Nowadays, there are few patients with either acute or chronic illness, who do not get in touch during their hospitalization, with the broad spectrum of interventional radiology proposals. Image-guided lung biopsies, porto-caval shunts, intra-cranial aneurysms are good examples to mention how the interventional alternatives have replaced the traditional surgical options.

This revolution needs a specific evolution of the radiologist role, either in mentality, technical tools and knowledge of the new techniques.

Interventional radiology (IR) was a definition created in the 1960s by Charles Dotter, a North American radiologist who is considered the godfather of many interventional procedures and new therapeutic innovations [1]. He used the percutaneous vascular catheterism, invented by Seldinger in 1952, as direct approach to multiple different territories in order to perform endovascular interventions [2]. Since then, after he accomplished the first percutaneous transluminal iliac recanalization, all the technologies, materials, imaging techniques have been developed year by year with a subsequent increase of the IR indications [3].

The first initial scepticisms were soon replaced by the evidence that the new treatments were less invasive (no surgical incision, rarely general anaesthesia) and less expensive (shorter hospitalization and sometimes one-day hospital admission).

We will discuss the main interventional applications in different fields: oncology, vascular, hemorrhagic emergencies, thoracic and abdominal surgery, central venous accesses and pain relief (Table I).

**INTERVENTIONAL ONCOLOGY**

Percutaneous image-guided biopsies are considered gold standard for most of the oncologic diagnoses; their technical improvements have been the basis for the more recent percutaneous locoregional treatments, working either by aspiration (mammotome for breast cancer) or by tumor disruption (percutaneous ethanol injection, radio-frequency ablation, cryotherapy, high intensity focused ultrasound) (Fig. 1).

**TABLE I**

<table>
<thead>
<tr>
<th>INTERVENTIONAL RADIOLOGY TECHNIQUES</th>
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<tr>
<td><strong>I. Embolizations</strong></td>
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<tr>
<td>Arterial or venous, definitive or temporary, vascular occlusion</td>
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<tr>
<td>Chemoembolization: vascular occlusion + intraarterial injection of antineoplastic agents</td>
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<td>Intraarterial chemotherapy</td>
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<td><strong>II. Angioplasty</strong></td>
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<td>Balloon angioplasty</td>
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<td>Stent placement</td>
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<tr>
<td>Endoprostheses (covered stent or stent-grafts) placement</td>
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<tr>
<td>Percutaneous porto-caval shunt</td>
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<tr>
<td>Intraarterial thrombolysis</td>
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<tr>
<td>Thromboaspiration</td>
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<tr>
<td>Percutaneous thrombectomy</td>
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<td><strong>III. Other endovascular techniques</strong></td>
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<td>Caval filter placement</td>
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<td>Endovascular foreign bodies retrieval</td>
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<td>Endovascular biopsies</td>
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<td><strong>IV. Percutaneous and other image-guided techniques</strong></td>
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<tr>
<td>Percutaneous biopsies</td>
</tr>
<tr>
<td>Percutaneous drainages: biliary, urinary (nephrostomy), pleural, abscesses, gastrostomy and jejunostomy</td>
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<tr>
<td>Colonic and esophageal stents</td>
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<tr>
<td>Percutaneous infiltration techniques, vertebroplasty, pain treatment</td>
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<tr>
<td>Tumor ablation therapies: percutaneous ethanol injection, radiofrequency, cryotherapy</td>
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<td>Fallopian tube recanalization</td>
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The transarterial chemotherapy aims to an injection of the antineoplastic agents just at the level of the tumor, in order to decrease the general chemotoxicity and concentrate locally a high drug dose. It usually stabilizes the tumoral growth in patients unsuitable for surgery. The trend for the near future is the use of microsphere particles loaded with the antitumoral drugs in order to optimize the procedure specificity by an even more distal drug releasing.

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“Endovascular intervention” is a more suitable term than “endovascular surgery”. Endovascular surgery is, in fact, a recent definition proposed, after a long period of scepticism, by the surgical specialists, just following this growing trend of innovative interventional techniques.

The arterial and the less frequent venous occlusive diseases, either chronic or acute, represent the widest fields of application for transcatheter procedures, which can involve all the anatomical territories. The placement of an endovascular endoprosthesis, or stent, often recanalizes an occlusive lesion without surgical intervention; intraarterial thrombolysis or thromboaspiration can be both performed in a patient with acute ischemia. The main applications for endovascular recanalizations are lower limbs, coronary and renal arteries. Controversy always persists about the usefulness of endovascular stents for cervico-encephalic arteries as compared to the standard of surgery.

EVAR (endovascular aneurysm repair) is a term which defines the endovascular treatment of aortic aneurysms by the use of covered endoprostheses (stent-grafts); these can be used also to treat aneurysmal or traumatic lesions in other large vessels. More recently, aortic dissection is now representing a new challenging indication for stent-graft implantation (Fig. 2). The complexity of the lesions justifies the combined usage of several endovascular stents: stent-grafts, bare stents, and fenestrated stents.

**Figure 1.** Percutaneous treatment of a hepatocarcinoma by radiofrequency ablation.

a. CT scan before the intervention: single nodule smaller than 3 cm in size in segment V of the liver (asterisk).

b. CT follow-up at 3 months: the tumoral lesion is completely replaced by avascular hypodense necrotic tissue which reaches the healthy hepatic tissue.

