Interventional Radiology  
ILSIR – Israeli Society of Interventional Radiology  
JSIR – Japanese Society of Interventional Radiology  
KSIR – Korean Society of Interventional Radiology  
PAIRS – Pan Arab Interventional Radiology Society  
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## Foreword

Interventional Radiology (IR) continues to rapidly grow and evolve as one of the newest branches of medicine. It is essential that interventional radiologists of the future develop and maintain both clinical and technical skills in carrying out safe and effective treatments for patients<sup>1</sup>. This needs to be reflected in training requirements, curriculum-based training and certification of training.

The aim of this revised IR curriculum is to ensure that the highest quality training standard is achieved for all those performing IR procedures within Europe and beyond. An aim that is shared with the European Union of Medical Specialists (UEMS) who “committed itself to contribute to the improvement of medical training at the European level through the development of European Standards in the different medical disciplines. No matter where doctors are trained, they should have at least the same core competencies.”<sup>2</sup> To this end, this document sets out to cover the requirements of the European Standards of Postgraduate Medical Specialist Training (formally chapter 6 of the Charter on Post Graduate Training).

The document seeks to not only support national radiology training programmes but also to harmonize training in IR worldwide so that patients and those commissioning health care are reassured that all IRs trained according to this curriculum have achieved a minimum standard and are competent and safe to practise. The curriculum has been used as the foundation for setting the syllabus for the certification of training – the European Board of Interventional Radiology (EBIR) examination. This assessment was endorsed by the UEMS CESMA in 2017 after a thorough auditing process.

With such a wide range of specialist practice, it is acknowledged that not all interventional radiologists will carry out every procedure listed in the syllabus. Nonetheless, the specific modules of the syllabus can be followed to deliver the appropriate training in these specialist areas of IR. It is also acknowledged that diagnostic radiology trainees will also perform many non-vascular procedures such as biliary intervention, GU intervention, biopsy drainage and ablation as covered under the radiology ETR (2018).

Apart from trainees, the document also outlines the requirements for IR trainers and IR training institutions. The latter need to meet a certain basic standard so that trainers will be appropriately qualified, there is exposure to the range of procedures in the curriculum and there are sufficient volumes to achieve competency. As new chapters, quality assurance, governance as well as professionalism and ethics have been included, only to name a few.

We would like to sincerely thank Roberto Cazzato, Patrick Chevallier, Laura Crocetti, Rok Dežman, Dimitrios Filippiadis, Belarmino Gonçalves, Mohamad Hamady, Roberto Iezzi, Marcus Katoh, Michael Lee, Andreas Mahnken, Stefan Müller-Hülsbeck, Rupert Horst Portugaller, Anthony Ryan, Maria Tsitskari, José Urbano, Otto van Delden, and the CIRSE office for their invaluable help in producing this document. Our thanks equally go to the members of the previous task forces whose work was essential for publishing the first and second edition of the European Curriculum and Syllabus for Interventional Radiology.

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<sup>1</sup> *The Provision of Interventional Radiology Services in Europe: CIRSE Recommendations. Tsetis D, Uberoi R, Fanelli F, Roberston I, Krokidis M, van Delden O, Radeleff B, Müller-Hülsbeck S, Szerbo-Trojanowska M, Lee M, Morgan R, Brountzos E, Belli AM. Cardiovasc Intervent Radiol. 2016 Apr; 39(4): 500-6. doi: 10.1007/s00270-016-1299-0. Epub 2016 Feb 9*

<sup>2</sup> *Template structure: Training Requirements for the Specialty of...;*  
<https://www.uems.eu/areas-of-expertise/postgraduate-training/european-standards-in-medical-training>

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# Table of contents

<b>1</b>	<b>CURRICULUM</b>	<b>7</b>
<b>1.1</b>	<b>Objectives</b>	<b>10</b>
<b>1.2</b>	<b>Training requirements for trainees</b>	<b>10</b>
1.2.1	Content of training and learning outcomes	11
1.2.2	Organization of training	14
1.2.2.1	Schedule of training	14
1.2.2.2	Curriculum of training	15
1.2.2.3	Technical skills	15
1.2.2.4	Assessment and evaluation	16
1.2.2.5	Governance	17
1.2.2.6	Recommendations for the maintenance of competence	17
<b>1.3</b>	<b>Training requirements for trainers</b>	<b>18</b>
1.3.1	Process for recognition as trainer	18
1.3.2	Quality management for trainers	19
<b>1.4</b>	<b>Training requirements for training institutions</b>	<b>20</b>
1.4.1	Process for recognition as training centre	20
1.4.2	Quality management within training institutions	22
<b>1.5</b>	<b>General topics in IR</b>	<b>23</b>
1.5.1	The IR team	23
1.5.2	IR clinical practice	23
1.5.3	Professionalism and ethics	24
<b>1.6</b>	<b>Curriculum review</b>	<b>26</b>
<b>2</b>	<b>SYLLABUS</b>	<b>27</b>
	<b>Section A</b>	
<b>2.1</b>	<b>Fundamental topics in interventional radiology</b>	<b>29</b>
2.1.1	Core syllabus	29
2.1.2	Using the syllabus for the EBIR examination	30
2.1.3	Patient safety	34
2.1.4	Recognizing and reducing occupational hazards	36
2.1.5	The interventional radiology team	40
2.1.6	Interventional radiology clinical practice	40
2.1.7	Pharmacology of interventional radiology	41
2.1.8	Imaging	42
2.1.9	Core procedures in interventional radiology	43

<b>2.2</b>	<b>Specific topics in interventional radiology</b>	<b>44</b>
	<b>Section B</b>	
<b>2.2.1</b>	<b>Vascular diagnosis and intervention</b>	<b>44</b>
2.2.1.1	Arterial disease	44
2.2.1.1.1	Peripheral arterial disease	44
2.2.1.1.2	Aortic and upper extremity arterial disease	49
2.2.1.1.3	Acute aortic syndromes and aneurysmal disease	49
2.2.1.1.4	Supra-aortic arterial disease	52
2.2.1.1.5	Stroke	52
2.2.1.1.6	Vascular malformations	53
2.2.1.1.7	Vascular trauma	54
2.2.1.1.8	Visceral arterial disease	55
2.2.1.1.9	Arterial problems in obstetrics and gynaecology	58
2.2.1.2	Prostate artery embolization (PAE)	59
2.2.1.2.1	Priapism	59
2.2.1.3	Venous disorders	60
2.2.1.3.1	Venous thrombosis and insufficiency	60
2.2.1.3.2	Pulmonary thromboembolic disease	61
2.2.1.3.3	Disease of the superior and inferior vena cava	61
2.2.1.3.4	Portal and hepatic venous interventions	62
2.2.1.3.4.1	Portal venous disease and transjugular intrahepatic portosystemic shunt (TIPS) and balloon-occluded retrograde transvenous obliteration (BRTO)	62
2.2.1.3.4.2	Hepatic venous disease and Budd-Chiari syndrome	63
2.2.1.3.5	Gonadal venous interventions	63
2.2.1.3.6	Haemodialysis vascular access	64
2.2.1.3.7	Central venous access	65
2.2.1.3.8	Venous sampling	67
	<b>Section C</b>	
<b>2.2.2</b>	<b>Non-vascular interventions in the chest, gastrointestinal tract and hepatobiliary systems</b>	<b>67</b>
2.2.2.1	Image-guided biopsy and drainage (including transjugular liver biopsy but excluding MSK)	67
2.2.2.2	Lymphatic embolization	68
2.2.2.3	Image-guided aspiration and drainage of collections including abscesses	68
2.2.2.4	Gastrointestinal interventions	69
2.2.2.4.1	Enteral tube placement (gastrostomy, gastrojejunostomy, jejunostomy, caecostomy)	69
2.2.2.4.2	Gastrointestinal stenting	70
2.2.2.5	Hepato-pancreatico-biliary (HPB) intervention	71
	<b>Section D</b>	
<b>2.2.3</b>	<b>Intervention of the genito-urinary tract and renal transplants</b>	<b>73</b>
2.2.3.1	Pelvic/lyceal and ureteric obstruction	73
2.2.3.2	Renal stone disease	75
2.2.3.3	Renal masses and perirenal collections	75
2.2.3.4	Genito-urinary interventions	76
2.2.3.4.1	Acute prostatitis (abscess)	76
2.2.3.5	Renal transplant interventions	76

---

<b>Section E</b>	
<b>2.2.4 Intervention of the musculoskeletal system</b>	<b>77</b>
2.2.4.1 Image-guided biopsy	77
2.2.4.2 Percutaneous ablation of bone and soft tissue lesions	78
2.2.4.3 Intra-articular injections under image guidance	78
2.2.4.4 Percutaneous osteoplasty	78
2.2.4.5 Spinal intervention	79
2.2.4.5.1 Interventions in vertebral body compression fractures (VBCF)	79
2.2.4.5.2 Spinal procedures for disc, nerves and facet joints	79
<b>Section F</b>	
<b>2.2.5 Interventional oncology (IO)</b>	<b>80</b>
2.2.5.1 Fundamental IO	80
2.2.5.2 Vascular interventional oncology	82
2.2.5.3 Non-vascular interventional oncology	85
2.2.5.3.1 Malignant chest and abdominal disease	85
2.2.5.3.2 Malignant biliary disease (see also HPB section 2.2.2.4)	86
2.2.5.3.3 Prostate cancer	86
2.2.5.3.4 Malignant musculoskeletal disease	87
<b>ABBREVIATIONS/ACRONYMS</b>	<b>88</b>
<b>APPENDIX 1: Different types of studies and trials</b>	<b>92</b>
<b>APPENDIX 2: Common terminology used in oncology treatments</b>	<b>94</b>





# 1 CURRICULUM



<b>1.1 Objectives</b>	<b>10</b>
<b>1.2 Training requirements for trainees</b>	<b>10</b>
<b>1.3 Training requirements for trainers</b>	<b>18</b>
<b>1.4 Training requirements for training institutions</b>	<b>20</b>
<b>1.5 General topics in IR</b>	<b>23</b>
<b>1.6 Curriculum review</b>	<b>26</b>





# Introduction

The European Curriculum and Syllabus for Interventional Radiology (IR) doubles as the European Training Requirements (ETR) for Interventional Radiology and is intended to promote excellence and harmonization of medical education and training in interventional radiology in Europe. The **curriculum** incorporates the three-part structure of the European Standards of Postgraduate Medical Specialist Training template derived from chapter 6 of the Charter on Post Graduate Training. This was adopted as early as 1994 by the UEMS, aiming to provide the recommendations at the European level for good medical education.

The **syllabus** comprises the specific theoretical and practical knowledge, clinical skills and competencies interventional radiologists should acquire throughout their training. This ETR primarily concerns itself with body IRs and does not include head and neck IR except in special circumstances where body IRs support services by performing selected interventions such as stroke thrombectomy and carotid stenting.

The IR curriculum outlines a framework for the process of training and the organization thereof. It is an educational guide to be implemented, interpreted and evaluated by local faculties, radiology schools and local training programme committees. Successful completion of the training pathway can be achieved through summative and formative assessment. The evaluation tool, the European Board of Interventional Radiology (EBIR) is available to all that qualify through their specialist training in radiology and the acquisition of the competencies described in this document.

The first edition of the curriculum was published in 2013 and updated with a second edition in 2017. Since that time, there has been significant expansion of interventional radiology practice supported by new concepts in science, requiring new interventional radiology skills, knowledge and competencies. The European Board of Interventional Radiology examination has also developed in terms of quality and accessibility and incorporates the significant changes that have taken place in IR practice.

The revised third edition of the curriculum is designed to reflect and incorporate these changes and new developments and the working group was a joint effort by members of CIRSE and the UEMS IR division.

## 1.1 Objectives

The IR curriculum aims to support the highest quality of training to ensure that all interventional radiologists have the skills, knowledge and competencies to provide a high-quality service, enabling them to take primary clinical responsibility for the patients they treat and to fulfil their role safely and effectively according to the principles outlined in the CIRSE clinical practice manual<sup>3</sup>. It also aims to ensure that all interventional radiologists show medical professionalism by supporting the values expressed in the Global Statement Defining Interventional Radiology<sup>4</sup>.

The programme provides the educational experiences necessary to fulfil the Essential Roles and Key Competence of Specialist Physicians as defined in CanMEDS 2000<sup>5</sup> and Guide to professional conduct and ethics for registered medical practitioners (amended) 2019<sup>6</sup>.

## 1.2 Training requirements for trainees

### **IR trainee responsibilities will include the following:**

- Should practise within their competence level in the training programme
- Practise in accordance with the standards expected of them in the unit to which they are attached
- Refer to more experienced IR colleagues/trainers/mentors when uncertain as to the best management of a particular patient
- Practise according to prevailing professional standards and requirements
- Practise self-directed learning shaped by feedback from trainers/mentors and/or learning from clinical practice/procedures under the supervision of trainers
- Keep a logbook of procedures performed during their training period
- Have knowledge of the educational requirements of the training programme to which they are attached
- Initiate meetings with their supervisor/mentor to regularly discuss and receive feedback on their progress in the training programme
- Fulfil all learning and assessment requirements of the training programme
- Attend teaching sessions organized within the training programme
- Act as a role model and mentor for junior doctors

<sup>3</sup> Mahnken, A.H., Boullosa Seoane, E., Cannavale, A. et al. *CIRSE Clinical Practice Manual. Cardiovasc Intervent Radiol* 44, 1323–1353 (2021). (<https://www.cirse.org/education/standards-of-practice/clinical-practice-manual/>).

<sup>4</sup> *Global Statement Defining Interventional Radiology. 2010 Cardiovasc Intervent Radiol*; 33:672-674

<sup>5</sup> Frank JR, Jabbour M, Tugwell P, et al. *Skills for the new millenium: report of the societal needs working group, CanMEDS 2000 Project. Annals Royal College of Physicians and Surgeons of Canada* 1996; 29:206-216

<sup>6</sup> *Medical Council Ireland. (2019) Guide to professional conduct and ethics for registered medical practitioners (amended). Dublin: Medical Council.*

## 1.2.1 Content of training and learning outcomes

### a) Theoretical knowledge, practical and clinical skills

Theoretical knowledge assessed within the syllabus and associated curriculum of training for interventional radiology:

- Knowledge
- Clinical and technical skills
- Attitudes
- Communication and interpersonal skills
- Teamwork and collaboration
- Patient relations
- Management

### b) Competencies

Clinical competencies in interventional radiology

The curriculum, including the training and assessments/evaluation of competence and knowledge, should be geared towards producing well-rounded clinicians whose practice will reflect:

- Understanding of the disease processes relevant to their specialty interest
- Understanding of the respective disease prognosis, with and without treatment
- Understanding of the respective treatment alternatives
- Understanding of the indications, contraindications, limitations and expected outcomes of IR procedures including complications
- Understanding of radiation protection and dose limitation
- Ability to perform IR procedures responsibly
- Ability to recognize and manage complications of IR procedures
- Ability to obtain consent from patients by explaining the above in a clear manner
- Ability to select the appropriate patients for treatment
- Ability to clinically manage patients under their care
- Ability to work within multi-disciplinary teams (MDTs) for optimal treatment strategy
- Ability to recognize their limitations and refer cases accordingly

### Levels of competencies within the IR curriculum

The following competencies will need to be achieved in each disease specific area. It is desirable to have a stratification of escalating competencies and a formal process of assessing these during training. The above will follow the formula as shown below:

- Knowledge
- Clinical skills
- Technical skills

“Knowledge” competencies will be assessed sequentially for levels as:

- Knows of
- Knows basic concepts
- Knows generally
- Knows specifically and broadly

“Clinical and technical skills” will be assessed sequentially for levels as:

- Level 1 – Has observed
- Level 2 – Can do with assistance
- Level 3 – Can do but may need assistance
- Level 4 – Competent to do without assistance including dealing with complications

To achieve level 4, the trainee must be able to work at a level expected from a specialist in the field.

The competencies expected from an IR trainee are listed in the table below for years 1 and 2 of dedicated IR training:

<b>Dedicated IR training</b>	<b>Competency Level</b>	
	<b>Year 1</b>	<b>Year 2</b>
<b>Fundamental topics in IR</b>		
Patient safety . . . . .	3	4
Recognizing and reducing occupational hazards . . . . .	4	4
The interventional radiology team . . . . .	4	4
Interventional radiology clinical practice . . . . .	4	4
Pharmacology of interventional radiology . . . . .	4	4
Imaging . . . . .	4	4
Core procedures in interventional radiology . . . . .	3	4
<b>Vascular diagnosis and intervention</b>		
Arterial disease . . . . .	3	4
Peripheral arterial disease . . . . .	3	4
Aortic and upper extremity arterial disease . . . . .	3	4
Acute aortic syndromes and aneurysmal disease . . . . .	3	3
Supra-aortic arterial disease . . . . .	2	3
Stroke . . . . .	2	3
Vascular malformations . . . . .	2	3
Vascular trauma . . . . .	3	4
Visceral arterial disease . . . . .	2	3
Arterial problems in obstetrics and gynaecology . . . . .	3	4
Prostate artery embolization (PAE) . . . . .	2	3
Priapism . . . . .	1	2
Venous disorders . . . . .	3	4
Venous thrombosis and insufficiency . . . . .	3	3
Pulmonary thromboembolic disease . . . . .	2	3
Disease of the superior and inferior vena cava . . . . .	3	4
Portal and hepatic venous interventions . . . . .	2	3
Portal venous disease and transjugular intrahepatic portosystemic shunt (TIPS) and balloon-occluded retrograde transvenous obliteration (BRTO) . . . . .	2	3
Hepatic venous disease and Budd-Chiari syndrome . . . . .	2	3
Gonadal venous interventions . . . . .	3	4
Haemodialysis vascular access . . . . .	3	4
Central venous access . . . . .	4	4
Venous sampling . . . . .	3	3

<b>Dedicated IR training</b>	<b>Competency Level</b>	
	<b>Year 1</b>	<b>Year 2</b>
<b>Non-vascular interventions in the chest, gastrointestinal tract and hepatobiliary systems</b>		
Image-guided biopsy and drainage (including transjugular liver biopsy but excluding MSK) . . . . .	4	4
Lymphatic embolization . . . . .	1	2
Image-guided aspiration and drainage of collections including abscesses . . . . .	4	4
Gastrointestinal interventions . . . . .	2	3
Enteral tube placement (gastrostomy, gastrojejunostomy, jejunostomy, caecostomy) . . . . .	2	4
Gastrointestinal stenting . . . . .	2	3
Hepato-pancreatico-biliary (HPB) intervention . . . . .	2	3
<b>Intervention of the genito-urinary tract and renal transplants</b>		
Pelvic/lyceal and ureteric obstruction . . . . .	4	4
Renal stone disease . . . . .	2	3
Renal masses and perirenal collections . . . . .	3	4
Genito-urinary interventions . . . . .	3	4
Acute prostatitis (abscess) . . . . .	3	4
Renal transplant interventions . . . . .	2	3
<b>Intervention of the musculoskeletal system</b>		
Image-guided biopsy . . . . .	3	4
Percutaneous ablation of bone and soft tissue lesions . . . . .	2	3
Intra-articular injections under image guidance . . . . .	2	4
Percutaneous osteoplasty . . . . .	2	3
Spinal intervention . . . . .	2	3
Interventions in vertebral body compression fractures (VBCF) . . . . .	2	3
Spinal procedures for disc, nerves and facet joints . . . . .	2	3
<b>Interventional IO</b>		
Fundamental IO . . . . .	3	4
Vascular interventional oncology . . . . .	2	3
Non-vascular interventional oncology . . . . .	3	3
Malignant chest and abdominal disease . . . . .	2	3
Malignant biliary disease (see also HPB section 2.2.2.4) . . . . .	2	2
Prostate cancer . . . . .	2	3
Malignant musculoskeletal disease . . . . .	2	3

**Table 1: Competencies expected of an IR trainee**

## 1.2.2 Organization of training

### 1.2.2.1 Schedule of training

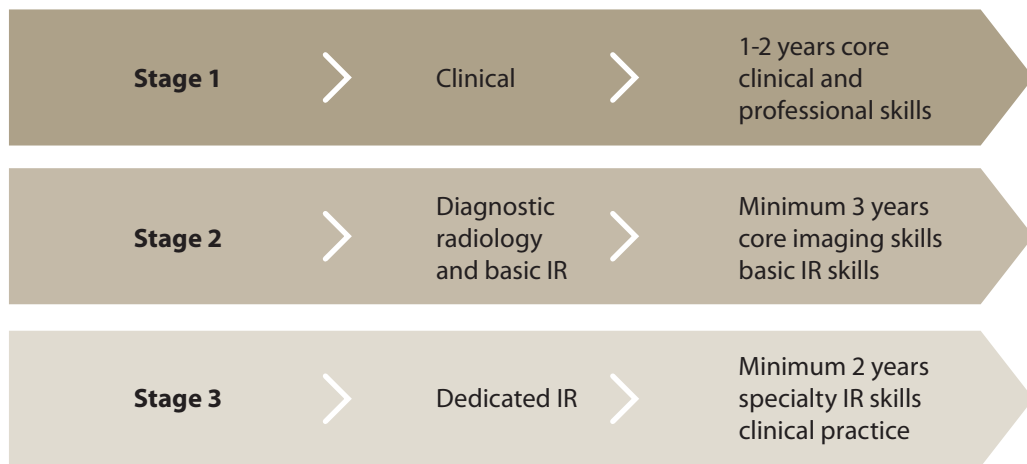
Training practices are not uniform throughout Europe and will depend on the national structures and processes.

The schedule of radiology training may also differ between European countries but ideally should encompass 3 stages as follows:

Stage 1: Development of diagnostic and ward-based clinical skills; learning of basic clinical signs, symptoms and principles (indicative duration 1-2 years).

Stage 2: Acquisition of imaging interpretative skills, radiation safety, participation in MDTs, communication skills, professionalism and ethical skills. Concomitant acquisition of technical IR skills will also take place including frequently performed basic procedures listed in Table 1 along with reinforcing clinical skills (minimum duration 3 years).

Stage 3: Development of transferable IR skills and special interest skills (minimum duration 2 years).



**Table 2: Ideal IR schedule of training**

#### Basic IR skills training in stage 2

- Procedural consent
- Patient safety and time out
- Communication
- Conscious sedation
- Local anaesthesia
- Indications for interventional procedures
- Appropriate imaging protocols, modalities and preparation for patients referred for interventional radiology procedures (in stroke, gastrointestinal bleeding, post-partum haemorrhage, abscess drainage, trauma, urinary and biliary obstruction)
- Abscess drainage
- Image-guided pleural aspiration
- Image-guided pleural drain insertion



- Image-guided paracentesis
- Image-guided biopsy (focal and non-focal liver, renal, prostate, thyroid and soft tissue)
- Venous access
- Adverse event management in radiology
- Adverse event reporting and quality meetings relevant to interventional radiology
- Follow up imaging protocols and imaging interpretation for patients that had interventional radiology procedures

While this ideal programme may not be currently possible in every European country, the common goal of specialist training should be the development of professional competency as described in the following paragraphs.

### 1.2.2.2 Curriculum of training

Entry into specialist training in IR will be after a suitable period of training in diagnostic radiology and a suitable period of training in clinical medicine/surgery (i.e. in many countries this is two years). Training in diagnostic radiology is required as a core skill to provide the IR with the skills required to investigate and diagnose patients as well as understanding the principles of imaging guidance.

The curriculum for the initial structured common training programme is in line with the revised ESR European Training Curriculum Level I + II and is available at the website of the European Society of Radiology, who provide a template for the first 3 years of training<sup>7</sup>. Subspecialty training builds on the core knowledge and skills of diagnostic radiology to develop the competencies to treat patients. The European Curriculum and Syllabus for Interventional Radiology defines the specific knowledge and skills required for trainees in IR over a two-year period and is intended to be combined with modular training in diagnostic radiology.

### 1.2.2.3 Technical skills

The trainee will develop the necessary practical skills to perform key IR procedures independently. Additional skills will be acquired to a variable degree. This will lead to achievement of different levels of competence in performing a range of procedures. Training should cover the full range of the specialty of IR leading to a goal of fully independent practice at the completion of training. To develop more advanced skills in IR depending on hospital need, increased competency levels may be required in specific diseases (see table 1: Competencies expected of an IR trainee).

Trainees will achieve the competencies described in the curriculum through a variety of learning methods:

#### **Work-based experience**

This is the apprenticeship model where there is gradual reduction in supervision according to increasing competence as judged by trainers. More responsibility is taken by the experienced trainee in performing the procedures that form the case mix of their training, but always with the appropriate level of supervision.

This should also include:

- Participation in ward rounds and outpatient clinics to understand the pre- and post-procedural care and management issues of patients undergoing IR procedures
- Involvement in multidisciplinary meetings, audits, morbidity meetings and on-call work

<sup>7</sup> <https://www.myesr.org/education/training-curricula>

**Formal teaching**

Formal teaching can be provided by:

- Lectures and small group teaching, journal clubs, clinical governance meetings, research and audit projects
- Attendance at national meetings and courses
- Attendance at international scientific society meetings and courses. Courses and workshops of the European School of Interventional Radiology (ESIR) are highly recommended. Each year a broad variety of IR topics are offered in different European cities (check the CIRSE events page for upcoming courses)<sup>8</sup>
- Practise on simulators and virtual reality models

**Independent self-directed learning**

Suggested activities include:

- Preparation for assessments and examinations
- Reading scientific, peer-reviewed journals; journal clubs
- Utilization of society and institutional sponsored web-based material (e.g. CIRSE Library, CIRSE Academy)
- Maintenance of personal portfolio and logbooks which should document the skills and experience attained and facilitate reflective learning

Trainees should be encouraged to develop an understanding of research methodology. All trainees should be able to assess and understand published work. Ideally, the opportunity for performing clinical and/or basic research should be available to the trainee with appropriate faculty supervision. Appropriate qualified faculty should supervise specific research projects as applicable. Protected time should be available within the two-year programme so that a trainee can participate in research.

## 1.2.2.4 Assessment and evaluation

Both formal summative assessment and continuous workplace-based assessment are recommended. A minimum of one workplace assessment is required for each year of training. The feedback generated by the trainer from these encounters should facilitate improvements in the performance of trainees by identifying strengths and specific areas that require further work.

The annual review will result in one of the following outcomes:

- Achieving progress and competencies at the expected rate
- Development of specific competencies required – additional training time not required
- Development of specific competencies required – additional training time required
- Inadequate progress – additional training time required
- Release from training programme

**a) Continuous assessment**

Regular appraisal with review of logbooks and constructive feedback by the IR responsible for training is not only pivotal to demonstrate up-to-date competence but is also important for a continuous learning process.

<sup>8</sup> <http://www.cirse.org>

**b) Workplace based assessment**

This assesses daily practice. The following recommended tools can be utilized:

- Case-based discussion (CBD)
- Direct observation of practice and procedures (DOPP)
- Objective structured clinical examination (OSCE)
- Peer assessment tools (PAT, 360-degree appraisal)
- IR specific procedure-based assessments (PBAs)
- Review of complications

**c) Assessment by formal examination**

Elements of IR should be tested as part of the national radiology examinations but these will be at a very basic level. Participation in the European Board of Interventional Radiology (EBIR) tests knowledge through clinical case scenarios with sequential questions and an IR clinical practice examination with single best answer questions. Passing the EBIR provides objective evidence of attainment of a satisfactory level of knowledge.

### 1.2.2.5 Governance

The national authority in each European country is a responsible body for the recognition and certification of training. In the subsequent sections from 1.2.2.6 – 1.5.3 there is guidance on developing and setting up the appropriate quality standards for ensuring good clinical governance and professional practice for IRs.

### 1.2.2.6 Recommendations for the maintenance of competence

To maintain competence, regular peer review and appraisals should take place. IRs are required to attend national and international scientific IR meetings regularly.

Participating in relevant courses for trained IRs encourages continuous advancement of skills and knowledge. Online courses and webinars of the CIRSE Academy or courses and workshops of the European School of Interventional Radiology (ESIR) are designed for this purpose and are particularly recommended.

Even though device-oriented industry courses represent a convenient method for acquiring a specific technique or experience with a particular device, they do not compare with training in a hospital under supervision of an experienced IR. Completion or “graduation” certificates attained at the end of such courses do not correspond to formalized credentialing standards endorsed by the respective scientific specialty societies and other national bodies responsible for training<sup>9</sup>.

<sup>9</sup> *Society of Interventional Radiology Position Statement: Mini Training Courses in Interventional Radiology Techniques 2010. SIR.*

## 1.3 Training requirements for trainers

### 1.3.1 Process for recognition as trainer

#### a) Qualifications and experience

Recognition across the EU as regards competence to be a trainer is covered by Directive 2005/36/EC (Paragraph C2/20) (updated 10/12/21)<sup>10</sup>. Trainers should be fully trained interventional radiologists or radiologists trained in IR as defined by their national postgraduate and credentialing bodies and fully registered with their national medical council. It is recommended that their training in IR be additionally certified by the European Board of Interventional Radiology (EBIR) examination. Relevant national requirements pertaining to training and accreditation to be a trainer, and subsequent appraisal, should be satisfied.

Trainers should serve as positive role models with respect to good medical practice and all aspects of professionalism. Trainers should be clinically experienced with a high level of competence. Specific additional training in clinical education skills is highly desirable and attendance at “train the trainers” or “teach the teachers” meetings should be undertaken. Local responsible bodies for training should set up these meetings for IR trainers to advise on learning theory and techniques focused on conceptual learning and behaviour.

Trainers are responsible for engaging positively with training, support and appraisal relating to their role, and are accountable for the resources they receive to support education and training. Trainers must also have dedicated time to devote to their training commitment and regular local lectures and case discussion on the IR Curriculum/ETR should be undertaken with trainees.

Trainers are expected to maintain and continue to develop their knowledge and skills on an ongoing basis via continuing professional development (CPD). Trainers should be supported to pursue certification of their training skills via higher diplomas/master’s programmes if so motivated.

Expertise in competency-based teaching and assessment are still limited and acquisition of these skills should be encouraged.

Ideally trainers should provide evidence of scholarly activities (clinical and/or basic research, publications in peer reviewed journals and participation in interventional radiology scientific meetings) involving the trainees under their supervision.

#### b) Core competencies

Core competencies for trainers should rely on teaching qualities that define teaching performance such as

- Creating a positive learning climate
- Professional attitude towards trainees
- Clear communication of learning goals based on this IR Curriculum/ETR
- Regular evaluation of trainees
- Regular feedback to trainees (as outlined by the System for Evaluation of Teaching Qualities (SETQ))<sup>11</sup>

<sup>10</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02005L0036-20211210>

<sup>11</sup> Lombarts KM, Bucx MJ, Arah OA. Development of a system for the evaluation of the teaching qualities of anaesthesiology faculty. *Anesthesiology*. 2009 Oct;111(4):709-16

## 1.3.2 Quality management for trainers

Training programmes in IR are the responsibility of an institution accredited in the field by the relevant national authority. Trainers must have enough time in their agreed job plans to meet their educational responsibilities so that they can support their trainees and carry out their role in a way that promotes safe and effective care and a positive learning experience. The education division of the institution monitors the validity of the workplace's accreditation and its adherence to the national training legislation, including the maximum number of trainees per trainer and the duration of training.

Educational support of trainers should be funded by their department and institution, permitting them to access appropriate professional development and educational training support, promotion of skill development, and encouragement of educational innovations among faculty e.g. using model-based simulation or endovascular simulators. These supports may be supplemented by national bodies and the Section and Board of Radiology of UEMS.

Trainers will require secretarial and administrative support.

The educational work of trainers should be appraised annually within their department/institution with the use of an objective, validated tool. The results of these appraisals may be used as part of re-accreditation of the workplace for training.

SETQ recommends that validated questionnaires completed by residents and faculty be used as tools for assessing teaching performance. The questionnaires should evaluate the 5 teaching qualities listed above.

The UEMS Council of European Specialist Medical Assessments (CESMA) has defined recommendations on the development and organization of assessment of trainers, in addition to their selection and training. Trainers have to set realistic aims and objectives for a rotation or training period. The trainer has to supervise the day-to-day work of the trainee in the radiology department, in the outpatient clinic and in the interventional suite. The trainer has to evaluate the trainees' procedural progress at the end of each rotation or training period and ensure that the assessments and reports are documented and signed both by the trainer and the trainee.

A trainer should be:

- Familiar with all aspects of the UEMS ETR / European Curriculum and Syllabus for IR as it relates to practise within his/her country
- Experienced in teaching and in supporting learners
- Skilled in identifying the learning needs of the trainees and in guiding the trainees to achieve their educational and clinical goals
- Able to recognize trainees whose professional behaviours are unsatisfactory, and initiate supportive measures as needed
- Trained in the principles and practice of medical education and follow regular updating in educational and team leader skills
- Have leadership skills to guide the trainee

## 1.4 Training requirements for training institutions

Training institutions offering postgraduate education in interventional radiology should be recognized and accredited by the national competent authority. Training institutions should ideally be attached to a university and should provide all of the training opportunities for the items in this IR Curriculum/ETR. If a training institution cannot provide the procedural experience for all of these IR Curriculum/ETR items, rotation to other training institutions will be required to achieve the broad coverage of the ETR required for IR trainees.

Training institutions should have access to the required surgical and medical disciplines available to allow the IR trainee to develop their skills in a team approach to patient care. A 24/7 emergency IR service should also be available on site.

Training institutions should also be capable of providing inpatient beds, outpatient clinic space and access to ambulatory care.

A European training institution must offer training that fits the European quality criteria and programmes suitable for the European IR ETR. Ideally it should take part in the educational European programmes (e.g. CIRSE Academy, ESIR courses, CIRSE webinars, CIRSE conferences such as ECIO, ET and CIRSE Annual Scientific meetings and IROS) and is a reference centre for training programmes.

### 1.4.1 Process for recognition as training centre

#### a) Requirement on staff and clinical activities

There should be a sufficient number of patients being treated within the unit as inpatients and outpatients with an appropriate case mix and volume to allow appropriate training as encompassed by the IR ETR. This may require shared training with other units and hospitals. There should be named trainers for all trainees who are professionally responsible for the educational needs of the trainee.

Training should be under the supervision of board-certified radiologists with significant experience and commitment to interventional radiology. Staffing within these units should be sufficient to allow a good ratio of trainers to trainees (maximum 1:2) to allow appropriate supervision and mentorship. Teaching staff should be motivated and ideally pursuing academic careers. In-house teaching should involve small group tutorials, lectures, skills training as well as one-to-one apprenticeship experience.

Case volume should comply with the logbook requirements to sit the EBIR at a minimum i.e.: The applicant must verify they have experience as the first operator, performing at least 250 IR procedures, 150 of which have to be interventions according to chapter 2.2.1 Vascular diagnosis and intervention and/or chapter 2.2.5.2 Vascular interventional oncology in the IR Curriculum/ETR.

Allied departments and specialties should be available within the training institution or institutional group to allow a multidisciplinary approach to patient care through multidisciplinary meetings as well as day to day consults. Required specialties should include:

Vascular Surgery  
General Surgery  
Urology  
Oncology and radiotherapy departments  
Gastroenterology  
Endocrinology  
Respiratory medicine  
Renal medicine  
Anaesthesiology  
Pathology and cytopathology  
24/7 emergency department  
Appropriate nursing and radiographic support both in and out of hours

**b) Requirement on equipment, accommodation**

Adequate space and accommodation for trainees should be available both in and out of hours. Training centres should provide access to journals and other e-learning aids. Access to a library containing the necessary IR books to facilitate training should be provided. Opportunities for research and training in research methodology are desirable. Training centres should also provide IT support to trainees as required. Space for practical learning of skills (e.g models and ultrasound machines to learn how to perform biopsy and drainage as well as simulation units for endovascular skills training should be provided either on or off site. AV equipment and rooms should be available to deliver the training programme.

An appropriate IR suite with full staffing containing a fixed C arm fluoroscopic unit capable of performing digital subtraction angiography (DSA) preferably with a flat panel detector is required. A laminar flow ventilation system is desirable. Access to cone beam CT and ultrasound in the interventional suite is highly desirable. Access to a technologist or physicist to monitor operator and patient doses is mandatory. Access to multi-slice CT, ultrasound and MR is mandatory for training. The equipment should comply with safety standards, should be in good technical condition and should be regularly serviced. A designated lead in radiation protection should be in place and monitored as per European standards. Access and support from other clinical services such as anaesthesiology should be available. The physical facilities and equipment for training should be evaluated regularly for their appropriateness and quality (accredited by the national competent authority; re-evaluation after 5 years).

## 1.4.2 Quality management within training institutions

### Accreditation

Recognition of teachers and training institutions at a national level: the training in radiology/interventional radiology is regulated by national authorities/national boards, which set standards in accordance with national rules and EU legislation. The standard for recognition of training institutions (training centres), teachers and trainers are defined by national authorities, in accordance with national rules and EU legislation.

It is recommended that accreditation should be performed on a 5-year cycle by a competent, independent authority co-ordinated by the national training authority.

Accreditation of training institutions should include the following:

Number and type of IR examinations (to ensure the trainee is exposed to the full range of items in the curriculum)

Trainee access to the full range of imaging, interventional techniques and clinical practice

Adequacy of trainer-trainee ratio

Teaching programmes provided

Teaching material available

Research activity of trainees

Clinical governance

Regular assessment of trainees

### Workforce planning

Workforce planning is under the jurisdiction of each member state according to their needs for IR specialists. However, workforce planning should be initiated by the radiology training body and should be based on the provision of safe care. Planning should take into consideration demographic changes in population, ageing, changing treatment modalities and workload.

### Internal quality programmes

The training institution must have an internal system of medical audit or quality assurance. There should be written guidelines with regard to patient care, patient consent, referrals, medical records, procedural documentation, vacation time, trainee work schedules and attendance at conferences or educational events. There should be regular morbidity and mortality meetings and structured procedures for incident reporting.

The hospital should have committees in place for quality control of infection, risk management and overall quality. Training in risk management should also be provided.

### Transparency of training programmes

Yearly anonymized evaluation of the training institution should be requested from the trainees and evaluated by the national training authority with feedback to individual training institutions provided.

Training programmes should be published and the activities registered in a logbook approved by national authorities ideally based on the requirements for obtaining the European Board of Interventional Radiology.



## 1.5 General topics in IR

The following elements are central to safe and effective IR practice.

### 1.5.1 The IR team

Understanding and promoting a team environment and recognition of the roles of clinical partnerships with other specialists including oncologists, surgeons, physicians, radiographers/technicians, nurses and other assistants in IR practice and maintaining a good professional relationship are essential to promote good working practices.

### 1.5.2 IR clinical practice

An IR should act as the patient's primary doctor and be clinically responsible for the patient whilst under their care. The IR should evaluate patients before and after a procedure, obtain valid consent and communicate effectively with referring physicians and patients and develop strategies to deal with complex clinical situations and difficult attitudes. Patient treatment should be based on the principles of evidence-based medicine and be in accordance with national and international guidelines, when available. All research in IR should be in line with the international rules of Good Clinical Practice<sup>12</sup>:

The IR should inform patients about the risks of the procedure and about possible alternative treatment options both on the ward and outpatient clinical environments.

The Clinical Practice in IR manual gives guidance for providing a comprehensive approach to patient care, emphasising the role of IRs as specialists assessing and treating organ systems or diseases and offers practical guidance on principles of clinical care<sup>13</sup>. Numerous well-structured forms for gathering data on patient or social history and conducting examinations are part of its content.

<sup>12</sup> EMEA ICH Topic E(R2) Guideline for Good Clinical Practice. EMA/CHMP/ICH/135/1995, June 201, [http://www.ema.europa.eu/docs/en\\_GB/document\\_library/Scientific\\_guideline/2009/09/WC500002874.pdf](http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2009/09/WC500002874.pdf)

<sup>13</sup> Mahnken, A.H., Boullosa Seoane, E., Cannavale, A. et al. CIRSE Clinical Practice Manual. *Cardiovasc Intervent Radiol* 44, 1323–1353 (2021). (<https://www.cirse.org/education/standards-of-practice/clinical-practice-manual/>)

## 1.5.3 Professionalism and ethics

As set out in the guidelines for good clinical practice and CanMEDS 2005<sup>14</sup>, IRs should show professionalism in the workplace at all times based on the three pillars of professionalism: partnership, practice and performance.

### Partnership encompassing the roles of communicator and collaborator

#### Trust

This is fundamental between IRs and their patients, IRs and their colleagues, the profession and society. Key to this is:

- Integrity and honesty in all aspects of their medical practice, including treating patients fairly, acting in good faith, and making decisions about providing or withholding treatment without discrimination
- Truthfulness both in communication with patients and colleagues, and in professional work such as record-keeping, running a practice, managing adverse events, and in research

#### Patient-centred care

Treat patients as individuals, take into account their personal preferences, goals and lifestyles, act with compassion and respect patients' dignity. Also support patients to make informed decisions about their own health and care.

#### Working together

- Listening to patients and colleagues and taking account of their views, knowledge, skills and experiences
- Where disagreements arise, you should try to resolve them through further discussion, showing respect for colleagues' or patients' opinions

#### Good communication

- Establish therapeutic relationships with patients/families
- Obtain and synthesize any relevant history from patients/families/communities and listen effectively
- Discuss appropriate information with patients/families and the health care team

#### Advocacy

- Act as an advocate for your patients and speak on behalf of individual patients to help make sure they receive appropriate healthcare
- Support all patients by promoting the fair distribution of limited resources and fair access to care

### Practice and being a leader

#### Caring when treating patients

Showing compassion, kindness and consideration to patients and those close to them, and making sure that patients' basic care needs, including nutrition and hydration, are met.

#### Confidentiality

Enabling patients to speak honestly and fully about their lives and symptoms.

<sup>14</sup> Frank, JR. (Ed). 2005. *The CanMEDS 2005 physician competency framework. Better standards. Better physicians. Better care.* Ottawa: The Royal College of Physicians and Surgeons of Canada.

**Promoting patient safety**

Complying with safety procedures, such as infection control measures and adverse incident reporting, raising concerns, protecting children and vulnerable people that directly affect your practice.

**Integrity**

Be truthful and act in patients' best interests at all times.

**Self-care**

IRs are entitled to good care and support from their colleagues and employers when they suffer ill health but ensure their own health does not cause patients harm.

**Practice management**

You should be satisfied with the systems that underpin your practice, for example record-keeping, and organization of rotas and cover arrangements, support good care of patients. Raise concerns if you believe that administration or other systems are impeding good patient care.

**Use of resources**

All doctors should use resources responsibly. You must consider the needs of all patients alongside your primary duty to your own patients.

**Conflicts of interest**

May happen where doctors, or their close family members, have financial interests in health or care providers, or in the medical devices or pharmaceutical industries. Where possible, avoid conflicts of interest that may affect, or be seen to affect, your clinical judgement. If you cannot, you should tell the patient and anyone else affected.

**Performance encompassing being a scholar and medical expert****Competence**

Strive to deliver the best possible care based on evidence, as far as it is available, by:

- Keeping up-to-date with developments in their field of practice and with clinical guidelines on best practice
- Critically appraising sources of medical information
- Contributing to development of new knowledge
- Engaging in continuing professional development (CPD) and in other formal and informal education, training and development
- Reviewing and reflecting on their activity levels and outcomes so they can identify and fix any problem areas within their practice
- Recognising areas of practice which they should not undertake without further training or supervision; and referring patients to a colleague if patients need investigation or treatment that involves knowledge or skills which fall outside of the doctor's clinical competence.

**Reflective practice**

Insight into professional practice is important to improve standards of care. This includes formal reviews through audit, informal reflection on how personal values may affect communication with patients, colleagues or others, and ultimately the care provided to patients.

**Acting as role models**

For medical students, trainees and other colleagues. Be aware of the impact your behaviour can have on others within the clinical environment.

**Teaching and training medical students and doctors new to practice**

This is key to the future provision of good care and to help provide formal or informal teaching, training and support for students, doctors and allied health staff.

## 1.6 Curriculum review

The Executive Committee of CIRSE and the UEMS IR Division are responsible for review of the curriculum. Formal review by a task force will take place every 3-5 years as IR training and education must reflect modern practice in a new and rapidly evolving field of medicine. The regular meetings of the Examination Board will allow opportunities for the curriculum to be discussed and amendments proposed in advance of any formal review.



# 2 SYLLABUS

Section A		
<b>2.1</b>	<b>Fundamental topics in interventional radiology</b>	<b>29</b>
2.1.1	Core syllabus	29
2.1.2	Using the syllabus for the EBIR examination	30
2.1.3	Patient safety	34
2.1.4	Recognizing and reducing occupational hazards	36
2.1.5	The interventional radiology team	40
2.1.6	Interventional radiology clinical practice	40
2.1.7	Pharmacology of interventional radiology	41
2.1.8	Imaging	42
2.1.9	Core procedures in interventional radiology	43
<b>2.2</b>	<b>Specific topics in interventional radiology</b>	<b>44</b>
Section B		
2.2.1	Vascular diagnosis and intervention	44
Section C		
2.2.2	Non-vascular interventions in the chest, gastrointestinal tract and hepatobiliary systems	67
Section D		
2.2.3	Intervention of the genito-urinary tract and renal transplants	73
Section E		
2.2.4	Intervention of the musculoskeletal system	77
Section F		
2.2.5	Interventional oncology (IO)	80



## 2.1 Fundamental topics in interventional radiology

The appropriate training of IRs is defined by the curriculum (see curriculum).

### 2.1.1 Core syllabus

For those radiologists who do not intend to specialize in IR but practise diagnostic radiology with an interest in basic IR skills, it is expected that access to parts of the modular training programme will be available. Such trainees should have a thorough knowledge of the performance and interpretation of diagnostic vascular techniques and a basic understanding of common IR procedures. All trainees should have this core set of skills before embarking on specialist IR training and will have obtained diagnostic skills during their initial diagnostic radiology training. This core syllabus also forms part of the specialized IR curriculum for practitioners who wish IR to be the major aspect of their professional practice.

The following fundamental principles will apply to all treatments within IR. At the conclusion of training, the trainee will have knowledge of the following aspects:

- Relevant anatomy for all the various organ systems in the body relevant to IR practice including embryology and normal variants
  - Understand the complementary roles of the various imaging modalities in the assessment planning, treatment and overall management of the system
- Epidemiology including expected outcomes
- Pathophysiology including:
  - Aetiology
  - Risk factors
- Clinical presentation
  - Be able to elicit any appropriate clinical history, perform physical examinations and assess and classify patients
- Investigation
  - Competency in requesting and interpreting laboratory tests relevant to interventional radiology with awareness of pre-analytical factors affecting specific laboratory test results and method limitations in interpreting results
  - Ensure proper management of biological samples obtained from fluid collection sampling to include sterile processing of samples, appropriate bottle selection for the various samples, appropriate volume of fluid for analysis and knowledge of transport systems of samples to the lab as well as traceability procedures. The trainee will also provide accurate and complete clinical information on all request forms
- Therapeutic options
  - Know the national licensing regulations of equipment and of materials
  - Know the indications, contraindications and understand the range of treatment strategies including medical, endovascular/interventional and surgical alternatives to a level sufficient to be able to discuss management with patients and formulate appropriate treatment plans within an MDT
  - Know the outcomes of interventional procedures including complications, how to avoid them and their management
  - Understand pre-, peri- and post-procedural drug requirements including the use of chemotherapeutic drugs used in oncology and embolizations
  - Patient selection and appropriate use of local sedo-analgesia and general anaesthesia
  - Have an understanding of assessment for anaesthetic risk and patient performance status to independently determine patient fitness with regards to undertaking interventions and thereby to determine the appropriateness of any such intervention

## 2.1.2 Using the syllabus for the EBIR examination

Based on this curriculum and syllabus, the EBIR strengthens careers in IR, helps to demonstrate clinical competence and skills, proves dedication to improving patient safety and promotes proficient practice of a broad range of minimally-invasive procedures.

The contents of the syllabus are used to create balanced examinations, taking into consideration each topic's relevance reflected through the overall frequency with which a procedure is carried out in Europe.

Every edition of the EBIR examination follows a plan, which in assessment theory is called the "examination blueprint", to make sure that relevant topics are examined often and those which may not occur in daily practice are examined less frequently.

To provide future candidates with maximum transparency and help in exam preparation, the EBIR Examination Committee has created an outline of the EBIR blueprint below.

Questions are drawn from 6 sections, A – F, and the traffic light system represents usage in the single examination blueprint.

- Green: this is a frequently encountered topic and will be tested at almost every examination
- Yellow: this a topic that will be tested in most examinations
- Red: this is a less frequently encountered topic and will be tested on rare occasions
- Purple: aspects of these topics are verified by the IR Programme Director, the Radiology Head of Department, a fellowship supervisor or a senior IR colleague by signing the EBIR Competency Checklist



## 2 SYLLABUS

### Section A

#### 2.1 Fundamental topics in interventional radiology

##### 2.1.1 Core syllabus

2.1.2 Using the syllabus for the EBIR examination

■ 2.1.3 Patient safety

■ 2.1.4 Recognizing and reducing occupational hazards

■ 2.1.5 The interventional radiology team

■ 2.1.6 Interventional radiology clinical practice

■ 2.1.7 Pharmacology of interventional radiology

■ 2.1.8 Imaging

■ 2.1.9 Core procedures in interventional radiology

#### 2.2 Specific topics in interventional radiology

### Section B

##### 2.2.1 Vascular diagnosis and intervention

■ 2.2.1.1 Arterial disease

■ 2.2.1.1.1 Peripheral arterial disease

■ 2.2.1.1.2 Aortic and upper extremity arterial disease

■ 2.2.1.1.3 Acute aortic syndromes and aneurysmal disease

■ 2.2.1.1.4 Supra-aortic arterial disease

■ 2.2.1.1.5 Stroke

■ 2.2.1.1.6 Vascular malformations

■ 2.2.1.1.7 Vascular trauma

■ 2.2.1.1.8 Visceral arterial disease

■ 2.2.1.1.9 Arterial problems in obstetrics and gynaecology

■ 2.2.1.2 Prostate artery embolization (PAE)

■ 2.2.1.2.1 Priapism

■ 2.2.1.3 Venous disorders

■ 2.2.1.3.1 Venous thrombosis and insufficiency

■ 2.2.1.3.2 Pulmonary thromboembolic disease

■ 2.2.1.3.3 Disease of the superior and inferior vena cava

■ 2.2.1.3.4 Portal and hepatic venous interventions

■ 2.2.1.3.4.1 Portal venous disease and transjugular intrahepatic portosystemic shunt (TIPS) and balloon-occluded retrograde transvenous obliteration (BRTO)

■ 2.2.1.3.4.2 Hepatic venous disease and Budd-Chiari syndrome

■ 2.2.1.3.5 Gonadal venous interventions

■ 2.2.1.3.6 Haemodialysis vascular access

■ 2.2.1.3.7 Central venous access

■ 2.2.1.3.8 Venous sampling

### Section C

#### 2.2.2 Non-vascular interventions in the chest, gastrointestinal tract and hepatobiliary systems

- 2.2.2.1 Image-guided biopsy and drainage (including transjugular liver biopsy but excluding MSK)
- 2.2.2.2 Lymphatic embolization
- 2.2.2.3 Image-guided aspiration and drainage of collections including abscesses
- 2.2.2.4 Gastrointestinal interventions
  - 2.2.2.4.1 Enteral tube placement (gastrostomy, gastrojejunostomy, jejunostomy, caecostomy)
  - 2.2.2.4.2 Gastrointestinal stenting
- 2.2.2.5 Hepato-pancreatico-biliary (HPB) intervention

### Section D

#### 2.2.3 Intervention of the genito-urinary tract and renal transplants

- 2.2.3.1 Pelvicalyceal and ureteric obstruction
- 2.2.3.2 Renal stone disease
- 2.2.3.3 Renal masses and perirenal collections
- 2.2.3.4 Genito-urinary interventions
  - 2.2.3.4.1 Acute prostatitis (abscess)
- 2.2.3.5 Renal transplant interventions

### Section E

#### 2.2.4 Intervention of the musculoskeletal system

- 2.2.4.1 Image-guided biopsy
- 2.2.4.2 Percutaneous ablation of bone and soft tissue lesions
- 2.2.4.3 Intra-articular injections under image guidance
- 2.2.4.4 Percutaneous osteoplasty
- 2.2.4.5 Spinal intervention
  - 2.2.4.5.1 Interventions in vertebral body compression fractures (VBCF)
  - 2.2.4.5.2 Spinal procedures for disc, nerves and facet joints

### Section F

#### 2.2.5 Interventional oncology (IO)

- 2.2.5.1 Fundamental IO
- 2.2.5.2 Vascular interventional oncology
- 2.2.5.3 Non-vascular interventional oncology
  - 2.2.5.3.1 Malignant chest and abdominal disease
  - 2.2.5.3.2 Malignant biliary disease (see also HPB section 2.2.2.4)
  - 2.2.5.3.3 Prostate cancer
  - 2.2.5.3.4 Malignant musculoskeletal disease



## 2.1.3 Patient safety

### Objectives

- Patient safety should be at the heart of all IR practice and trainees should be involved in governance, service improvement, adherence to national/international standards, risk management on a daily basis, regular attendance at morbidity and mortality meetings, undertake audit and submission of data to local and national registries
- Appropriate care is central to patient safety and satisfaction with a procedure. Trainees must learn to assess and manage patients before, during and after procedures. At the conclusion of training, the trainee will be able to:

#### Select patients for invasive procedures

- Determine which patients will benefit from an invasive diagnostic or therapeutic procedure and advise on the most appropriate course of management through a review of:
  - Clinical history and examination
  - Pre-procedural non-invasive imaging studies
  - Results of laboratory investigations
  - Proposed and expected outcomes of the procedure
- The trainee is expected to recognize when there is insufficient information to allow adequate evaluation of the patient
- Use a dedicated IR patient safety checklist (e.g. [www.cirse.org/Checklist](http://www.cirse.org/Checklist))
- The trainee will demonstrate proper communication with the patient and referring physician(s) regarding procedure appropriateness
- If a procedure is deemed inappropriate, the trainee should be able to establish the correct management pathway in conjunction with the patient and the referring physician
- The trainee should have access to and know when to refer patients to an anaesthetic pre-assessment clinic if the patient is judged to be at risk for conscious sedation<sup>15</sup>.

#### Properly evaluate a patient before an IR procedure

- Elicit a relevant clinical history
- Perform a focused physical examination
- Demonstrate understanding of history/physical findings or treatment scenarios that require discussion with/referral to other disciplines
- Identify medications that may require adjustment before any proposed therapeutic procedure

#### Identify factors that increase procedural risk and risk for conscious sedation and assign an American Society of Anaesthesiology (ASA) score from

- Patient history and physical examination
- The results of appropriate laboratory tests
- A request for any appropriate further support from other clinical teams (e.g. anaesthesiology)<sup>15</sup>.

<sup>15</sup> Hinkelbein et al. *European Society of Anaesthesiology and European Board of Anaesthesiology guidelines for procedural sedation and analgesia in adults. Eur J Anaesthesiol* 2018; 35:6-24

**Consent is a process which can be spread over several weeks to allow the patient time to consider the information, culminating with a signed form. In order to obtain informed consent, discussion of the procedure with the patient should be undertaken to explain**

- The purpose of the intervention
- The likely outcome of the therapeutic intervention regarding:
  - Technical success
  - Clinical success
  - Rate of recurrence
- The risks of the intervention
- The benefits of the intervention
- Any follow-up studies/procedures required
- Alternative therapeutic options

**The trainee will demonstrate**

- Proper communication with the patient and relevant clinicians regarding potential risks and their implications for management
- Recognize and understand the role of other specialties in the shared management of patients and collaborate respectfully and efficiently with other specialties
- Ability to assign the proper medication regimens/precautions before, during or after a procedure for:
  - Blood sugar abnormalities
  - High or low blood pressure
  - Infection/antibiotic therapy
  - Renal dysfunction
  - Coagulopathy/anticoagulation
  - Drug/contrast reactions and interactions
  - Conscious sedation
  - Anaesthesia/analgesia
- Familiarity with up-to-date methods of resuscitation
- Ability to recognize peri-procedural complications or problems and know how to manage them and when to call for specialist help, e.g.:
  - Contrast reaction
  - Excessive sedation
  - Pain and anxiety
  - Nausea/vomiting
  - Decreased oxygen saturation/arrested respiration
  - Arrhythmia and cardiac arrest
  - Sepsis
  - Hypertension/hypotension
  - Abnormal blood sugar
  - Haemorrhage/haematoma

**Ensure appropriate peri-procedural care for the patient including**

- Adequate staffing levels: nurse, radiographic, operating department assistant (ODA), etc.
- Adequate monitoring: pulse, BP, oxygen saturation, etc.
- Prompt recognition (by operator or other trained staff) of monitoring abnormalities
- Prompt recognition (by operator or other trained staff) of physical signs and symptoms that need immediate attention
- Implementation of an emergency plan for appropriate treatment of any problems

**Ensure appropriate aftercare for the patient by**

- Recording a plan of aftercare in the patient record
- Communicating the plan effectively to radiology, clinical ward staff and to the patient
- Ensuring unusual elements of care are expressly relayed to ward teams

**Provide appropriate patient follow-up in the inpatient and outpatient settings by**

- Reviewing the patient post-procedure and ensuring appropriate care
- Managing and advising on issues related to the procedure such as:
  - Drainage tubes
  - Pain control
  - Post-embolization/ablation syndrome
  - Haematoma and false aneurysm
- Communicating with other appropriate physicians, the patient and their relatives
- Providing appropriate procedure-specific literature on discharge with regard to discharge instructions
- Arranging appropriate outpatient review and follow-up investigations
- Ensuring all procedural specimens reach the appropriate laboratory

## 2.1.4 Recognizing and reducing occupational hazards

### Objectives

At the conclusion of training, the trainee will be able to minimize:

- Complications of IR procedures
- The risks of ionizing radiation to the patient and IR staff
- The trainee will build on the radiation protection module taken during diagnostic radiology training as depicted in the European Training Curriculum Level I + II. Know the importance of working according to the ALARA (As Low As Reasonably Achievable) principle<sup>16</sup>.
- In addition, those trainees specialising in IR will achieve the learning outcomes set out in table 3.

At the end of the training the trainee will:

- Demonstrate knowledge of the risks from pathogens, hazardous drugs and materials
- Identify patients at high risk for blood and body fluid borne pathogens
- Demonstrate knowledge of the incidence and methods of transmission of common pathogens, e.g. viral hepatitis, HIV and MRSA in the IR patient population
- Demonstrate knowledge of the regulatory framework regarding notifiable diseases in the country of practice
- Understand the methods of reducing transmission to attending staff and other patients including:
  - Protective clothing
  - Proper use and disposal of contaminated clothing and sharp instruments
  - Immunological protection
- Understand how to prevent and manage needlestick injury
- Understand the risks of injury during patient transfers
- Describe how to limit/reduce work-related musculoskeletal injuries

<sup>16</sup> For more information on ALARA please refer to <http://www.eurosafeimaging.org/eman>, the website of the European Medical ALARA Network.

Table 3: Additional learning outcomes for interventional radiologists in radiation protection<sup>17</sup>

Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
<p><b>Radiation physics K1.</b> Understand special requirements of image formation and image quality aspects with respect to fluoroscopy</p>	<p><b>S1.</b> Apply radiation physics to optimise interventional protocols, using minimal exposure to reach the desired procedure outcome</p>	
<p><b>Equipment K2.</b> Understand and explain in detail the following features of fluoroscopes: flat-panel/image intensifier detectors (including problems with image intensifiers such as geometric distortion, environmental magnetic field effects), continuous and pulsed acquisition including frame rate, automatic brightness control, high dose rate fluoroscopy, cine runs, last image hold, roadmapping</p> <p><b>K3.</b> Explain the principles of medical device (including associated software) management including planning, evaluation of clinical needs, specification for tender purposes, evaluation of tendered devices, procurement, acceptance testing, commissioning, constancy testing, maintenance and decommissioning; service contract management</p>	<p><b>S2.</b> Use the technical features of the specific equipment, on a daily basis, applying all quality-improving and dose-sparing factors but recognising the limits of the imaging machine and interventional devices in use</p>	<p><b>C1.</b> Choose the best interventional equipment for your patient spectrum based on the resources available</p> <p><b>C2.</b> Be informed of maintenance procedures and supervise these in cooperation with local legislative and hospital authorities</p>

<sup>17</sup> European Commission, Radiation Protection No 175: European Commission. Guidelines on Radiation Protection Education and Training of Medical Professionals in the European Union. 2014

Table 3: Additional learning outcomes for interventional radiologists in radiation protection

	Knowledge (facts, principles, theories, practices)	Skills (cognitive and practical)	Competence (responsibility and autonomy)
<b>Radiobiology</b>	<b>K4.</b> Explain radiobiological dose-effect relationships relevant to Interventional Radiology with respect to patient safety including discussion of the physical and biological background, response of tissues to radiation on molecular, cellular and macroscopic level, models of radiation induced cancer and hereditary risks and radiation effects on humans in general, children and the conceptus		
<b>Radioprotection in Interventional Radiology (X-rays)</b>	<p><b>K5.</b> Define ALARA and its applicability to Interventional Radiology settings</p> <p><b>K6.</b> Explain the meaning of justification and optimization as applied to Interventional Radiology practices</p> <p><b>K7.</b> Explain the concepts and tools for dose management in Interventional Radiology of adult and paediatric patients</p> <p><b>K8.</b> Explain the factors influencing image quality and dose in Interventional Radiology</p> <p><b>K9.</b> Describe the methods and tools for dose management in Interventional Radiology</p> <p><b>K10.</b> Explain the basic concepts of patient dose measurement and calculation in Interventional Radiology</p> <p><b>K11.</b> Describe the key considerations relevant to radiation protection when designing an Interventional Radiology unit</p> <p><b>K12.</b> List expected doses (to a reference person) for the main Interventional Radiology procedures</p> <p><b>K13.</b> Explain quantitative risk and dose assessment for workers and public in Interventional Radiology</p>	<p><b>S3.</b> Optimise procedure protocols by using standard operating procedures (SOPs) for interventional radiology and by adapting these to the specific patient size</p> <p><b>S4.</b> Individually choose the best compromise between risk-benefit ratio, image quality, procedure outcome and radiation exposure</p> <p><b>S5.</b> Supervise the use of personal protective equipment of interventional staff, support the regular workplace and individual monitoring and exposure assessment, investigation and follow up, health surveillance and records</p> <p><b>S6.</b> Apply and advise on the use of radiation protection measures in Interventional Radiology</p> <p><b>S7.</b> Estimate effective doses from Interventional Radiology procedures based on measurable exposure parameters (KAP, skin dose)</p> <p><b>S8.</b> Estimate high skin dose cases</p> <p><b>S9.</b> Calculate patient risk from measurement data of the dosimetry quantities used to assess adverse biological effects</p>	<p><b>C5.</b> Advise patients on the radiation-related risks and benefits of a planned interventional procedure</p> <p><b>C6.</b> Take responsibility for justification of radiation exposure in any individual patient undergoing Interventional Radiology procedures, with special consideration of pregnant (or possibly pregnant) patients</p> <p><b>C7.</b> Take responsibility for optimizing the technique/protocol used for a given Interventional procedure based on patient-specific needs</p> <p><b>C8.</b> Take responsibility for applying the principles of justification (risk/benefit assessment), optimization (including ALARA) and the setting up of reference levels to protect the patient from unnecessary risk from radiation</p> <p><b>C9.</b> Take responsibility for applying the optimal size- and problem-adapted individual protocol for high-dose procedures (TIPS etc.)</p> <p><b>C10.</b> Take responsibility for avoiding very high skin doses causing deterministic effects</p> <p><b>C11.</b> Follow-up patients for checking for appearance of deterministic effects</p>



Table 3: Additional learning outcomes for interventional radiologists in radiation protection

	Knowledge <i>(facts, principles, theories, practices)</i>	Skills <i>(cognitive and practical)</i>	Competence <i>(responsibility and autonomy)</i>
<b>Quality</b>	<p><b>K14.</b> Define Quality Assurance (QA) in Interventional Radiology, QA management and responsibilities, outline a QA and radiation protection program for Interventional Radiology</p> <p><b>K15.</b> List the key components of image quality and their relation to procedural patient exposure during</p> <p><b>K16.</b> Explain the principle of diagnostic reference levels (DRLs) in Interventional Radiology procedures</p>	<p><b>S10.</b> Understand the effects of poor-quality images in Interventional Radiology procedures</p> <p><b>S11.</b> Avoid unnecessary patient radiation exposure in Interventional Radiology procedures by optimizing the techniques performed, (size and positioning of the x-ray field, gonad shielding, tube-to- skin distance, correct beam filtration, minimizing and recording the fluoroscopy time, excluding non-essential projections)</p> <p><b>S12.</b> Develop an organizational policy to keep doses to the IR personnel as low as reasonably achievable (ALARA)</p>	
<b>Law and regulations</b>	<p><b>K17.</b> Specify the relevant regulatory framework governing Interventional Radiology practice in your country</p>	<p><b>S13.</b> Find and apply the relevant regulations in any clinical situation in Interventional Radiology</p>	<p><b>C12.</b> Take responsibility for conforming with patient protection regulations (including procedural reference levels, where applicable)</p>

## 2.1.5 The interventional radiology team

### Objectives

At the conclusion of training, the trainee will be able to:

Recognize and promote a team environment in the practice of IR including:

- Radiographers/technicians
- Nurses
- Radiology helpers
- Other clinicians including oncologists, surgeons and physicians

Help to provide a safe, stimulating working environment in which all IR team members are encouraged to participate

- Support the continuing medical education of IR team members
- Involve team members in research and audit
- Integrate the various members of the IR team in quality assurance programmes teaching and mentoring

As trainees progress, their role evolves to becoming trainers and mentors in their own right to the more junior trainees and other staff. They will need to acquire the skills to teach and encourage skills development of members of the IR team

- Understand the potential responsibilities and limitations in IR practice of:
  - Radiographers/technicians
  - Nurses
- Encourage team members to acquire new skills which will improve job satisfaction and career advancement, e.g. vascular ultrasound, venous access

## 2.1.6 Interventional radiology clinical practice

### Objectives

At the conclusion of training, the trainee will be able to:

#### **Understand the importance of interprofessional communication**

- To ensure appropriate prioritization and management of all referrals
- To ensure that patients are assessed and advised by an appropriate clinician
- To ensure awareness of the entire skills repertoire of the IR
- To ensure they are informed regarding management of their patients
- To ensure appropriate management and follow-up by other clinical teams
- To communicate effectively with multiple staff groups including:
  - nursing, physician assistants, junior medical staff, consultants from other relevant disciplines, clerical staff
- To ensure that information is readily available to other clinical care teams
- To facilitate research and audit

#### **Understand the necessity of developing and maintaining an IR clinic in order to**

- Evaluate patients pre- and post-procedure
- Provide information and obtain informed consent in advance of procedures
- Facilitate formal documentation in the patient's case records
- Promote IR as a clinical practice

**Understand healthcare coding systems**

- To understand the financial and business model for the IR service
- To ensure appropriate contracts for safe and sustainable service provision

**Provide care for patients as necessary utilizing the IR clinic**

- To ensure optimal patient care
- To effectively communicate and build a rapport with patients
- To properly assess outcome measures
- To facilitate research and audit

**Recognize the value of becoming a hub for patient referrals**

- To promote effective team working within the hospital
- To ensure prompt referral to the appropriate clinical teams
- To facilitate obtaining relevant clinical advice for patient management
- To understand the importance of attending relevant MDT meetings

**Data protection, adhere to institutional and national information privacy and ethical standards with regard to**

- All medical records
- Correspondence
- Use of patient information for research purposes

**Understand the mechanisms and requirements for continually monitoring quality assurance including**

- Regular documentation and classification of complications from IR procedures
- Regular morbidity and mortality meetings
- Effective audit
- Contribution to national audits of practice and outcomes in IR

## 2.1.7 Pharmacology of interventional radiology

### Objectives

At the end of training the trainee will understand the indications, contraindications, interactions and side effects of the principal pharmacological agents in common usage in IR, including but not restricted to:

- Aetiology, prevention and treatment of contrast medium reactions
- Contrast media (understand use, limitation and hazards including carbon dioxide (CO<sub>2</sub>) and gadolinium (Gd)<sup>18</sup>)
- Local anaesthetics
- Analgesics
- Sedatives
- Vasoactive drugs
- Drugs affecting coagulation including new oral anticoagulants
- Drugs used in diabetes
- Drugs used in hypertension control
- Statins
- Antibiotics
- Antiemetics
- Chemotherapeutics commonly used in IR (e.g. cisplatin, doxorubicin etc.)
- Management of circulatory collapse and shock
- Management/pharmacology of cardiorespiratory arrest

<sup>18</sup> <https://www.esur.org/esur-guidelines-on-contrast-agents/>

## 2.1.8 Imaging

### Objectives

The trainee understands the mechanisms, complementary roles and limitations of the different imaging techniques including ultrasonography, magnetic resonance angiography, computed tomography angiography, catheter angiography (including digital subtraction angiography and 3D rotational angiography) cone beam CT and image fusion in the investigation and treatment guidance in the different organ systems.

At the end of training, the trainee should be competent in carrying out imaging and integrating the different range of imaging modalities for the relevant organ systems for diagnosis, staging, follow-up and directing therapies including ultrasound, MR (including MR angiography), CT (including CT angiography), PET-CT, scintigraphy and image fusion.

#### Ultrasound

The trainee should demonstrate a thorough understanding and be able to perform/interpret the following:

- Duplex ultrasound, including both arterial and venous examinations
- Normal and abnormal arterial and venous Doppler waveforms
- Common Doppler examinations, such as carotid, hepatic, mesenteric and renal arterial Doppler studies and lower extremity venous and arterial duplex examinations
- Contrast-enhanced ultrasound imaging (CEUS)

#### CT and CT angiography (CTA)

The trainee should have a thorough understanding of:

- The basic physics of helical, multi-detector and dual energy CT
- CT and CTA protocols including contrast materials used and reconstruction techniques
- Radiation doses for different CT techniques including CTA and methods to reduce these
- Advantages and disadvantages of CTA versus other techniques

#### MR and MR angiography (MRA)

The trainee should have knowledge of:

- Magnetic resonance imaging including the effects of and on implanted materials, e.g. pacemakers, vascular stents and implants, prosthetic joints
- MR physics including MRA techniques
- Advantages and disadvantages of different contrast materials used for MR and MRA
- Differences between contrast-enhanced and unenhanced techniques pertaining to MRA
- Advantages and disadvantages of MRA compared to other techniques

### Diagnostic (catheter) angiography/venography

The trainee should be competent to carry out these procedures in an emergency and elective setting.

#### General principles

The trainee should have knowledge of:

- The basic chemistry of the different contrast materials used, including CO<sub>2</sub> and gadolinium, as well as the indications, contra-indications, advantages and disadvantages of each for angiography
- Mechanisms to minimize nephrotoxicity in high-risk patients, such as patients with diabetes or renal impairment

**Arterial puncture technique**

The trainee should have a thorough knowledge of:

- Standard groin anatomy, including the position of the inguinal ligament and the femoral nerve, artery and vein
- The Seldinger technique of arterial and venous puncture
- Ultrasound-guided vessel puncture
- Mechanisms for guidewire, sheath and catheter insertions into the groin
- Mechanisms of puncture site haemostasis including manual compression and the use of common closure devices
- Alternative sites of arterial puncture, such as brachial, axillary, radial, ulnar popliteal, tibial, and pedal
- Understand the roles and the advantages and disadvantages of each access

**Diagnostic catheter angiography**

The trainee should have knowledge of:

- Guidewires, sheaths and catheters (pigtail and selective) used for common diagnostic angiographic procedures
- Digital subtraction angiographic techniques, bolus chase techniques, road mapping, smart mask and pixel shift techniques
- Standard arterial and venous anatomy and variations in anatomy throughout the body
- Peripheral vascular angiography
- Mesenteric and renal angiography
- Abdominal aortography
- Thoracic aortography
- Carotid, vertebral and subclavian angiography
- Diagnosis of atherosclerotic disease, vasculitis, aneurysmal disease, thrombosis, embolism and other vascular pathology
- Post-procedural care regimens for standard diagnostic vascular procedures

Trainees should understand the risks associated with the different imaging modalities including:

- The complication rates for common diagnostic catheter procedures
- Exposure to ionizing radiation, both for the patient and the IR team
- Physical injury during/as a result of arterial catheterization

## 2.1.9 Core procedures in interventional radiology

The following procedures are deemed vital in ensuring a safe and sustainable 24/7 emergency IR service. Regardless of subspecialty interests, these are considered core skills that all IRs should be able to deliver. Trainees should ensure that they learn and maintain these competencies during training and as established, practising IRs. These topics will be tested more frequently in the EBIR examination.

1. Haemorrhage control
  - a) Embolization of GI bleeding
  - b) Embolization of trauma bleeding
  - c) Stentgrafting in trauma
2. Sepsis control
  - a) Biliary drainage and stenting
  - b) Nephrostomy
  - c) Abscess drainage
3. Thrombolysis and adjunctive angioplasty and stenting
  - a) Arterial for acute limb ischaemia
  - b) Venous for phlegmasia

## 2.2 Specific topics in interventional radiology

### 2.2.1 Vascular diagnosis and intervention

Vascular interventional radiologists encounter a wide range of conditions affecting almost every organ system and affecting both arteries and veins.

#### 2.2.1.1 Arterial disease

##### 2.2.1.1.1 Peripheral arterial disease

###### Knowledge

###### Upper limb:

- Describe the anatomy relevant to thoracic outlet syndrome (TOS)
- Describe provocative measures for eliciting subclavian steal on non-invasive studies
- Describe measures for accentuating thoracic compression syndromes

Describe and recognize collateral pathways for patients with arterial occlusive disease:

- Describe the important branches of the external iliac, internal iliac, common femoral and profunda femoris, arteries and their role in collateral pathways of the pelvis, abdomen, and lower extremity
- Describe the collaterals/anastomoses around the shoulder which supply the upper extremity in a case of proximal occlusion, thoracic compression syndromes
- Describe the angiosome concept

Understand the bony and soft tissue anatomy of arterial puncture sites and recognize their importance in avoiding complications of arterial puncture when accessing:

- The common femoral artery
- The brachial artery
- The radial or ulnar artery
- The popliteal artery
- The pedal arteries
- The axillary artery
- The common carotid artery

###### PAD

- Recognize the association with coronary artery disease and cerebrovascular disease
- Recognize the prognostic implication of PAD in terms of life expectancy compared to age-matched controls and related to aetiology of the disease
- Recognize differences in incidence and prognosis for upper and lower limb vascular disease
- Know the:
  - Causes of peripheral ischaemia, e.g. atherosclerosis, peripheral emboli, arteritis, fibromuscular dysplasia, congenital and acquired coarctation of aorta, endofibrosis of the external iliac artery, popliteal aneurysm (with secondary thromboembolism), popliteal entrapment, adventitial cyst of the popliteal artery, trauma and irradiation injury, thromboangiitis obliterans (Buerger's disease), thrombosis of a persistent sciatic artery
  - Rheological factors, e.g. viscosity, clotting mechanism, prothrombotic states
  - Recognition of the risk factors for development and progression of PAD
  - The specific significance of diabetes-related PAD

### Atherosclerosis

- Major histological and biochemical features and associations of atheroma
- Know the PAD grading systems according to the Society for Vascular Surgery (SVS) and the International Society for Vascular Surgery (ISVS)
- Describe and categorize intermittent claudication (including Leriche syndrome) according to CIRSE/SVS/ISVS
- Categorize chronic critical limb ischaemia according to current systems, i.e. SVS/ISVS
- Describe and categorize acute critical limb ischaemia according to SVS/ISVS systems
- Recognize and understand the clinical management of thrombangiitis obliterans (Buerger's Disease)

### Diabetic foot syndrome

- Understand the specific clinical and imaging features of diabetic foot syndrome
- Understand how diabetic angiopathy differs from atherosclerotic disease
- Understand the difference between an ischaemic ulcer and a neuropathic ulcer

### Peripheral embolism

- Understand the sources of emboli and the clinical manifestations and management strategies for peripheral arterial emboli
- Understand the nature, cause and treatment of blue digit syndrome
- Understand how to investigate other sources of embolism including cardiac
- Describe management strategies for peripheral arterial emboli
- Understand factors that influence the management strategy
- Recognize the appearance and causes of livedo reticularis

### Fibromuscular dysplasia

- Describe histological and angiographic findings common to the forms of fibromuscular dysplasia that may affect the medium-size aortic branches
- Recognize signs or symptoms of the disease, depending on what artery is affected by fibromuscular dysplasia
- Describe associations with other disease entities (e.g. pheochromocytoma, Ehlers-Danlos syndrome type IV, neurofibromatosis, Alport's syndrome, cystic medial necrosis, coarctation of the aorta)

### Vasculitis

- Describe the typical findings of vasculitis including Takayasu's arteritis, giant cell arteritis and polyarteritis nodosa
- Understand the relevant biochemical investigations
- Define Raynaud disease and Raynaud's phenomenon
- List disease processes that demonstrate Raynaud's phenomenon
- Recognize the anatomic distribution of lesions in collagen vascular diseases including scleroderma, polyarteritis nodosa, rheumatoid arthritis and systemic lupus erythematosus
- Recognize clinical signs of thromboangiitis obliterans and its association with smoking

### Trauma

- Recognize the clinical manifestations and angiographic findings of blunt or penetrating trauma
- Recognize the clinical manifestations and angiographic findings of irradiation vascular injury and endofibrosis of the external iliac artery
- List occupations or activities that may contribute to hypothenar hammer syndrome and recognize the associated angiographic findings

#### Entrapment syndromes

- Understand the anatomy relevant to popliteal entrapment syndrome: Describe the anatomical relationships between the popliteal artery and the gastrocnemius or popliteus muscles in the four types of popliteal entrapment
- Recognize the different imaging findings

#### Neoplastic disease

- Know the pathophysiological process with regard to tumour angiogenesis and invasion of blood vessels

#### Syndromes with a major vascular component

- Have a practical and working knowledge of the management of an assortment of uncommon syndromes and generalized diseases all of which have a major vascular component such as Behcet's, Marfan's, middle aortic syndrome, William's syndrome, neurofibromatosis, polyarteritis nodosa, systemic lupus erythematosus, Ehlers-Danlos, rubella and cholesterol embolization
  - Have knowledge of anklebrachial index (ABI), toe pressure, transcutaneous oxygen pressure (TcPo2) measurements and their interpretation
  - List causes of bypass graft failure

### Clinical skills

- Be able to elicit and understand the role/limitations of the ankle brachial index measurement and assess and classify patients with acute and chronic peripheral ischaemia and graft follow-up
- Understand the complementary roles of the various imaging modalities in the assessment of PAD
- Describe strategies for modifying/managing risk factors for cardiovascular disease
- Understand the various strategies for management of chronic and acute limb ischaemia
- List the absolute and relative contraindications to pharmacologic and mechanical thrombolysis
- Understand the treatment options for thoracic outlet syndrome
- Understand the treatment options for popliteal entrapment syndrome
- Understand the range of treatment strategies including medical, endovascular/interventional and surgical alternatives sufficiently to discuss management with patients and formulate appropriate treatment plans
- Understand measures to protect renal function as well as control blood pressure peri-procedure
- Differentiate between venous and arterial ischaemia
- Recognize the difference between arterial and spinal "claudication"
- Be able to describe the signs and symptoms of acute and chronic critical limb ischaemia and the clinical findings in blue toe syndrome
- Recognize compartment syndromes
- Recognize the non-viable limb which requires primary amputation rather than revascularization
- Describe the presentation of thoracic outlet syndrome
- Describe the presentation of popliteal entrapment syndrome
- Describe the presentation of cystic adventitial disease
- Understand the treatment options for cystic adventitial disease
- Understand pre-procedure, intra-procedure and post-procedure pharmacological management for patients undergoing peripheral vascular interventions including:
  - Anticoagulation
  - Thrombolytic agents
  - Antiplatelet agents
  - Vasodilators



- Be able to define primary patency, assisted primary patency and secondary patency, target vessel revascularization, target lesion revascularization
- Understand the use of life table analysis of outcomes
- Be up to date with the evidence for different technologies in treating PAD, e.g. drug-eluting balloons, stents, atherectomy devices, etc.
- Be able to understand the specific clinical presentation of the diabetic foot
- Be able to evaluate patients after vascular reconstruction or by-pass surgery

### **Imaging**

Describe strategies for imaging patients with PAD including algorithms for patients with:

- Acute and chronic ischaemia
- Diabetic foot syndrome
- Critical ischaemia and claudication
- Absent femoral pulses
- Contraindications to iodinated intravascular contrast
- Arterial bypass grafts
- Endografts
- Vascular trauma
- Entrapment syndromes including the use of stress and postural manoeuvres

### **Specific imaging modalities**

#### **Non-invasive imaging**

- Ultrasonography
  - Have knowledge of the indications for ultrasound imaging in surveillance of vascular grafts and the assessment of post-angioplasty/stenting patients
  - Describe the sonographic findings of the complications of femoral artery puncture; e.g. haematoma, arterial occlusion or dissection, pseudoaneurysm and arteriovenous fistula
  - Understand the role of ultrasonography in guiding access to vessels
- MRA
  - Understand the compromise that must be made between resolution, acquisition time and scan volume
  - Recognize artefacts associated with MRI/MRA, e.g. susceptibility, wrap, and venous contamination and be able to suggest strategies to minimize them
  - Understand the potential for MRA to both overestimate and underestimate stenosis and the reasons for this
  - Understand how to set up for a peripheral arterial scan including positioning of volumes of interest, contrast dose and injection rates and timing
  - Understand the role of open MRA in procedural imaging guidance
- CTA
  - Understand the methods used to time imaging in relation to contrast bolus injection
  - Understand how to set up for a peripheral arterial scan including contrast dose and injection rates and timing of image acquisition
  - Understand the method of acquisition of volume data using CT systems, e.g. multidetector arrays
  - Recognize artefacts associated with CT, e.g. metallic densities, physiological movement and be able to suggest strategies to minimize them
  - Understand the limitations of CTA in lower limb critical ischaemia

#### **Invasive imaging**

- Catheter angiography
  - List advantages and disadvantages of various forms of angiography of the lower extremity including bolus chase DSA and incremental or stepped static stations for DSA
  - Describe strategies for optimizing lower extremity angiography when only limited amounts of iodinated contrast may be used, or if Gd or CO<sub>2</sub> angiography is to be utilized

- List strategies for optimizing tibial and foot vessel visualization during angiography including selective angiography and pharmacological vasodilatation
- Understand the contraindications to catheter angiography including abnormal coagulation, renal dysfunction, contrast reaction, absent pulses
- Understand how to image those patients in whom catheter angiography is contraindicated
- Describe the angiographic features of vasospasm in the lower extremities
- Describe a “standing wave” seen on angiography and discuss its clinical significance
- Describe the complications of catheter angiography and their management
- Intra-vascular ultrasound be aware of the limited applications and basic interpretation in vascular disease
- Describe an imaging strategy for bypass graft surveillance
- Recognize the sonographic features of a failing bypass graft
- Recognize the angiographic findings in anastomotic pseudoaneurysms
- Recognize the angiographic findings in thrombosis of bypass grafts
- Describe angiographic findings associated with graft failure
- Recognize the angiographic features of a clamp injury to an artery or a bypass graft

### Technical skills

- Demonstrate ability to plan optimal vascular access and vascular closure
- Demonstrate technical competence of puncture site management
- Be able to categorize arterial lesions according to the expected outcome, e.g.:
  - Technical success
  - Complications
  - Clinical outcome
  - Restenosis
- Demonstrate technical competence in the performance of peripheral vascular interventions including:
  - Crossing stenosis with selective catheters and guidewires
  - Recanalization techniques of total occlusions including subintimal recanalization and use of re-entry devices
  - Balloon angioplasty and stent placement
  - Catheter-directed thrombolysis and percutaneous aspiration and mechanical thrombectomy
  - Management of complications
- Demonstrate correct selection and use of equipment including:
  - Guidewires
  - Catheters
  - Sheaths
  - Balloons
  - Atherectomy devices
  - Stents and stent-grafts
- Understand the role of intravascular pressure gradients including the use of vasodilators to assess the outcome of vascular interventions
- Differentiate between embolic occlusion and in situ thrombosis in cases of acute limb ischaemia and tailor therapy accordingly
- Demonstrate ability to recognize and manage the potential complications of endovascular procedures such as balloon angioplasty, stenting, stent grafting and catheter-directed thrombolysis/percutaneous aspiration and mechanical thrombectomy
- Understand the indications, contraindications and limitations of puncture site closure devices
- Recognize the role of emerging treatments for restenosis or calcified plaques including:
  - Local drug delivery
  - Percutaneous atherectomy
  - Endovascular brachytherapy
  - Shockwave angioplasty
  - Laser angioplasty

### 2.2.1.1.2 Aortic and upper extremity arterial disease

#### Knowledge

- Know the difference between an aortic pseudoaneurysm and a ductus diverticulum
- Know the potential causes of “dysphagia aortica” and “dysphagia lusoria”
  - Know the advantages and limitations of relevant devices including stents and balloons

#### Clinical skills

- Know the clinical presentation of upper extremity arterial pathology
- Describe the imaging findings in atherosclerotic, syphilitic, mycotic, post-traumatic and congenital aneurysms
- Recognize chest radiography and CT findings in the setting of traumatic disruption of the aorta
- Recognize the indications for and angiographic findings in various forms of trauma including blunt trauma, penetrating trauma, blast trauma and iatrogenic trauma
- Recognize the angiographic findings associated with different forms of aortitis
- Recognize imaging findings and typical distribution of abnormalities in Takayasu’s disease
- Recognize the imaging findings in the vascular components of connective tissue disorders (e.g. Marfan syndrome and Ehlers-Danlos syndrome)
- To be able to assess clinical status of the patient

#### Technical skills

- Demonstrate technical competence in catheterizing the great vessels in normal and variant anatomy
- Demonstrate competence in performing angioplasty, stenting and embolization of supra-aortic branches
- Demonstrate competence in detecting and managing angiographically-induced complications of any of the above vessels
- Demonstrate competence in detecting and managing puncture site complications

### 2.2.1.1.3 Acute aortic syndromes and aneurysmal disease

#### Knowledge

- Know the levels of arterial connection between the aorta and the spinal cord, the angiographic appearance of the artery of Adamkiewicz and understand its clinical significance
- Know the pathological spectrum of acute aortic pathology including intramural haematoma, aortic ulceration, penetrating aortic ulcer, and aortic dissection
- Know the factors predisposing to aortic dissection, e.g. atherosclerosis, hypertension, connective tissue disorders, arterial inflammatory conditions, bicuspid aortic valve, and pregnancy
- Know the natural history of aortic dissection including acute and chronic phases, the potential for late aneurysm formation and the implications for treatment
- Know the mechanisms for traumatic pseudo-aneurysm formation in the thoracic aorta as a result of deceleration injury

#### Clinical skills

- Recognize the symptoms and physical signs associated with:
  - Compression of adjacent structures by large arch or descending aortic aneurysms
  - Distal embolization of aneurysm thrombus
  - Aorto-caval fistula

- Aorto-enteric fistula
- Intra-thoracic rupture of aortic aneurysm
- Intra-abdominal rupture of aortic aneurysm
- Aortic dissection and its complications
- Recognize the difference between an aortic pseudo-aneurysm and a ductus diverticulum
- Be able to integrate appropriate pre-procedural imaging workup for aortic aneurysms and dissection
- Be able to define the imaging criteria for the presence of aortic aneurysm and describe the common configurations and classifications
- Be able to define and distinguish the imaging criteria for the presence of aortic dissection, intramural haematoma and penetrating ulcer
- Be able to identify the typical signs of the true and false lumen of a dissection on catheter angiography, CTA and MRA
  - Recognize the difference between static and dynamic type of dissection
- Understand how intravascular US can be an adjunct to identifying the true and false lumen and how it may impact endovascular interventions for the treatment of dissection
- Be able to identify the typical signs of branch vessel compromise
- Know the full range of endovascular and surgical treatment options currently available for aortic aneurysms and dissections
- Understand the endovascular and surgical strategies for isolated iliac artery aneurysms
- Classify thoracic and abdominal aortic aneurysms with respect to suitability for endovascular repair and define the anatomical information required in case selection and planning, including:
  - Assess the dimensions of the aortic aneurysms
  - Condition and dimensions of the proximal sealing zone
  - Presence of significant angulation of the proximal neck
  - Centre line distance between the limits of the proximal and distal fixation zones
  - Condition and dimensions of distal sealing zone
  - Condition and dimensions of the access vessels
  - For thoracic lesions: the need for adjunctive carotid-subclavian bypass, carotid-carotid bypass or elephant trunk procedure
  - For peri-renal and Group IV thoracoabdominal aortic aneurysms: suitability for fenestrated or branched stent-grafts
  - For aneurysms involving the iliac segments: the need for embolization of the internal iliac arteries or suitability for a branched stent-graft
  - Assessment of the need for occlusion of large branch vessels involved in an aneurysm sac
- Recognize the limitations of endovascular treatment for thoracic and abdominal aortic aneurysms and identify those patients best suited for open surgical repair
- Classify aortic dissection and:
  - Define the indications for medical treatment as opposed to surgical intervention
  - Define the indications for the use of aortic stent-grafts in acute or chronic aortic dissection
  - Define the indications for the use of alternative endovascular interventions such as fenestration and/or bare stent placement in order to restore patency in compromised branch vessels
- Define the anatomical information required in case selection and planning, including:
  - The site and extent of the primary intimal tear
  - The level of the distal re-entry site
  - Extent of involvement and compromise of significant branch vessels
  - Extent and diameter of any associated aortic aneurysm
  - Condition and dimensions of the proximal and distal sealing zones
- Understand the requirements for medium and long-term surveillance of aortic stent-grafts, including the detection of:
  - Structural failure
  - Device migration

- Component dislocation within modular devices
- Graft occlusion
- Endoleaks
- Sac expansion with or without endoleak
- Describe the methods available for medium and long-term surveillance of aortic stent-grafts including:
  - Plain radiographs
  - Contrast-enhanced ultrasound
  - CTA (all stent-grafts)
  - MRA (nitinol stent-grafts)
  - Intra-sac pressure monitoring devices
  - Define the concept of “endoleak”, the imaging criteria by which the 5 subtypes may be classified and the indications for reintervention
- Understand the advantages and limitations of endovascular stent-grafts for aortic dissections or aneurysms with specific attention to:
  - Morbidity and mortality in comparison to open repair
  - Quality of life
  - Financial implications
  - Durability of current devices

### Technical skills

- Demonstrate competence in planning stent-graft repair using cross sectional imaging on a high-quality workstation
- Demonstrate competence in the techniques of endovascular repair of aortic aneurysms or dissections, including:
  - Pre-/peri-procedural transcatheter occlusion of significant branch vessels
  - Preparation, insertion and deployment of the current aortic stent graft devices
  - Post-deployment manoeuvres required to safely remove the device introducer and close the access site
- Recognize patients with anatomy unsuitable for conventional access for endovascular repair and suggest alternative methods of stent-graft placement
- Recognize the complications that may arise during endovascular repair and their appropriate management:
  - Dissection, occlusion or rupture of the access vessels, the aorta or the aneurysm sac
  - Coverage of important branch vessels, e.g. the carotid, subclavian, spinal, renal or internal iliac arteries
  - Distal embolization of the arch vessels or the mesenteric, renal or lower limb vessels
  - Contrast reactions and contrast-induced nephropathy (CIN)
  - Cardio-respiratory complications related to prolonged general anaesthesia in patients with poor cardiovascular reserve
- Demonstrate competence in the techniques for the management of endoleaks including:
  - Balloon remodelling, deployment of large bare stents or extension cuffs and occasionally transcatheter embolization of the endoleak lumen to achieve seal in type I endoleaks
  - Transcatheter embolization of feeding and draining branch vessels or percutaneous trans-sac injection of embolic materials to treat type II endoleaks
  - Insertion of extensions, cuffs, new bifurcated stent-grafts or conversion to aorto-uni-iliac stent graft to treat type III endoleaks

### 2.2.1.1.4 Supra-aortic arterial disease

#### Knowledge

- Understand the role of cerebral protection devices in percutaneous carotid interventions
- Categorize carotid bifurcation lesions as to their appropriateness for percutaneous therapy
- Know the current treatment algorithms for asymptomatic and symptomatic carotid artery lesions
  - Know post-intervention clinical and imaging follow-up examinations

#### Clinical skills

- Be able to identify patients with symptomatic carotid, vertebral and subclavian stenosis, occlusion and aneurysm disease
- Integrate and evaluate pre-intervention non-invasive imaging in patients with supra-aortic vascular disease
- Understand pre-, peri- and post-procedural pharmacology requirements
- Understand the role of the variety of available angioplasty balloons, stents, stent-grafts, guiding catheters, wires and cerebral protection devices
- Recognize the role of endovascular treatment of traumatic carotid injuries such as dissection and pseudoaneurysm

#### Technical skills

- Demonstrate technical competence performing carotid and supra-aortic interventions including but not limited to balloon angioplasty, stent placement and use of cerebral protection devices
- Manage acute embolic complications during percutaneous carotid interventions with catheter-directed thrombolysis and other techniques

### 2.2.1.1.5 Stroke

#### Knowledge

- Have knowledge of the most up-to-date literature on this topic including the principles of medical management of patients with stroke
  - Know the most commonly used thrombectomy devices (stent-retrievers, hydrodynamic devices)
- Know the potential risks and complications (dissection, perforation, thrombus dislodgement) and their management
- Know the differences between a stroke event in the posterior and anterior circulation
- Know the most commonly used neurological classifications/scores (NIHSS; modified Rankin scale)
- Know and understand the indications and contraindications for mechanical thrombectomy, and thrombus aspiration
- Have knowledge of grading scales of ischaemic brain damage (ASPECT score)
- Have knowledge of the factors which strongly influence the indication for stroke treatment (time window, imaging findings)
- Have knowledge of mismatch imaging (penumbra)
- Have knowledge of the most important drugs used in the acute and post-acute phase (Aspirin, Clopidogrel, Glycoprotein IIb/IIIa inhibitors)

### Clinical skills

- Understand the most commonly used scales for angiographic outcome (TICI score)
- Understand the discrepancy between angiographic and clinical outcome

### Technical skills

- Demonstrate competence in performing a mechanical thrombectomy procedure
- Have knowledge of the materials needed for transarterial thrombectomy (i.e. guiding catheters, microcatheters, microguidewires)
- Demonstrate competence in performing intra-arterial thrombolysis

## 2.2.1.1.6 Vascular malformations

### Knowledge

- Know how to classify vascular malformations according to their clinical presentation and natural history (e.g. ISSVA classification)
- Know syndromes in which a vascular malformation is part of the clinical features (e.g. Klippel-Trenaunay syndrome, hereditary haemorrhagic telangiectasia, Kasabach-Merritt syndrome)
- Understand the role of IR and its place in the multidisciplinary team

### Clinical skills

- Be able to evaluate patients and categorize lesions as either high-flow or low-flow based on history, physical examination and imaging findings
- Recognize the clinical presentation of congenital haemangioma and understand the role of B blockers and interventions in this condition
- Recognize the clinical presentation of lymphatic malformation and understand treatment options
- Recognize the clinical presentation of patients with low-flow vascular malformations and the indications for treatment and the possible complications
- Recognize the clinical presentation of patients with high-flow vascular malformations and the indications for treatment and the possible complications
- Establish a strategy for pre- and post-intervention imaging of vascular malformations

### Technical skills

- Demonstrate competence and understanding of the principles, agents and techniques used in treatment of high-flow vascular malformations
- Demonstrate competence in managing complications of treatment of high-flow vascular malformations
- Demonstrate competence and understanding of the principles, agents and techniques used in treatment of low-flow vascular malformations
- Demonstrate competence in managing complications of treatment of low-flow vascular malformations
- Demonstrate competence and understanding of the principles, agents and techniques used in the treatment of lymphatic malformations
- Demonstrate competence in managing complications of treatment of lymphatic malformations

## 2.2.1.1.7 Vascular Trauma

### Knowledge

- Know the typical mechanism of trauma leading to vascular injuries
- Know the typical patterns of vascular injuries
- Know and understand the role of staging of major trauma to solid organs
- List the indications and contraindications for embolization and/or stenting
  - Have knowledge of the success and complication rates for embolization and/or stenting
  - Have knowledge of the complications of splenectomy
- Have knowledge of appropriate timing of pelvic arteriography with other interventions such as exploratory laparotomy or external fixation of pelvic fractures in patients with multiple traumatic injuries
  - Have knowledge of different strategies for treating pelvic haemorrhage

### Clinical skills

- Identify and stage major trauma to solid organs as well as vascular injuries on CTA and arteriography
- Understand the principles of selecting an appropriate embolic agent
- Recognize the potential role for bare and covered stents in treating traumatic vascular injuries with regard to blunt and penetrating injuries to the liver, spleen and kidneys:
  - Understand the roles of exploratory laparotomy and non-operative management in patients with traumatic hepatic injuries

With regard to blunt and penetrating injuries to the pelvis:

- Understand the limitations of surgical exploration in patients with pelvic haemorrhage
- Understand the commonly injured vessels that are associated with specific patterns of pelvic fracture
- Understand the role of diagnostic arteriography and arterial embolization in haemodynamically stable and unstable patients

With regard to blunt and penetrating injuries to the extremities:

- Demonstrate competence in identifying various clinical findings of extremity arterial injury based on the clinical examination
- Identify traumatic arterial injury on angiography, CTA, Doppler US and eventual MRA
- Understand the potential collateral pathways and identify the role of embolization proximal and distal to the level of arterial injury

With regard to blunt and penetrating injuries to the face and neck:

- To understand the zonal classification of penetrating injuries to the neck including which proximity injuries warrant angiographic evaluation
- Identify the potential collateral pathways between the intracranial and extracranial circulation that may determine a patient's candidacy for embolization

### Technical skills

- Demonstrate competence in placement of aortic occlusion balloons in major haemorrhage without image guidance
- Demonstrate competence in selective catheterization skills, including the use of microcatheters and guidewires
- Demonstrate familiarity with the characteristics of various embolization agents, stents and stent-grafts
- Demonstrate competence in the selection of the appropriate embolization material in accordance to the vascular lesion
- Demonstrate competence with the use of stent-grafts and/or stents in vascular trauma



## 2.2.1.1.8 Visceral arterial disease

### Knowledge

- Know the strategies for imaging of the arterial, portal and mesenteric venous systems

### Clinical skills

- Describe angiographic techniques and catheters that help in selective catheterization of the visceral arteries
- Understand the pros and cons of different access routes and access systems

### Technical skills

- Demonstrate competence in superselective catheterization and selection of wires, catheters, stents and suitable embolic materials according to anatomical site
- Demonstrate technical competence in performing angioplasty, stenting, stent-grafting and embolization in these vascular territories

## Gastrointestinal haemorrhage

### Knowledge

- Understand the role of anticoagulants, vasodilators and thrombolytic agents in the complete evaluation of occult acute and chronic gastrointestinal blood loss
- Understand and evaluate the potential medical, endoscopic, surgical and endovascular treatment options in acute and chronic gastrointestinal blood loss

### Clinical skills

- Recognize the clinical presentations and relevant physical signs in acute and chronic gastrointestinal blood loss
- Be able to interpret the imaging findings in patients with acute and chronic gastrointestinal blood loss
- Management of patient's medication which is relevant to bleeding
- Understand the concept of 'front and back door occlusion'

### Technical skills

- Demonstrate competence in the techniques and use of equipment in embolization for acute and chronic gastrointestinal blood loss
- Demonstrate familiarity in the selection of the appropriate embolization materials

## Visceral artery aneurysms

### Knowledge

- Know and understand the differences in aetiology and treatment strategies between true aneurysms and pseudoaneurysms

### Clinical Skills

- Understand the clinical presentations and relevant physical signs in visceral artery aneurysms and the indications for treatment
- Integrate and direct the non-invasive imaging evaluation of patients with suspected visceral artery aneurysms
- Describe the cross sectional and angiographic findings in a patient with a visceral artery aneurysm
- Describe appropriate follow-up strategies

### Technical skills

- Demonstrate competence in the techniques and the range of equipment used in embolization and or use of stents and stent grafts for the exclusion of visceral artery aneurysms
- Undertake techniques to manage potential complications and preventative strategies in the treatment of visceral artery aneurysms

## Visceral artery ischaemia

### Knowledge

- Know the potential presentations of coeliac artery compression syndrome
- Know the significance of the median arcuate ligament and the coeliac neural plexus and understand the potential treatment options
- Know the treatment options including probable need for combining with open laparotomy
- Know commonly used techniques/devices for endovascular treatment

### Clinical skills

- Know the expected immediate and long-term results for percutaneous interventions in mesenteric vascular disease
- Understand how and when to use the endovascular management options for the treatment of occlusive and non-occlusive mesenteric ischaemia

### Technical skills

- Demonstrate competence in the angiographic techniques for the assessment of acute and chronic mesenteric ischaemia
- Demonstrate competence in the techniques and use of equipment in the endovascular management including thrombolysis, thrombectomy, angioplasty and stenting
- Competence in the endovascular management of the potential complications and their preventative strategies

## Vasculitis

### Knowledge

- Know the anatomic distributions of disease in patients with vasculitis
- Know the commonly used medical treatment strategies

### Clinical skills

- Know the clinical presentations and relevant physical signs in the common forms of vasculitis including Polyarteritis Nodosa, giant cell arteritis, Takayasu's arteritis, Buerger's disease and Behcet's disease
- Understand the role of treatment options including medical therapy, surgery and endovascular therapy and expected outcomes

### Technical skills

- Demonstrate competence in performing angiography in a patient with vasculitis
- Demonstrate competence in the endovascular treatment of vasculitis

## Renovascular disease

### Knowledge

- Know the role of medical therapies and when to use endovascular techniques
- Understand the potential role endovascular treatments for restenosis in renovascular interventions
- Know how to exclude non-renal causes of hypertension

### Clinical skills

- Recognize the angiographic findings and indications for intervention in patients with fibromuscular dysplasia as well as the appropriate treatment and expected results in this specific patient population
- Recognize the role of renal protective agents in the pre- and post-procedure management of patients with renovascular disease to minimize contrast induced nephropathy
- Management of antihypertensive medications pre-, peri- and post procedure

### Technical skills

- Demonstrate competence with the equipment and techniques used in the treatment of renal artery stenosis
- Integrate the use of intra-procedural intra-arterial pressure measurements in assessing the results of renovascular interventions
- Recognizing common complications of renovascular interventions and demonstrate competence in the management of those
- Demonstrate competence in the techniques and equipment used in the treatment of renal haemorrhage secondary to iatrogenic or direct trauma and embolization of tumours

## Bronchial and pulmonary arteries

### Knowledge

- Understand the role of bronchial and pulmonary arterial embolization for patients with recurrent haemoptysis
- Recognize normal and abnormal arterial patterns seen in patients presenting with haemoptysis
- Recognize the arterial network of the spine including the Adamkiewicz and its clinical significance

### Clinical skills

- Describe important potential collateral pathways from non-bronchial systemic arteries and pulmonary arteries
- Understand when to perform and when to avoid bilateral bronchial artery embolization in patients with haemoptysis

### Technical skills

- Demonstrate competence in catheterizing and embolizing the bronchial and pulmonary arteries
- Demonstrate familiarity with the technique and equipment used in embolization of these vessels
- Demonstrate familiarity of how to undertake pulmonary arterial thrombolysis
- Demonstrate familiarity with commonly used devices for pulmonary thrombectomy

## 2.2.1.1.9 Arterial problems in obstetrics and gynaecology

### Knowledge

- Know the indications for uterine artery embolization for the following patient groups:
  - Uterine fibroids
  - Adenomyosis
  - Post-partum haemorrhage
  - Malignancy
  - Abnormal placentation, i.e. Placenta accreta and percreta
  - Post-surgery
  - Other indications, e.g. trophoblastic disease, uterine arteriovenous malformation

### Clinical skills

- Direct and interpret imaging for patient selection, and specific issues regarding appropriate selection, e.g. fibroid location, presence of adenomyosis, endocavitary lesions
- Understand the presence of collateral blood flow between the uterus and the ovaries, and physiologic ramifications of embolization in these territories
- Be able to work in a multi-disciplinary team in the treatment and prevention of post-partum haemorrhage
- Direct post-procedural imaging, patient management and appropriate laboratory evaluation
- Understand the principles of post-fibroid embolization care with special attention to pain control and post-embolization syndrome
- Understand the principles of patient care after prophylactic occlusion balloon placement and removal, with or without uterine artery embolization

### Technical skills

- Demonstrate technical competence in pelvic angiography and uterine artery catheterization and embolization
- Appropriate selection from a wide variety of catheters and understand the pros and cons of the different embolic agents
- Demonstrate the correct placement occlusion balloons

## 2.2.1.2 Prostate artery embolization (PAE)

### Knowledge

- Understand the indication and place for prostate artery embolization
- Know the imaging appearances of benign and malignant prostatic disease
- Know the follow-up protocols for pre- and postembolization
- Knowledge of symptom assessment in BPH using IPSS (International Prostate Symptom Score) and other questionnaire-based assessments

### Clinical skills

- Understand the clinical presentation of BPH
- Understand the concepts of lower urinary tract symptoms in men (LUTS) and understanding of voiding (obstructive) symptoms and storage (irritative) symptoms
- Acquire the necessary competence to perform and interpret TRUS and MR prostatography
- Have a good understanding of surgical and non-surgical treatment options including minimally invasive surgical treatments such as Holmium laser, endoscopic prostatic surgery, UroLift and prostatic stents

### Technical skills

- Acquire the necessary competence to carry out prostate artery embolization
- Understand the complications of PAE and how to manage them

### 2.2.1.2.1 Priapism

#### Knowledge

- Understand the postulated mechanism of both high (arterial or non-ischaemic) and low flow (venous or ischaemic) priapism
- Have knowledge of embolic agents for endovascular treatment (temporary embolization material: autologous clots, gelatinous foam and permanent embolization material: endovascular coils or N-butyl-cyanoacrylate)

#### Clinical skills

- Be able to make the clinical and radiological evaluation of priapism
- Understand the surgical and radiological treatments for high flow priapism and their relative merits and discuss these with your patient
- Describe the expected clinical outcome and the short-term and long-term morbidity

#### Technical skills

- Demonstrate technical competence in internal pudendal and cavernosal artery cannulation and embolization
- Choose and discuss the correct equipment including selective catheters and microcatheters

## 2.2.1.3 Venous disorders

### 2.2.1.3.1 Venous thrombosis and insufficiency

#### Knowledge

- Know the anatomy of the superficial and deep venous system and clearly distinguish:
  - Perforating veins
  - Varicose veins
  - Lipodermatosclerosis
  - Phlegmasia cerulea dolens
- Describe the haemodynamics of chronic venous insufficiency
- Outline the major risk factors for venous thrombosis including acquired and hereditary hypercoagulable conditions
- Know the consequences of venous thrombosis on normal venous patency and valve function
- Know the definition of chronic venous insufficiency, its relationship with acute deep vein thrombosis and the long-term sequelae
- Know the manifestations of May-Thurner and Nutcracker syndromes
- Know the manifestations of Paget Schroetter syndrome

#### Clinical skills

- Be able to diagnose peripheral venous thrombosis and phlegmasia cerulea dolens
- Be able to differentiate congenital from acquired forms of venous insufficiency
- Differentiate the clinical features of superficial venous insufficiency from deep vein insufficiency and/or combination of the two
- Describe the common staging systems for staging venous disease such as “CEAP” classification system of chronic venous insufficiency
- Describe the characteristics of venous stasis ulcers and differentiate from other types of ulcers (e.g. arterial)
- Understand the principles of conservative management of lower extremity chronic venous insufficiency: ambulation, elevation, exercise therapy and elastic support
- Be able to discuss the types of available therapy for superficial venous insufficiency (varicose veins) including elastic stockings, elevation, sclerotherapy, glue, laser and radiofrequency ablation, stab avulsion, stripping and their relative merits and potential complications
- Be able to discuss the types of available catheter directed therapies for acute deep vein thrombosis, the optimal timing and indications/contraindications for treatment
- Understand the use of various mechanical devices and techniques available for thrombolysis and their indications and contraindications

#### Technical skills

- Demonstrate competence in percutaneous therapies such as laser, radiofrequency ablation and foam sclerotherapy and avoidance of complications
- Recognize the relative risks and benefits associated with treatment of varicose veins including DVT, infection, skin slough, etc.
- Demonstrate competence in mechanical and pharmacological thrombolysis and its complications
- Demonstrate knowledge of various venous stents and appropriate placement of venous stents

### 2.2.1.3.2 Pulmonary thromboembolic disease

#### Knowledge

- Have knowledge of guidelines for management of venous thromboembolism
- Understand the medical, surgical and endovascular treatment options in these patients

#### Clinical skills

- Classify patients with acute and chronic thromboembolic disease based on history and physical as well as physiologic and imaging findings
- Understand the criteria for patient selection including CTPA appearances for when to perform and when to avoid interventional therapies (catheter-directed thrombolysis, thrombectomy or a combination of both) in patients with pulmonary embolism
- Understand pre-procedural, intra-procedural and post-procedural pharmacological management for patients undergoing IVC filter placement including anticoagulation
- Understand how to use thrombolytics, aspiration and mechanical thrombectomy devices in treating thrombo-embolic disease

#### Technical skills

- Know how to use a wide range of interventional equipment including guidewires, catheters, aspiration and mechanical thrombectomy catheters and permanent and optional IVC filters
- Understand the potential advantages and limitations of various types of filters including the maximal caval diameter in which each type of device may be placed
- Demonstrate technical competence in the performance of femoral and jugular venous access using ultrasound guidance, pulmonary angiography, pulmonary thrombolysis and mechanical thrombectomy, inferior vena cavography, IVC filter placement and retrieval
- Integrate the use of intraprocedural pressure monitoring in performing pulmonary angiography
- Ensure post-procedural protocols are in place, including date for retrieval of optional filters

### 2.2.1.3.3 Disease of the superior and inferior vena cava

#### Knowledge

- Know the causes and clinical manifestations of SVC and IVC obstruction (SVCO and IVCO)

#### Clinical skills

- To advise on the optimal treatments based on the clinical success rates and complication rates reported for SVC and IVC stenting in the current medical literature compared to other treatment options

#### Technical skills

- Demonstrate technical competence in the performance of SVC and IVCO recanalization, including venous access using ultrasound guidance, catheter-directed thrombolysis, balloon dilatation and stent placement
- To demonstrate the ability to use interventional equipment including guidewires, sheaths, catheters, balloons and various types of stents/stent-grafts
- To be able to use re-entry devices

## 2.2.1.3.4 Portal and hepatic venous interventions

### 2.2.1.3.4.1 Portal venous disease and transjugular intrahepatic portosystemic shunt (TIPS) and balloon-occluded retrograde transvenous obliteration (BRTO)

#### Knowledge

- Demonstrate a fundamental knowledge of chronic liver disease and its clinical manifestations
- Integrate patient clinical information into a classification scheme such as the Child-Pugh and MELD score
- Have knowledge of the equipment used in the TIPS procedure including guidewires, sheaths, catheters, balloons, stents, embolic materials, and transhepatic cannulation kits
- Discuss the benefits of using covered stents versus bare stents
- Know the normal ranges for portal venous pressures, central venous pressures, and portosystemic pressure gradients, including target ranges for post-TIPS portosystemic pressure gradients
- Demonstrate knowledge of the anatomical relationship between portal vein and systemic intrahepatic veins and their impact for TIPS
- Know the medical indications and contraindications for TIPS

#### Clinical skills

- Evaluate laboratory data in patients with chronic liver disease, with a specific understanding of liver function studies and other parameters useful in classifying liver disease
- Demonstrate clinical skill in distinguishing prehepatic, intrahepatic, and post hepatic portal hypertension
- Demonstrate a fundamental knowledge of portal hypertension, including its clinical manifestations, and potential complications including ascites, hepatic hydrothorax, gastro-oesophageal varices, portal gastropathy, hepatorenal syndrome, and hepatic encephalopathy
- Know the role of balloon dilation and stent placement in the management of extrahepatic vein stenosis
- Understand the role of TIPS in patients being considered for liver transplantation
- Understand the role of variceal embolization in patients undergoing TIPS for variceal bleeding
- List frequent surgical locations for the creation of porto-systemic shunts and be able to recognize them with angiography and CT
- Outline a strategy for TIPS surveillance using colour Doppler ultrasound and list expected shunt velocities and profiles in a patent shunt
- Describe abnormal Doppler ultrasound findings and their importance to outcome
- Understand the rationale of BRTO as a good alternative for the treatment of gastric varices

#### Technical skills

- Recognize the patterns of portal vein occlusion including cavernous transformation of the portal vein and the important collateral pathways
- Demonstrate technical competence in the performance of all procedural aspects of TIPS using fluoroscopic and ultrasound guidance
- Recognize and manage intra- and post-procedural complications of TIPS, including haemoperitoneum, haemobilia, biliary-shunt fistula formation, progressive liver failure, shunt thrombosis or occlusion, right heart failure, and hepatic encephalopathy
- Demonstrate competence in the performance of TIPS revision procedures, including the management of shunt stenosis, shunt occlusion and the need for shunt reduction
- Demonstrate competence in the performance of variceal embolization using a variety of agents including coils, plugs, glue, Onyx, etc.
- Demonstrate competence in the performance of BRTO



#### 2.2.1.3.4.2 Hepatic venous disease and Budd-Chiari syndrome

##### Knowledge

- Understand the role of TIPS and variceal embolization in patients with hepatic venous outflow obstruction
- Have knowledge of the equipment used including guidewires, sheaths, catheters, balloons, stents, embolic materials, TIPS sets and transhepatic cannulation kits
- Know the normal ranges for portal venous pressures, central venous pressures, and portosystemic pressure gradients, including target ranges for post-TIPS portosystemic pressure gradient
- Know the role of anticoagulant therapy after TIPS procedure
- Demonstrate a fundamental knowledge of Budd Chiari, including its clinical manifestations, and potential complications including ascites, hepatic failure and the sequelae of portal hypertension including hydrothorax, gastro-oesophageal varices, portal gastropathy, hepatorenal syndrome, and hepatic encephalopathy

##### Clinical skills

- Recognize and interpret the typical findings of hepatic outflow obstruction on imaging (CT, MRI and US doppler)
- Recognize the possible etiology of prothrombotic state and have knowledge of available medical therapies
- Understand the clinical utility and performance of hepatic vein recanalization/dilatation and/or stent insertion (through a transjugular approach, a percutaneous transhepatic and a combined approach)
- Understand the role of TIPS and variceal embolization in patients with hepatic venous outflow obstruction
- Understand the role of TIPS in Budd Chiari's treatment

##### Technical skills

- Demonstrate technical competence in performing hepatic vein recanalization, dilatation and stent insertion
- Demonstrate technical competence in the performance of TIPS
- Demonstrate competence in the performance of variceal embolization
- Recognize and manage intra- and post-procedural complications including haemoperitoneum, haemobilia, biliary-shunt fistula formation, progressive liver failure, shunt thrombosis or occlusion, right heart failure, and hepatic encephalopathy
- Ensure post-procedural management protocols for follow-up are in place

#### 2.2.1.3.5 Gonadal venous interventions

##### Knowledge

- Be aware of the different possible causes of pelvic pain in women
- Know the common staging techniques for varicoceles
- Know pelvic and gonadal vein anatomy
- Know the rate of varicocele and pelvic vein varices recurrence after embolization
- Be aware of the surgical alternatives to embolization of varicocele
- Be aware of the venous compressive syndromes (May-Thurner, Nut Cracker) and how they might influence the treatment and results of a pelvic congestion syndrome
- Have knowledge of the relationship between pelvic varices and lower limb varices
- Have knowledge of the pros and cons of the different embolic and sclerosant agents used in the treatment of gonadal veins and internal iliac veins

- Have knowledge of the detection and embolization of collateral veins and connections between pelvic and lower limb varices
- Have knowledge of normal sperm count range values in male patients to correctly assess the results of spermatic vein embolization with regards to fertility
- Have knowledge of the different image techniques for diagnosis of varicocele or pelvic congestion syndrome. Advantages and drawbacks of transvaginal US, scrotal US, CTA, MR, MRA and venography

### **Clinical skills**

- Clinical assessment of varicocele in men
- Understand specific reproductive/fertility/menopausal effects, symptom resolution, and comparison to standard genitourinary or obstetrics and gynaecology surgical techniques, compared to embolization

### **Technical skills**

- Demonstrate technical competence in performing venous access from different routes (jugular, antecubital, femoral) under ultrasound guidance and performing venography
- Re-assess and undertake re-intervention or additional embolization for persistence of symptoms and or dilated veins

## **2.2.1.3.6 Haemodialysis vascular access**

### **Knowledge**

- Know the anatomical locations and their preferred order of creation, of fistulae and synthetic grafts together with their expected outcomes
- Know the pathophysiology of arteriovenous access failure including failure of maturation of fistula, central venous stenosis, aneurysms and steal phenomena
- Understand the preferred access sites and preferred duration of temporary haemodialysis catheters
- Know the advantages and disadvantages of different line tip positions
- Know the pros and cons for the different techniques used to treat thrombosed grafts and fistulas
- Have knowledge of the most common sites for fistula and graft stenosis
- Have knowledge of the treatment of patients with infected haemodialysis catheters
- Have knowledge of the rationale, indications and contraindications for the various techniques for intervention in failing dialysis access
- Have familiarity with the recommendations of the American National Kidney Foundation Dialysis Outcomes Quality Initiative for vascular access (DOQI)

### **Clinical skills**

- Understand the preferred venous access sites for the placement of haemodialysis catheters and the evaluation of patients with physical examination and ultrasound prior to their placement
- Be aware of the need to avoid certain sites for venepunctures in patients with renal impairment
- Understand the clinical methods for surveillance and evaluation of dialysis access fistulae using physical examination and volume flow methods, as well as imaging (see below)
- Be able to clinically assess signs of complicated, failing or failed haemodialysis access including failure of maturation of a native fistula, high pressure or low flow in the dialysis machine, prolonged post-dialysis bleeding, decreased Kt/V, decreased creatinine clearance, arm oedema and steal syndrome

- Have knowledge of the evaluation of patients with malfunctioning haemodialysis catheters
- Understand the causes of catheter malfunction and the expected outcomes of intervention in malfunctioning catheters
- List alternative access possibilities when conventional venous access is not available
- Understand the clinical aspects of the pre-operative workup of patients for permanent haemodialysis
- Demonstrate knowledge of the incidence of central vein stenosis in dialysis patients including risk factors and preventive strategies
- List the surveillance methods for assessing vascular access including their advantages and disadvantages
- Understand the differences between primary, primary-assisted and secondary patency and the published literature relating to these different outcome points

### Technical skills

- Demonstrate competence in duplex US of the dialysis vascular access
- Have knowledge of the vascular access exploration: pulse, thrill, vein collapse
- Demonstrate competence in the techniques for the insertion of temporary dialysis catheters including preferred sites and the DOQI guidelines for maximum recommended duration of temporary catheters
- Be competent in the techniques of placement of a number of different tunnelled haemodialysis catheters, and describe their advantages and disadvantages
- Demonstrate competence in the management of collateral veins when there is a poor fistula maturation
- Demonstrate competence in the management of vascular access dysfunction: PTA of venous, arterial and anastomotic stenosis using high pressure balloons, drug-eluting balloons, cutting balloons, stents and stent-grafting
- Demonstrate competence in the management of vascular access acute thrombosis, catheter-directed thrombolysis, thrombo-aspiration and mechanical thrombectomy
- Be competent in techniques for haemostasis post-fistula or graft salvage
- Demonstrate knowledge and competence in treating steal syndrome including angioplasty, fistula restriction, surgical bypass and ligation
- Demonstrate competence in percutaneous radiological placement of peritoneal dialysis catheters, their complications and their management
- Demonstrate competence in the management of false aneurysms

## 2.2.1.3.7 Central venous access

### Knowledge

- Know the range of central venous catheters, tunnelled and non-tunnelled, ports, PICCs, dialysis and apheresis lines
- Know the advantages and disadvantages of the different types of catheter and ports
- Know the optimal tip position of central lines
- Know about the care of central lines
- Understand there are differences in flow rates and the maximum pressures to which lines may be subjected

### Neck

- Describe ways to augment jugular venous size to facilitate venous access
- Recognize on US the differences between veins, lymphadenopathy and thyroid cysts
- Describe the position and relevance of valves in the internal jugular and subclavian veins

**Upper limb**

- Describe preferred sites for placement of upper limb lines and ports
- Describe how the tip position of central lines placed from the arm may vary depending on the position of the arm
- Understand the effect that the phases of respiration have on venous size and central venous pressure

**Lower limb**

- Know the common sites for access

**Chest**

- Describe preferred sites for the exit points of subcutaneous tunnels on the anterior chest wall and how these may vary depending on the body habitus of the patient
- Describe preferred sites for placing subcutaneous ports on the chest wall

**Miscellaneous**

- Know the possibility of translumbar, transhepatic or transumbilical access for central line placement in some special clinical scenarios

**Clinical skills**

- Be able to interpret venous anatomy by various imaging modalities including ultrasound, plain radiography, fluoroscopy, venography, CT and MR
- Understand the rationale for the use of central venous access and the interaction of drugs and other solutions with venous endothelium
- Recognize that a central catheter is abnormally sited on post-procedural radiographs and know the range of possible locations for line tips that are in branch veins or outside the venous system
- Understand approaches to prevention of line infection and how the risk of infection varies according to the anatomical site of access
- Recognize the complications of line infection and know how to treat a line infection
- Understand how fibrin sheaths develop and how these compromise catheter function
- Understand the causes of venous stenosis and venous occlusion
- Describe strategies for imaging the venous circulation in patients with suspected or documented venous occlusive disease
- Understand the pathophysiology and treatment of air embolus
- Understand the cause of “pinch off” syndrome leading to fragmentation of infraclavicular central catheters via the axillary/subclavian route
- Be able to instigate and interpret the imaging of patients with suspected complications of central venous access, including venous thrombosis, atrial thrombus, endocarditis, pulmonary embolus, catheter fracture, fibrin sheaths, pseudoaneurysm, arteriovenous fistula and lines suspected to be inadvertently in the arterial tree

**Technical skills**

- Demonstrate proficiency in Doppler US for demonstrating and assessing venous anatomy
- Demonstrate competence in US-guided puncture of the internal jugular, external jugular, axillary, subclavian, upper limb and femoral veins
- Be competent in insertion of temporary and tunnelled lines via the jugular, subclavian and femoral approaches
- Be competent in placement of arm and chest wall ports
- Recognize when a central catheter is in an abnormal position on post-procedural imaging
- Be aware of alternative strategies where standard routes of access are unavailable, including tunnelled femoral lines, translumbar IVC lines, transhepatic lines, US-guided puncture of the innominate veins and recanalization of occluded central veins to facilitate access
- Be competent in SVC or iliac vein recanalization prior to a central line placement

**Management of complications, i.e.:**

- Know techniques for repositioning malpositioned lines
- Be able to perform fibrin sheath stripping or clearance with thrombolytic agents
- Be competent in insertion of chest drains for pneumothorax and haemothorax
- Be competent in snare retrieval of intra-vascular catheter fragments
- Be competent in management of massive air embolus

### 2.2.1.3.8 Venous sampling

**Knowledge**

- Know the clinical presentation of endocrine disease requiring functional investigation

**Clinical skills**

- Understand the use of provocative medication, e.g. calcium, secretin, ACTH-like drugs
- Be able to interpret laboratory results
- Be able to select patients suitable for venous sampling in a multi-disciplinary team setting

**Technical skills**

- Demonstrate competence in performing venous sampling and peripheral venous or arterial stimulation
- Select appropriate catheters, microcatheters and wires used in venous sampling

## 2.2.2 Non-vascular interventions in the chest, gastrointestinal tract and hepatobiliary systems

### 2.2.2.1 Image-guided biopsy and drainage (including transjugular liver biopsy but excluding MSK)

**Knowledge**

- Know which lesions are best diagnosed and/or approached with fine needle aspiration versus core biopsy and when and how to send the material for microbiological evaluation if infection is suspected
- Have knowledge of a variety of biopsy needles (for histology, cytology) and techniques

**Clinical skills**

- Appropriately manage pre-procedure workup including coagulation status and appropriate laboratory values
- Identify alternatives to percutaneous biopsy where suitable, e.g. EUS (endoscopic ultrasound)-guided biopsy for pancreatic and subcarinal masses

**Technical skills**

- Demonstrate competence in safely performing percutaneous biopsy of lesions in the chest, abdomen and pelvis
- Be able to treat patients with post-biopsy pneumothorax including conservative management or placement of a chest drain if necessary
- Be able to manage patients with significant haemorrhage following biopsy

## 2.2.2.2 Lymphatic embolization

### Knowledge

- The drainage pathway for the lymphatic system
- Common causes for lymphatic leak
- Know the techniques for treating lymphatic leaks
- Know the equipment commonly used to undertake lymphangiography
- Know the commonly used embolic agents for lymphatic embolization

### Clinical skills

- Assess imaging techniques to look for lymphatic leaks including MRI and Lipiodol lymphangiography

### Technical skills

- Be able to carry out US-guided lymph node puncture in order to undertake lymphangiography
- To demonstrate the technique for lymphatic duct/cysterna chyli puncture
- To demonstrate the technique for embolization

## 2.2.2.3 Image-guided aspiration and drainage of collections including abscesses

### Knowledge

- Know about specific causes such as intestinal perforation, post-operative surgical complications i.e. anastomotic leak, acute necrotizing pancreatitis, acute cholecystitis and specific types of infection
- Understand specific risk factors according to location, underlying condition, general patient factors and significant comorbidities (e.g. describe the indications and contraindications of diagnostic aspiration of pleural fluid collections and percutaneous chest tube drainage of complicated pleural effusion/empyema)
- Have basic knowledge of chemical sclerotherapy techniques for pleurodesis and other types of sclerotherapy
- Have knowledge of a wide variety of coaxial needles, drainage catheters and guidewires for the purposes of percutaneous abscess drainage
- Have a fundamental knowledge of chest tube drainage systems including water seal drainage systems and evaluation for persistent air leaks in patients with pneumothorax

### Clinical skills

- Assess appropriate laboratory investigations confirming clinical picture and procedural risks (access routes, coagulopathy, etc.)
- Be able to undertake appropriate patient selection for percutaneous interventions
- Understand and recognize the common patterns and variety of presentations of conditions leading to loculated or diffuse fluid collections
- Understand the range of treatment strategies including medical, interventional and surgical alternatives sufficient to be able to discuss management with referring physicians and patients and formulate appropriate treatment plans

- Show an understanding of the advantages and disadvantages of CT guidance, CT fluoroscopy, ultrasound guidance and fluoroscopy guidance for different types of fluid collections in different locations
- Assess complications including drain displacement, bowel perforation, worsening sepsis, and haemorrhagic complications
- Attend and review the clinical progress of the patient
- Arrange and interpret appropriate post-procedural imaging and follow-up visits

### Technical skills

- Identify the safest and most expeditious route of drainage for collections in various anatomic locations throughout the chest, abdomen and pelvis
- Demonstrate skill at image-guided puncture and drainage of a range of target lesions in common sites and conditions
- Demonstrate understanding of dilatation of established drainage tracks for placement of larger bore catheters
- Identify potentially difficult cases such as multiloculated abscess cavities that may require placement of multiple catheters for adequate drainage, flushing regimens or instillation of fibrinolytic agents to aid with drainage
- Be able to undertake patient monitoring requirements during and after procedures with the use of sedation including knowledge of the use of antidotes for sedatives and treatment of complications of sedation
- Provide optimal follow-up care post-percutaneous abscess drainage with post-procedural imaging and with repositioning or replacement of drainage catheters as necessary
- Understand when percutaneous abscess drainage catheters can be removed and demonstrate experience in their removal

## 2.2.2.4 Gastrointestinal interventions

### 2.2.2.4.1 Enteral tube placement (gastrostomy, gastrojejunostomy, jejunostomy, caecostomy)

#### Knowledge

- Know the roles of the different techniques including when to place a gastrostomy, gastrojejunostomy, jejunostomy or caecostomy for appropriate patient selection
- Have knowledge of a wide variety of tubes as well as retention systems
- Know the range of available alternative techniques

#### Clinical skills

- Consider ethical factors prior to placement of enteral feeding access in this patient population
- Ensure adequate patient preparation including prior nasogastric, nasojejunal intubation or prior oral contrast to opacify the colon
- Understand the strengths and weaknesses of the different tube systems
- Understand the role of bowel fixation systems
- Understand the role of surgical placement of tubes and other methods of feeding or decompression
- Understand the need to be part of a multidisciplinary team to coordinate care

## Technical skills

- Demonstrate technical competence in carrying out the procedures with selection of the most appropriate image guidance
- Demonstrate how to use guide wires, catheters and fixation-systems to primarily place a gastrostomy or use these for a retrograde approach to allow placement of a pull type gastrostomy
- Converting a gastrostomy to a gastrojejunostomy
- Recognize and treat complications including pain, bleeding, tube displacement and peritonitis
- Ensure clear pre-procedural and post-procedural instructions (fasting, antibiotics, etc.) and pathways for tube care

### 2.2.2.4.2 Gastrointestinal stenting

#### Knowledge

- Understand the natural history and complications of benign and malignant upper and lower gastrointestinal strictures
- Know and understand the role of stent insertion for palliation of malignant dysphagia and malignant enteric obstruction and alternative treatment options
- Know and understand the 'bridge-to-therapy' concept and the limited role of temporary stenting for benign lesions (e.g. strictures resistant to conventional therapy and the use of stents for bleeding varices)
- Know and understand the different properties of different stent constructions, stent materials, the role and relative merits of biodegradable, covered and uncovered stents and the options offered by removable and anti-reflux stents

#### Clinical skills

- Be able to advise on the appropriate combination of pre-stent imaging procedures including endoscopy
- Be able to understand the information provided by EUS
- Know and understand the indications, complications and contraindications for insertion of self-expanding stents for the oesophagus, stomach, duodenum and colon
- Identify patients requiring endoscopic assistance for duodenal and colonic strictures
- Be able to advise patients regarding complications and their rate of occurrence
- Be able to discuss aspects of disease process, progress and survival with patients and their relatives
- Appreciate the importance of a multi-disciplinary workup and continued follow-up of stent patients

#### Technical skills

- Be able to perform and interpret imaging investigations such as a barium/water soluble enema, enteroclysis, and CT colonography
- Have knowledge of the wide variety of stents and delivery systems
- Understand the technical aspects of catheter and wire combinations for crossing strictures and occlusions and the types and roles of support wires and sheaths
- Demonstrate technical competence in crossing occlusions and strictures and in the use of support wires and other techniques like "buddy wires" in straightening out tortuous anatomy prior to stent insertion and the implications of this for stent length and type
- Demonstrate technical competence in stent insertion and retrieval
- Be able to advise and manipulate through an endoscope in combined procedures
- Recognize and treat complications of stent insertion, including secondary stent failures such as migration and re-occlusion



## 2.2.2.5 Hepato-pancreatico-biliary (HPB) intervention

### Knowledge

- Understand the variety of causes of bile duct obstruction such as stones, benign and malignant strictures and extrinsic causes
- Demonstrate awareness of the various techniques of percutaneous management of biliary calculi including assisting endoscopic access, percutaneous sphincterotomy, stone crushing and retrieval
- Demonstrate an understanding of:
  - The selection of endoscopic, percutaneous transhepatic or roux loop approaches
  - The selection of a drainage route(s) most appropriate to segmental anatomy and disease distribution
  - The assessment of potential complications related to individual patient anatomy
- Understand how disease processes alter anatomy and the implications for interventional strategies (e.g. level and cause of obstruction, post-surgical anatomy, and endoscopic vs. percutaneous approaches)
- Understand the causes and treatment of biliary leaks
- Demonstrate familiarity with a wide array of percutaneous biliary access systems, and commonly used equipment for HPB interventional procedures including access and drainage systems, balloons, baskets, stents and endoscopic devices, etc.

### Clinical skills

- Be able to assess the patient's overall clinical status with regard to the risks and benefits of intervention
- Recognize the various clinical presentations in patients with HPB disease including benign and malignant biliary obstructive jaundice, cholangitis and biliary stone disease
- Understand disorders of haemostasis/multiple organ dysfunction in jaundiced patients and the impact of additional sepsis and the implications for patient selection, optimizing medical condition pre-, intra- and post-procedurally
- Know various methods for obtaining biopsies and/or cytology of biliary strictures
- Know the complications of HPB disease (ascites, portal hypertension/thrombosis)
- Be able to interpret laboratory investigations
- Integrate proper pre-procedure imaging workup in patients with benign and malignant biliary obstruction
- Know the anatomical changes following surgical intervention for HPB cancer
- Be able to discuss prognostic issues with the patient and allow the patient to have realistic expectations where appropriate
- Discuss imaging strategies for patients with suspected HPB diseases including algorithms for jaundice, sepsis, cholangitis, biliary colic, biliary leak and fistula as well as non-specific presentations of suspected HPB malignancy

### Technical skills

- Demonstrate skills in percutaneous transhepatic cholangiography and biliary drainage under a combination of fluoroscopic and ultrasound guidance
- Demonstrate appropriate placement of biliary stents across strictures and/or occlusions
- Demonstrate appropriate use of baskets and balloons to remove and/or dislodge stones
- Organize appropriate post-procedural management following drainage procedures to assess response to the intervention and recognize and manage complications including haemorrhage, infection, drain displacement
- Arrange post-drainage procedures and interventions including, as appropriate, check cholangiography, conversion to internal drainage, biliary stenting by percutaneous or combined radiological – endoscopic methods

- Manage patients with arterio-biliary fistulae or bleeding following percutaneous biliary drainage
- Demonstrate skills in treating complications of pancreatitis including recognizing and treating further complications such as haemorrhage
- Demonstrate skills in treating focal liver diseases such as liver abscess and symptomatic liver cysts (e.g. drainage and sclerotherapy)

## **Spinal intervention in oncology**

### **Interventions in vertebral body compression fractures (VBCF)**

#### **Knowledge**

- Understand bone repair and changes post-radiotherapy of vertebrae
- Understand how to approach soft tissue extensions of bone lesions
- Know when there is a benefit to the patient by doing a combination therapy
- Know when embolization is indicated before ablation or surgery
- Identify unstable fractures and the surgical options in these patients
- Understand when the patient may need a surgical intervention immediately after treatment (such as laminectomy post-sclerotherapy for vertebral haemangiomas)
- Know which patients with metastatic disease need to be assessed for radiotherapy before or after the procedure. Discuss with the radiotherapy team prior to treatment for better planning

#### **Clinical skills**

- Appropriately identify patients with symptomatic VBCF
- Categorize VBCF as to their appropriateness and expected response for treatment with percutaneous techniques
- Identify patients who might benefit from vertebral augmentation techniques (use of stents, peek cages, etc.) and understand the differences between these methods and their indications

#### **Technical skills**

- Demonstrate understanding of correct techniques for vertebral body access (transpedicular, parapedicular)
- Have knowledge of interventional equipment and their use including cements and cement delivery systems, needles, vertebroplasty-vertebral height enhancing devices (stents, peek cages, etc.) and x-ray screening facilities
- Understand when percutaneous vertebroplasty (PV) can be combined with other curative or palliative minimally invasive techniques of ablation (thermal and cryoablation)
- Have knowledge of all measures to protect and monitor sensitive neural structures in the spine (including active and passive thermoprotection by means of air or CO<sub>2</sub> injection, thermocouples, evoked potentials, etc.)
- Have knowledge of sclerotherapy for vertebral haemangioma, how to use sclerogel as well as how to monitor the patient for need of emergency decompression, or plan as simultaneous decompression procedure after the sclerotherapy
- Have knowledge of the use and technique of a vertebroplasty after a sclerotherapy procedure

## **Percutaneous osteoplasty**

#### **Knowledge**

- Have knowledge of the commonly used interventional equipment in percutaneous osteoplasty

### **Clinical skills**

- Select patients with peripheral bone lesions who will benefit from osseous augmentation
- Identify patients who may benefit from a combination of osteoplasty and ablation techniques

### **Technical skills**

- Demonstrate knowledge of proper osseous access techniques
- Understand when percutaneous osteoplasty can be combined with other minimally invasive techniques of ablation (thermal and cryoablation) aiming for cure or palliation or screw fixation. In these cases of combined treatments, one should have knowledge of all protective measures (including active and passive thermoprotection by means of air or CO<sub>2</sub> injection, thermocouples, evoked potentials, etc.)

### **Soft tissue tumours (desmoids, lymph nodes, etc.)**

Soft tissue tumours such as desmoids, sarcomas and lymph node metastases require a basic knowledge of their pathology and management using the principles as described previously.

## **2.2.3 Intervention of the genito-urinary tract and renal transplants**

### **2.2.3.1 Pelvicalyceal and ureteric obstruction**

#### **Knowledge**

- Understand the causes of acute and chronic renal obstruction, both benign and malignant and their impact on planning interventions
- Understand the renal physiological changes pre- and post-ureteric obstruction
- Know the pros and cons of different ways of relieving obstruction including nephrostomy, retrograde and antegrade ureteric stenting
- Know the bladder anatomy post-cystectomy or post-bladder augmentation
- Know the fluoroscopic and endoscopic techniques for retrograde ureteric stent exchange
- Know how to manage post procedural infection
- List the relative risks related to a different choice of calyceal access
- Describe the maintenance of long-term nephrostomy drainage, catheter exchange and replacement of dislodged catheters
- Knowledge of the different surgical techniques used to form ureteroileal anastomosis in ileal conduits

#### **Clinical skills**

- Understand the common disorders of the genito-urinary tract (including renal transplants)
- Understand upper and lower tract urodynamics
- Understand the clinical presentation and physical signs associated with upper urinary tract obstruction
- Plan the radiological investigation of suspected ureteric obstruction or ureteric leaks and their treatment

- Understand the role of interventional radiology in the overall management of the common disorders of the genito-urinary tract and renal transplants and discuss the most appropriate management
- Understand the need for regular stent changes
- Understand and explain the expected outcomes from ureteric occlusion
- Understand the role of renal ablation

### Technical skills

- Be able to correctly position the patient for percutaneous interventions
- Demonstrate competence and correct selection of equipment needed
- Needles (18-22G, sheathed and non-sheathed, standard and diamond-tip)
- Guidewires (0.018-0.035 inch, flexible, stiff and hydrophilic)
- Dilators and sheaths (including peel-away sheaths)
- Manipulation catheters
- Drainage catheters and various locking mechanisms available
- Demonstrate competence in performing percutaneous nephrostomy and ureteric interventions (see below)

#### Percutaneous nephrostomy insertion

- Describe percutaneous puncture techniques available:
  - Ultrasound (freehand and guided techniques)
  - Fluoroscopy
  - Computed tomography
  - Blind puncture
- Be able to plan and understand appropriate access intervention
- Describe the correct technique for placement of external drainage nephrostomy catheter

#### Ureteric stent insertion

- Demonstrate knowledge of the types of ureteric stent available
- Describe the available techniques for ureteric stent insertion and potential benefits of each
  - Antegrade ureteric stenting (AUS)
  - Retrograde ureteric stenting (RUS)
  - Combined ureteric stenting
- Describe the various techniques used to cross an obstructed ureter, including use of balloon dilatation, micro guidewires and catheters
- Describe the correct technique for insertion of an antegrade ureteric stent, use of guidewire, peel-away sheath and covering nephrostomy drainage catheter types

#### Ureteric therapeutic occlusions

- Describe the various techniques available for achieving ureteric occlusion and have knowledge of commonly used materials

#### Retrograde ureteric stent insertion

- Understand how to use the rendezvous procedures
- Understand the role of retrograde urological interventions in ileal conduits and retrograde stent insertion
- Describe the fluoroscopic and endoscopic techniques for retrograde ureteric stent exchange
- Describe the correct technique for insertion of an antegrade ureteric stent, use of guidewire, peel-away sheath and covering nephrostomy drainage catheter types

**Ureteric balloon dilatation**

- Demonstrate competence in the technique of balloon dilatation ureteroplasty

**Removal of foreign bodies**

- Demonstrate competence in the techniques to remove foreign bodies from the urinary tract
- Demonstrate competence in the use of the equipment available for foreign body removal

## 2.2.3.2 Renal stone disease

**Knowledge**

- Understand stone structure and composition and the value of dual energy CT in their assessment for planning therapeutic options

**Clinical skills**

- Understand and describe the different presentations of stone disease
- Understand the differential diagnosis of presenting symptoms and signs (e.g. haematuria, flank pain, etc.)
- Understand the associated morbidity and urgency of management in the presence of obstruction and infection
- Understand and list the factors affecting the choice of management options (presentation, size, site, anatomical, etc.)
- Understand planning of safe access sites to treat stones in different calyces
- Understand the indications for conservative management and importance of follow-up

**Technical skills**

- Be able to use of all instruments used to establish a percutaneous track
- Demonstrate competence in handling needles, guidewires and dilatation kits
- Demonstrate competence in nephrostomy placement, antegrade ureteric dilatation, stent insertion and PCNL

## 2.2.3.3 Renal masses and perirenal collections

**Knowledge**

- Know the incidence and classification of solid and cystic renal mass lesions
- Know the range of needles, guidewires, drainage catheters and drainage kits
- Have knowledge of a range of needles and devices available for percutaneous biopsy

**Clinical skills**

- Understand the clinical presentation of, and physical findings in, patients with renal masses and perirenal collections
- Understand the pre-procedure workup of patients undergoing drainage and biopsy procedures, including laboratory examinations
- Demonstrate detailed understanding of patient preparation, local anaesthetic administration and sedation
- Understand the role of diagnostic aspiration and percutaneous biopsy
- Understand the role of sclerotherapy in the management of cystic renal lesions

### Technical skills

- Demonstrate technical competence in image-guided aspiration and drainage of peri-renal collections
- Demonstrate technical competence in image-guided percutaneous biopsy of renal masses
- Describe use of the sclerosant agents available
- Describe the techniques available to access difficult lesions with ultrasound and/or CT
- Provide optimal follow-up care for patients following percutaneous biopsy and drainage including catheter care, further imaging and intervention and catheter removal

## 2.2.3.4 Genito-urinary interventions

### 2.2.3.4.1 Acute prostatitis (abscess)

#### Knowledge

- Know the treatment options
- Know the natural history and expected clinical outcome
- Know the commonly used instruments for transrectal and percutaneous drainage

#### Clinical skills

- Understand the clinical presentations
- Have knowledge of the methods of diagnosis and treatment of prostate abscess
- Demonstrate knowledge and competence in the appropriate use of prophylactic antibiotics in urological intervention

#### Technical skills

- Describe the techniques used for the different approaches (trans-rectal, trans-perineal) for draining prostate abscesses under image guidance (CT or TRUS)
- Demonstrate competence in handling needles, guidewires and dilatation kits

## 2.2.3.5 Renal transplant interventions

#### Knowledge

- Understand the various late and early causes of transplant dysfunction
  - The role of intravenous urography, antegrade pyelography and upper tract urodynamics in the assessment of dilatation of the transplant kidney pelvicalyceal system
  - Understand the role of grey scale ultrasound, diagnostic aspiration and biochemical analysis in the evaluation of the origin and relevance of peri-nephric collections
  - List the indications and role for percutaneous nephrostomy, ureteric dilatation and stenting in the short- and long-term management of ureteric obstruction, stenosis and leak
  - Know the outcomes, advantages and disadvantages of each procedure
- Know the role of perinephric collections in the causation of ureteric obstruction, their evaluation and percutaneous management, including sclerotherapy

## Clinical skills

- Be able to discuss:
  - The clinical evaluation of transplant renal artery stenosis (TRAS)
  - The relevance of TRAS in the context of post-transplant hypertension, dysfunction and unstable pulmonary oedema
  - The role of catheter angiography and intra-arterial pressure measurement in defining the grade of stenosis
  - The reasons for, the risks of, and outcomes of renal angioplasty and stenting
  - The advantages of ipsilateral and contralateral arterial approach, as tailored to the surgical anastomosis
  - To recognize the role of renal protective agents in the pre- and post-procedure management of patients with TRAS to minimize contrast-induced nephropathy
- Understand the surgical aspects of ureteric and vascular anastomosis and the surgical orientation of the renal transplant and how this impinges on interventional approaches to the transplanted kidney. The differences between a live donor and cadaver kidney should be understood, and how this influences surgical anastomosis
- Be able to discuss the investigation and management of transplant ureteric dilatation:
  - Understand the pathological conditions that affect the transplant ureter
  - Understand the differences between native and transplant pelvicalyceal dilatation and differentiate between simple pelvicalyceal dilation and true ureteric obstruction

## Technical skills

- Demonstrate competence in performing angiography and vascular interventions on transplant kidneys
- Utilize alternative contrast agents in the evaluation and treatment of renovascular disease
- Demonstrate competence with the equipment and techniques used in the treatment of renal artery stenosis
- Integrate the use of intra-procedural intra-arterial pressure measurements in assessing the results of renovascular interventions
- Demonstrate competence in selecting the safest percutaneous approach to the calyceal system of the transplant kidney, using either ultrasound or fluoroscopic guidance or both
- Demonstrate knowledge of the differences between native and transplant calyx access and nephrostomy insertion techniques
- Competence in selecting the types and size of ureteric stent used in a transplant ureter

## 2.2.4 Intervention of the musculoskeletal system

### 2.2.4.1 Image-guided biopsy

#### Knowledge

- Know the advantages and disadvantages of various imaging modalities for guiding the biopsy of bone and soft tissue lesions
- Know the advantages and disadvantages of various imaging modalities for the biopsy of ribs, long bones and spinal lesions
- Know the use of different needle types for dense cortical bone, trabecular bone, lytic bone lesions and marrow aspirates
- Know how many samples one should try to obtain in one biopsy session
- Be aware of the requirements for correct labelling, preservation, preparation and packaging and specimens for histological, cytological, microbiological investigations and ensure their prompt transfer to the appropriate laboratory

### **Clinical skills**

- Identify safe approaches to percutaneous biopsy of bone and soft tissue lesions demonstrating knowledge of overlying neurovascular and compartmental anatomy
- Be aware of the consequences of inappropriate biopsy (including use of needle pathways that would exclude or impair a subsequent surgical treatment) of primary bone/soft tissue sarcomas
- Have knowledge of when to send material for appropriate microbiological evaluation if infection is suspected
- Identify and have understanding of the management algorithm of patients experiencing significant haemorrhage following biopsy

### **Technical skills**

- Be able to use the coaxial technique
- Undertake procedures under sonographic, fluoroscopic and computed tomography guidance
- Describe the use of targeting software
- Be able to perform post-biopsy tract embolization via a coaxial access
- Be able to manage peri- and post-procedural pain

## **2.2.4.2 Percutaneous ablation of bone and soft tissue lesions**

Please see the interventional oncology section (2.2.5 pages 80-87)

## **2.2.4.3 Intra-articular injections under image guidance**

### **Knowledge**

- Know the possible surgical options for the patient
- Know the pharmacological agents to inject for diagnostic or therapeutic purposes
- Know the clinical benefits of the injections

### **Clinical skills**

- Be able to identify the articulation to be injected and the planned percutaneous approach
- Select the appropriate imaging guidance for each joint

### **Technical skills**

- Demonstrate competence in both diagnostic and therapeutic image-guided injections

## **2.2.4.4 Percutaneous osteoplasty**

### **Knowledge**

- Understand the predominant biomechanics of target bones
- Understand the biomechanical properties of bio-compatible cements
- Have knowledge of interventional equipment used for osteoplasty procedures



### Clinical skills

- Be able to identify benign and malignant conditions that may benefit from injection of bio-compatible cements
- Be able to make a clinic-radiological correlation allowing the identification of patients that may benefit the most from injection of bio-compatible cements

### Technical skills

- Describe the technique for undertaking osteoplasty
- Be able to treat patients who develop common complications following percutaneous osteoplasty

## 2.2.4.5 Spinal intervention

### 2.2.4.5.1 Interventions in vertebral body compression fractures (VBCF)

#### Knowledge

- Understand the predominant biomechanics of the vertebral body
- Understand the biomechanical properties of bio-compatible cements

#### Clinical skills

- Be able to identify benign and malignant spinal conditions that may benefit from injection of bio-compatible cements
- Be able to recognize clinical conditions that may benefit from vertebral augmentation with expandable devices
- Be able to make a clinic-radiological correlation allowing the identification of patients that may benefit the most from vertebral augmentation

#### Technical skills

- Describe the use of interventional equipment used for vertebral augmentation procedures
- Be able to treat patients who develop complications following vertebral augmentation

### 2.2.4.5.2 Spinal procedures for disc, nerves and facet joints

(E.g. selective nerve root blocks, epidural steroid injections, facet joint blocks, discography, percutaneous decompression of intervertebral discs)

#### Knowledge

- Understand the medical and surgical treatment options in these patients
- Demonstrate appropriate knowledge of steroids, anaesthetics and other agents used in spinal injection procedures
- Have knowledge of interventional equipment as used in spinal injection procedures

### Clinical skills

- Appropriately identify patients with spinal pain syndrome
- Appropriately identify possible origins of spinal pain syndrome according to clinical and radiologic elements
- Appropriate selection of patients for spinal injection and percutaneous disc decompression procedures

### Technical skills

- Describe the percutaneous techniques (mechanical, thermal and chemical) of disc decompression techniques and the appropriate equipment

## 2.2.5 Interventional oncology (IO)

### 2.2.5.1 Fundamental IO

All the general training requirements for training from preceding sections apply to IO

#### Knowledge

- Epidemiology and risk factors of tumours of different organs
- Tumour classification according to:
  - Histology subtypes
  - Molecular profiles
- Tumour markers and their significance
- Tumour staging (TNM and others relevant to specific tumours)
- Tumour prognostic systems
- Diagnostic criteria (choice of preferred imaging modality and fundamentals in imaging interpretation)

#### Treatment

- Know the different IR treatment options for the relevant tumours in the various systems, i.e. ethanol, cryotherapy, RF, microwave, irreversible electroporation, laser, HIFU, etc. and their outcomes
- Know which device, probe, probe size and positions relevant to the tumour, location and size
- Recognize the imaging appearances and end points during treatment i.e. progress of the ice ball and when to stop

#### Radiation physics and dose

For information on dose reduction and management, please refer to section 2.1.3.

#### Radio-resistance

Certain molecular markers suggest relative radio-resistance: hypoxia, P21 and P53 mutations and a low proliferation rate. Absence of HPV-influence in head and neck cancer patients (HPV-positive HNSCC are more radiosensitive).

**Radiotherapy** (See also appendix 2)

- External beam
- IMRT
- Brachytherapy
- Intra-operative
- Stereotactic radiotherapy
- Proton therapy
- Radio-pharmaceuticals

**Radiotherapy side effects****• Acute (within 3 months after treatment)**

Skin desquamation, nausea, diarrhoea, oedema. Specific side effects by disease site (proctitis in pelvic RT, dysphagia in head and neck RT, etc.)

**• Chronic (more than 3 months)**

Radiation fibrosis, vascular obliteration: complex cellular mechanism including myofibroblast activation and up-regulated fibrogenesis.

**Systemic therapy**

- A trainee should know the systemic therapy regimens available for different tumours, their mode of delivery and have an understanding of the terminologies used, e.g. adjuvant, neoadjuvant, first line, etc.
- Knowledge of recent advances in systemic therapy e.g. kinase inhibitors, immune-checkpoint inhibitors, combination therapies

**Pharmacology**

As well as knowledge pertaining to standard medications used in IR, IO requires knowledge of pharmacokinetics and pharmacodynamics as well as toxic effects of systemic therapy agents.

**Clinical skills**

- Understand the importance of multidisciplinary tumour board discussion
- Understand surgical oncology procedures in different organs, their complications and post-operative imaging features
- Know the most appropriate imaging guidance for the different organs and tumour sites
- Understand the anatomical changes with regard to vascular and organ anatomy following surgery to plan IR therapeutic procedures
- Understand the importance of patient positioning required for a procedure to avoid injury
- Know how to avoid trauma to local structures or nerves, i.e. the brachial plexus in patients whose arm will need to be extended over the head in a prone position over an extended period of time
- Know which are the pressure points and how to protect them from trauma during procedures
- Know how to prevent trauma to joints and muscles during positioning and transfer of patients
- Have a basic understanding of systemic therapy, radiotherapeutic procedures and the relevant terminology (see appendix 2)
- Understand the effect of thermal ablation on adjacent structures and the adverse effects of thermal ablation and how to use dissection techniques in avoiding collateral injury
- Assess the patient during and after image-guided ablation and or other cancer therapies
- Recognize the prognostic implications of active surveillance of certain tumours, such as in renal cancer with metastatic, small volume or indolent disease
- Be able to determine patient fitness for discharge

- Devise, with the referring clinician, a plan for patient follow-up with imaging, laboratory tests and clinical evaluation in order to assess treatment success and detect disease recurrence or new lesions
- Decide when to treat bilateral disease in the same setting or in a second setting
- Recognize the differences between the lung and parenchymal organs such as liver and kidney in terms of thermal and electrical conductivity which result in differences in ablation times and protocols

### Technical skills

#### Describe the techniques for the following:

##### Intraarterial infusion

- Hepatic arterial perfusion (oxaliplatin, 5FU, irinotecan)
- Isolated perfusion for limb, peritoneal, pelvic and hepatic disease (melphalan, etc.)

##### Drug delivery platforms

- Drug-eluting particles
- Drug emulsions with Lipiodol for TACE (doxorubicin, cisplatin, epirubicin, idarubicin, etc.)
- Palliative IR procedures such as gastrostomy insertion, drains, nephrostomies, ascites drainage catheters or ports, etc.
- Patients in palliative care are often referred for pain management amongst other things

##### Mode of action and types of drugs (see appendix 2)

- Be able to interpret post-treatment images and follow-up images with reference to post-treatment sequelae
- Be able to identify local post-treatment recurrences
- Be able to interpret imaging changes in post-operative patients
- Be able to interpret imaging changes in patients on different systemic therapies, including anti-angiogenic and immunotherapeutic drugs

## 2.2.5.2 Vascular interventional oncology

At completion of training, the trainee should have the following:

### Knowledge

- Understand the concept of “end” arteries
- Know the pathophysiological process with regard to:
  - Tumour angiogenesis
  - The process of tumour invasion of blood vessels
  - The natural history and patterns of response of tumours suitable for arterial embolization

## Clinical skills

- Describe the clinical presentation of common tumours where either assessment of vascular invasion or treatment by embolization plays an important part
- Understand and interpret imaging, in particular:
  - Have knowledge of characteristic patterns of vascularity in tumours particularly those which are hypervascular
  - Have knowledge of imaging features of vascular invasion
  - Have knowledge of signs of vascular invasion with respect to assessing resectability
- Understand the potential objectives of arterial embolization (e.g. palliation, cure, control of haemorrhage, etc.)
- Be aware of the signs, symptoms and natural history of post-embolization syndrome and their management

## Technical skills

- Demonstrate technical competence in bland, chemo and radio-embolization
- Describe how to use the different embolization materials
- Describe the specific qualities, applications, advantages and disadvantages of materials used in embolization
- Demonstrate competence in the endovascular management of complications

## Hepatic disease

### Knowledge

- Understand hepatic anatomy in terms of right/left lobar dominance and recognize the alterations caused by portal vein insufficiency and/or thrombosis (both bland and tumoural)
- Understand and look for parasitisation of blood supply to hepatic tumours prior to vascular treatments
- Know the alterations of hepatic anatomy caused by vascular and diffuse liver disease including liver cirrhosis large intrahepatic tumours
- Know how malignant tumours within the liver can alter hepatic blood supply and the bearing this will have on vascular and non-vascular interventions
- Recognize the relationship between the malignant process and major hepatic vascular and biliary structures, which can be damaged during treatments, and their bearing on any proposed intervention
- Know the relations between the liver and other structures such as extrahepatic bile ducts, gallbladder, bowel, diaphragm and body wall, and their bearing on any proposed intervention
- Know the process of development of metastatic malignancy in the liver with particular reference to tumour vascularization and its bearing on appropriate therapies, both vascular and non-vascular
- Know the causes of cirrhosis and implications for therapy in patients with coexisting hepatic malignancy
- Know when to use conventional TACE (chemolipiodol) and when to use drug-eluting bead TACE
- Know when a single lobar or segmental treatment needs to be done and when both lobes can be treated simultaneously

## Clinical skills

- Evaluate hepatic reserve using clinical, morphological criteria and laboratory criteria as well as functional studies and understand the impact on therapeutic options
- Understand how previous liver and visceral surgery will impact proposed interventions in terms of altered anatomy, hypertrophic change, vascular insufficiency, etc.
- Use MR contrast agents such as Gadolinium and hepatocyte-specific MR contrast agents and their utility in imaging hepatic disease
- Use the various MRI sequences including DWI (diffusion weighted imaging) in the detection and characterization of liver lesions
- Be able to describe strategies for imaging of patients with hepatic malignancy including algorithms for primary liver tumours, metastatic colorectal disease and metastatic neuroendocrine tumours (including gut carcinoid) and other metastatic hepatic malignancy including breast, lung, kidney, etc.
- Be able to balance the relative merits of various oncologic interventions in the setting of metastatic colorectal disease, neuroendocrine disease and primary hepatic malignancy as well as other metastatic disease processes
- Have an understanding of the relative merits of adjunctive treatments such as embolization and chemoembolization prior to image-guided ablation (IGA)
- Identify tumour types that respond well to chemoembolization and/or radioembolization
- Identify tumours that will respond to intra-arterial chemoperfusion
- Identify patients at high risk for infectious complications following chemo/radioembolization/ ablations and strategies to prevent such complications
- Understand when selective or superselective treatments will be beneficial over lobar treatments
- Understand the concept of radiation segmentectomy
- Understand the concept of bland embolization for neuroendocrine metastases

## Vascular hepatic oncologic interventions

### Technical skills

- Demonstrate technical competence in performing lobar, segmental and targeted embolization therapy
- Utilization of different types of catheters, guidewires and sheaths available to make access easier
- Utilization of micro-catheters and micro-guidewires for superselective treatments (especially chemo-embolization)
- Be able to use embolic material in combination therapies and correctly identify which embolic materials to use
- Be able to protect adjacent structures (duodenum, stomach, skin, etc.) during radio-embolization
- Selection of different radio-embolic particles available and the difference between them
- Understand how to plan a dose for radio-embolization
- Correct selection of different types and sizes of drug-eluting beads in various tumours
- Select the correct chemotherapy to charge the beads depending upon the tumour
- Be able to manage tumour bleeds (intra and extra tumoural)

## Preoperative portal vein embolization (PVE)

### Knowledge

- Understand the concept of anticipated future liver remnant volumes (FLR) prior to major hepatectomy and the concept of flow redistribution-related hypertrophy of the liver
- Know the differences and indications for ipsilateral and contralateral transhepatic approaches in PVE
- Know the concept of adjunctive embolization of hepatic veins and when this is appropriate to perform

### Clinical skills

- Correct patient selection who may need a larger FLR because of reduced hepatic regeneration after liver resection
- Be able to calculate FLR volume on CT images and how to adjust it to individual patient size
- Correct selection of functional tests (including radionuclide studies) to assess (increase in) liver function after PVE
- Outline a strategy for FLR hypertrophy surveillance using functional (including radionuclide) and imaging studies and software-assisted volumetric evaluation

### Technical skills

- Recognize the anatomy of intrahepatic portal vein branches and their relationships with tumour bearing liver segments
- Correct selection of the equipment used in PVE and or hepatic veins including guidewires, sheaths, catheters, embolic materials and transhepatic cannulation kits
- Be competent at US-guided transhepatic puncture of intrahepatic portal vein branches
- Demonstrate technical competence in the performance of all procedural aspects of PVE and or hepatic veins, for ipsilateral and contralateral transhepatic approaches

## 2.2.5.3 Non-vascular interventional oncology

### 2.2.5.3.1 Malignant chest and abdominal disease

#### Knowledge

- Know the different tumour types and presentations in the relevant territories
- Know the optimal timing for interventional procedures in relation to other therapies

#### Clinical skills

- Understand the value of tumour biopsy, its indications and accuracy
- Recognize the limitations of current ablation technologies and have knowledge of techniques used to achieve larger volumes of ablation (e.g. overlapping ablations, perfused devices and adjunctive techniques)

### Technical skills

- Be able to perform image-guided fine needle aspiration or biopsy of tumours
- Demonstrate competence in the current technologies available in IGA including ethanol, radiofrequency and microwave ablation
- Describe the role of evolving technologies in this area including cryotherapy, chemosaturation, reversible and irreversible electroporation

## 2.2.5.3.2 Malignant biliary disease (see also HPB section 2.2.2.4)

### Knowledge

- Understand sclerosing cholangitis and other precursors to cholangiocarcinoma like Caroli's syndrome
- Understand tumour markers and their variations in patients with cholangiocarcinoma
- Understand biliary obstruction secondary to primary disease, metastases and surgical resection and anastomoses

### Clinical skills

- Be able to assess patients for metastatic disease
- Understand how the procedure will affect future therapies (chemotherapy, surgery, ablation or chemoembolization/radio-embolization, etc.)
- Understand the effect of previous therapies (surgical resection, portal vein embolization, chemoembolization, recent chemotherapy, etc.) will affect the outcome of the procedure

### Technical skills

- Have an understanding of evolving technologies in this area including endoluminal ablation, combined transhepatic and endoscopic procedures, and cholangioscopy
- Describe appropriate access and delivery of treatments

## 2.2.5.3.3 Prostate cancer

### Knowledge

- Have knowledge of the different probes and needles/biopsy devices used for biopsies (TRUS-guided and MRI-guided)
- Understand the concept of multiple zone sampling during biopsies for malignancy and mapping of the prostate gland

### Clinical skills

- Understand the clinical presentation of prostate cancer and importance of PSA, DRE and prostate biopsies
- Acquire the necessary competence to perform and interpret transrectal ultrasound (TRUS)
- Understand the triaging of patients presenting with high PSA



### Technical skills

- Acquire the necessary competence to carry out TRUS-guided prostate biopsies according to local protocols
- Competence in guidance for brachytherapy implants
- Competence in guidance for fiducial marker implants for prostate radiotherapy
- Have knowledge of planning for cryotherapy of prostate gland
- Understanding of planning for HIFU and how to place the probe for tumour ablation
- Understanding and planning for laser ablation
- Correctly select the appropriate number of laser fibres needed and where to place them to achieve an effective and complete ablation

## 2.2.5.3.4 Malignant musculoskeletal disease

### Knowledge

- Know benign bone tumours especially those that can be treated with ablation
- Recognize the progressive features of bone metastases in the appropriate clinical setting, depending on the type and stage of primary tumour

### Clinical skills

- Recognize features of progressive and metastatic disease which would guide appropriate therapy
- Be able to anticipate potential injuries, such as articular cartilage necrosis, epiphyseal growth plate injury and neural injury and be able to inform patients about these risks
- Understand the clinical case for image-guided ablation of bone tumours and its feasibility in different locations and clinical settings
- Understand the role of new and evolving technologies for the treatment of primary and secondary bone neoplasms

### Technical skills

- Understand adjunctive interventions (e.g. embolization) that can be performed to improve the outcome of image-guided ablation
- Recognize the need to place thermocouples to monitor the temperature of sensitive structures during ablative procedures
- Recognize bone lesions at risk of fracture and understand when to combine ablation with cementoplasty in order to provide additional structural support
- Describe the correct placement of osteosyntheses in the pelvic bones, neck of femur, sacrum and scapula
- Plan the placement of screws in optimal position and be able to decide on the number of screws required
- Appropriate selection of the type and size of screws for placement
- Be able to decide if there is a need to inject cement along with the screws
- Be able to monitor motor and sensory functions of the extremities to rule out neural damage after ablation of lesions close to major nerve bundles

## Abbreviations/Acronyms

<b>ABI</b>	Ankle Brachial Index
<b>ACTH</b>	Adrenocorticotrophic Hormone
<b>ALARA</b>	As Low As Reasonably Achievable
<b>ASA Score</b>	American Society of Anaesthesiology
<b>ASPECT</b>	Alberta Stroke Program Early CT Score
<b>AUS</b>	Antegrade Ureteric Stenting
<b>BP</b>	Blood Pressure
<b>BPH</b>	Benign Prostatic Hyperplasia
<b>BRTO</b>	Balloon-occluded Retrograde Transvenous Obliteration
<b>CA 19-9</b>	Cancer Antigen 19-9
<b>CanMEDS</b>	Canadian Medical Education Directives for Specialists
<b>CBD</b>	Common Bile Duct / Case-based Discussion
<b>CEA</b>	Carcino-embryonic Antigen
<b>CEAP score</b>	Clinical Severity Etiology Anatomy Pathophysiology
<b>CE Marking</b>	European Conformity Marking
<b>CESMA</b>	Council of European Specialist Medical Assessments
<b>CEUS</b>	Contrast-enhanced Ultrasound Imaging
<b>CIN</b>	Contrast Induced Nephropathy
<b>CIRSE</b>	Cardiovascular and Interventional Radiological Society of Europe
<b>CME</b>	Continuing Medical Education
<b>CPD</b>	Continuing Professional Development
<b>CT</b>	Computed Tomography
<b>CTA</b>	Computed Tomographic Angiography
<b>ctTACE</b>	Conventional Transcatheter Arterial Chemoembolization
<b>CTPA</b>	CT Pulmonary Angiogram
<b>CVA</b>	Cerebro-Vascular Accident
<b>DCB TACE</b>	Drug-Coated Bead Transcatheter Arterial Chemoembolization
<b>DSA</b>	Digital Subtraction Angiography
<b>DOPP</b>	Direct Observation of Practice and Procedures
<b>DOQI</b>	Dialysis Outcomes Quality Initiative (US National Kidney Foundation)
<b>DRE</b>	Digital Rectal Examination
<b>DVT</b>	Deep Vein Thrombosis
<b>DWI</b>	Diffusion Weighted Imaging
<b>EBIR</b>	European Board of Interventional Radiology
<b>ECIO</b>	European Conference on Interventional Oncology
<b>ESIR</b>	European School of Interventional Radiology
<b>ESR</b>	European Society of Radiology
<b>ET</b>	European Conference on Embolotherapy

<b>ETR</b>	European Training Requirements
<b>EUS</b>	Endoscopic Ultrasound
<b>FLR</b>	Future Liver Remnant
<b>FU</b>	Flourouracil
<b>Gd-BOPTA</b>	Gadobenate dimeglumine (Contrast agent)
<b>Gd-EOB</b>	Gadolinium Ethoxybenzyl (Contrast agent)
<b>HIFU</b>	High Intensity Focused Ultrasound
<b>HNSCC</b>	Head and Neck Squamous Cell Carcinoma
<b>HPB</b>	Hepato-Pancreatico-Biliary
<b>HPV</b>	Human Papillomavirus
<b>IGA</b>	Image-Guided Ablation
<b>IMRT</b>	Intensity Modulated Radiotherapy
<b>IO</b>	Interventional Oncology
<b>IPSS</b>	International Prostate Symptom Score
<b>IR</b>	Interventional Radiology
<b>ISVS</b>	International Society for Vascular Surgery
<b>ISSVA</b>	International Society for the Study of Vascular Anomalies
<b>IV</b>	Intravenous
<b>IVC</b>	Inferior Vena Cava
<b>IVCO</b>	Inferior Vena Cava Obstruction
<b>LUTS</b>	Lower Urinary Tract Symptoms
<b>MDT</b>	Multi-Disciplinary Team
<b>MELD score</b>	Model for End-stage Liver Disease
<b>MIBG</b>	Meta-Iodo Benzyl Guanidine
<b>MR</b>	Magnetic Resonance
<b>MRA</b>	Magnetic Resonance Angiography
<b>MRI</b>	Magnetic Resonance Imaging
<b>MRSA</b>	Methicillin-Resistant Staphylococcus Aureus
<b>MSK</b>	Musculoskeletal
<b>NIHSS</b>	National Institute of Health Stroke Scale
<b>NSF</b>	Nephrogenic Systemic Fibrosis
<b>ODA</b>	Operating Department Assistant
<b>OSCE</b>	Objective Structured Clinical Embolization
<b>PAD</b>	Peripheral Arterial Disease
<b>PAE</b>	Prostate Artery Embolization
<b>PAT</b>	Peer Assessment Tools
<b>PBA<sub>s</sub></b>	Procedure-based Assessments
<b>PCNL</b>	Percutaneous Nephrolithotomy

<b>PET</b>	Positron Emission Tomography
<b>PICC</b>	Peripherally Inserted Central Catheter
<b>PSA</b>	Prostate Specific Antigen
<b>PV</b>	Percutaneous Vertebroplasty
<b>PVE</b>	Portal Vein Embolization
<b>QA</b>	Quality Assurance
<b>RCT</b>	Randomized Controlled Trial
<b>RF</b>	Radiofrequency Ablation
<b>RUS</b>	Retrograde Ureteric Stenting
<b>SETQ</b>	System for Evaluation of Teaching Qualities
<b>SR</b>	Systematic Reviews
<b>ST</b>	Soft Tissue
<b>SVC</b>	Superior Vena Cava
<b>SVCO</b>	Superior Vena Cava Obstruction
<b>SVS</b>	Society of Vascular Surgery
<b>TACE</b>	Transcatheter Arterial Chemoembolization
<b>TcPo2</b>	Transcutaneous Oxygen Pressure
<b>TICI</b>	Thrombolysis in Cerebral Infarction
<b>TIPS</b>	Transjugular Intrahepatic Portosystemic Shunt
<b>TOS</b>	Thoracic Outlet Syndrome
<b>TRAS</b>	Transplant Renal Artery Stenosis
<b>TRUS</b>	Transrectal Ultrasound
<b>UAE</b>	Uterine Artery Embolization
<b>UEMS</b>	European Union of Medical Specialists
<b>UFE</b>	Uterine Fibroid Embolization
<b>US</b>	Ultrasound
<b>VBCF</b>	Vertebral Body Compression Fractures



## APPENDIX 1: Different types of studies and trials

### **Randomized controlled trials**

Clinical trials to study the effect of a type of therapy. They help compare between the study group and a control group. Can be blinded (less bias) or non-blinded. They are planned experiments providing sound evidence.

### **Systematic reviews (SR)**

They focus on a clinical topic or answer a specific question. Studies with sound methodologies are selected from a collection of all studies on the topic found after an extensive literature search. These studies are reviewed, assessed for quality and the results are summarized with reference to specific predetermined criteria set to answer the question.

### **Meta-analyses**

Examine thoroughly all valid studies in literature on the study topic, use the data from all of them as a single large data which is then used in accepted statistical models to give results.

### **Observational studies**

#### **Case studies and reports**

Are presentations of a series of cases or some cases with similar clinical problems and their outcomes after a particular therapy. However, no control group or comparison group exists. This has low statistical evidence but can form the basis or stepping stones for future trials.

#### **Case control studies**

Observational studies in which two existing groups differing in outcome are identified and compared on the basis of some supposed cause. They are less expensive and easier to do. However, they do not give as robust evidence as RCT or cohort studies. These are retrospective studies.

#### **Cohort studies (retrospective cohort or historical cohort)**

They are generally prospective studies. These are comparative studies of two groups in which one receives the treatment compared with another that receives another treatment. These can be expensive and time consuming. However, retrospective cohort or historical cohort studies can also be conducted.

#### **Cross sectional studies**

Studies that examine the relationship between diseases (or other health-related characteristics) and other variables of interest as they exist in a defined population at one particular time (i.e. exposure and outcomes are both measured at the same time). This is a snap study done at the same time of the intervention.

### Levels of evidence and grades of recommendation: Interventional Radiology

Grade of recommendation and level of evidence therapy or harm\*

#### A

- 1a** Systematic review, with homogeneity, of RCTs
- 1b** Individual RCT with narrow confidence interval
- 1c** "All-or-none" case series

#### B

- 2a** Systematic review, with homogeneity, of cohort studies
- 2b** Individual cohort study or low-quality RCT (e.g. 80% follow-up)
- 2c** Outcomes research, ecological studies
- 3a** Systematic review, with homogeneity, of case-control studies
- 3b** Individual case-control study

#### C

- 4** Case series (and poor-quality cohort and case-control studies)

#### D

- 5** Expert opinion without explicit critical appraisal; based on physiologic information, "bench" research results, or "first principles"

Grades of recommendations

- A consistent level 1 studies
- B consistent level 2 or 3 studies or extrapolations from level 1 studies
- C level 4 studies or extrapolations from level 2 or 3 studies
- D level 5 evidence or troublingly inconsistent or inconclusive studies of any level

## APPENDIX 2: Common terminology used in oncology treatments

General tumours have a subpopulation of actively dividing cells termed the principles growth fraction; other cells will be in growth arrest or necrotic. The growth fraction cells tend to be the ones that are most sensitive to chemotherapy. Some agents act only in certain cell cycle phases whereas others may act at any cell cycle phase. Agents may act by a range of mechanisms to damage DNA, prevent DNA synthesis or arrest the cell cycle. Principles of combination chemotherapy to reduce the occurrence of drug resistance. Regime types by intent: induction, consolidation, adjuvant, neoadjuvant and maintenance.

### Drug side effects

Understanding of key common toxicities for chemotherapy generally and more detailed toxicity profiles for agents relative to their field of specialization and action is important.

Some chemotherapy drugs induce leukopenia. Therefore, it is important to know when to avoid performing procedures and which is the best window in which procedures can be performed on patients receiving this type of chemotherapy.

### Radio-resistance

Certain molecular markers suggest relative radio-resistance: hypoxia, P21 and P53 mutations and a low proliferation rate. Absence of HPV-influence in head and neck cancer patients (HPV-positive HNSCC are more radiosensitive).



## Types of radiotherapy

### External beam

May be delivered as electrons, photons or protons. Tumour targeting is achieved by beam collimation and image guidance, shielding and selection of the optimal type of radiation and energy which dictates the depth of penetration.

### IMRT

Intensity modulated radiotherapy (IMRT): Highly targeted RT using computer and CT controlled multiple beams with automatic collimation in linear accelerators. Used in avoiding radiation damage to critical structures and target dose escalation such as CNS in sarcomas, parotid gland in head and neck cancers, bowel in prostate cancer, etc.

### Brachytherapy

Direct placement of radioactive sources into the tumour or tumour bed. Able to deliver higher focal RT doses with relative sparing of normal tissue due to rapid dose fall-off around the sources (e.g. Iridium 192 after-loading for cervical and breast cancer, radioactive iodine seeds for prostate cancer). These produce mainly electrons and photons.

### Intra-operative

A number of applications for intra-operative radiotherapy such as in breast conservation surgery.

### Stereotactic radiotherapy

Systems such as cyber knife, external beam radiotherapy, tomotherapy, gamma knife or linear accelerator based used to deliver RT to the brain, liver and lung metastases and small primary tumours. They may achieve highly targeted treatment areas by means of multiple highly collimated beams with a need for precise fixation of the target area.

### Proton therapy

Protons can be precisely targeted, with little side scatter, at a well-defined range and release most of their energy in the last few mm of this range. Protons are useful for specific indications (e.g. chordoma, ocular melanoma). Limited equipment availability.

### Radio-pharmaceuticals

Use of Iodine 131 bound either to thyroxine or Meta Iodo Benzyl Guanidine (MIBG) to treat thyroid cancer or neuroendocrine tumours.