**Figure 2**

Type B aortic dissection treated with stent-graft implantation.

a. Preoperative CT showing true lumen’s compression (*) by the intimal flap and dilatation of the false lumen.

b. CT follow-up at one month after stent graft placement: reexpansion of the true lumen and thrombosis of the false lumen (arrows) with reconstitution of the normal aortic caliber.
Endovascular embolization is often the main therapeutic option for intracranial and visceral aneurysms, congenital arteriovenous malformations, iatrogenic arteriovenous fistulae, wherever the site of the lesions (Fig. 3).

Most recently, patients with diseases or lesions traditionally considered as surgical candidates are becoming suitable for curative endovascular embolization, such as the uterine fibroids and renal angiomyolipomas.

HEMORRHAGIC EMERGENCIES

The hemostatic embolization has completely revolutionized the management of an acute hemorrhagic syndrome.

Posttraumatic patients are evaluated first by helical CT angiography in order to identify the bleeding site and to direct a subsequent endovascular occlusion of the damaged vessels (Fig. 4). In other traumatic contexts, the endovascular repair by stent-grafts is becoming the new gold standard for traumatic thoracic aortic rupture, because of the lower rate of paraplegia as compared to surgery, and the current possibility to perform an urgent placement.

For other acute non traumatic hemorrhagic diseases, as meningeal, postpartum, or visceral hemorrhage, the embolization has even become the new gold standard, to achieve hemostasis and sometimes even to treat the main cause of bleeding.

ADJUVANT ROLE IN VISCERAL SURGERY

Another important field of application is represented by the surgical patients. In many preoperative situations IR can offer valid options such as preoperative embolization of certain solid tumors for decreasing tumor hypervascularization and bleeding at the time of surgery, preoperative percutaneous catheter drainage of intraabdominal, cholecystic, sigmoid diverticular or appendicular abscesses.

FIGURE 3
Renal artery aneurysm treated with endovascular embolization in a 25-year-old woman aiming at pregnancy.

a. Selective renal arteriography showing a saccular aneurysm of an inferior polar branch (white arrow).

b. Angiographic control after the embolization performed using metallic detachable microcoils. A complete exclusion of the aneurysmal sac was obtained with persistent patency of the lower branch (black arrow).

FIGURE 4
Pelvic embolization after posttraumatic hematoma of the corpus cavernosum responsible for a high-flow priapism.

a. Superselective arteriography of the left pudendal artery showing extravasation of the contrast media from the ipsilateral cavernosal artery (black arrow).

b. Embolization with microcoils: absence of opacification of the artery with suppression of the extravasation (black arrow). Rapid clinical improvement was observed soon after the treatment.
can be used as a temporizing measure prior to definitive surgery.

After surgery, interventional radiologists can help the surgeon in case of complications, for example percutaneous catheter drainage can be performed to evacuate postoperative abscesses after thoracic or abdominal surgery.

Many interventional proposals are valid minimally invasive palliative alternatives for avoiding surgery in high-risk patients considered poor candidates to surgery. In oncologic patients some palliative interventional treatments are very useful and less aggressive than surgery such as percutaneous gastrostomy or jejunostomy, and gastrointestinal, biliary, urinary internal drainage using endoprothesis.

Complications of acute pancreatitis such as pancreatic abscess or pseudocysts are generally treated by CT-guided percutaneous drainage, and TIPS (Transjugular Intrahepatic Porto-systemic Shunt) has totally replaced surgical porto-caval anastomosis (Fig. 5).

PAIN RELIEF

An increasing field of application for the IR is the treatment of chronic pain; this has been possible mainly because of the improvements in image-guided interventions, specially CT-guided, which make feasible a precise, targeted drug injection. In the future MRI guidance will probably replace CT-guidance.

The percutaneous lysis of neurologic plexuses is performed by local application of physical (radiofrequency or laser) or chemical (alcohol) agents which destroy the peripheral nerves.

The purpose of cementoplasty, mainly used in vertebral lesions (vertebroplasty), is to consolidate the skeleton by injecting acrylic cement, in order to relieve the intractable pain from neoplastic or osteoporotic lesions. In addition many neoplastic osteolytic lesions can be treated also percutaneously under imaging guidance by the radiofrequency thermal ablation technique combined with an injection of cement.

CENTRAL VENOUS ACCESS

The central venous access placement can definitely benefit from the image guidance and the experience of the interventional radiologist. Lower complications rates have been already reported when interventional radiologists were performing this procedure. The role of IR is furthermore carried out in the management of access complications, especially in dialysed patients, for example venous stenoses can be treated by stent placement or an acute occlusion can be subjected to thromboaspiration or thrombolysis or thrombectomy, all performed percutaneously. A migrated catheter or a detached catheter fragment is an infrequent problem that can be managed by an interventional radiologist using a specific retrieval device.
The placement of temporary or definitive vena cava filter is currently performed by percutaneous approach under radiological guidance.

**PERSPECTIVES**

This overview illustrates the important role of IR. The dynamism of practitioners and the growth of IR will not stop. The fields of development are numerous, it first concerns the methods of imaging guidance, in particular the use of MRI which allows an immediate control of therapeutic result [4]. The exact and more precise targeting of the lesion could improve the local drug delivery and allow the use of vascular gene transfer therapy. Another development in oncologic intervention is the application of different kinds of focused physical energies for tumoral destruction or ablation. Prevention of vascular restenosis is another challenge which needs new concepts as drug eluting balloon angioplasty or resorbable stent [5].

**CONCLUSION**

Recognized as effective by the medical community IR has reached its maturity. With the technical improvements in image guidance and materials, IR offers now valid and alternative therapeutic options for many pathologies. The innovative IR is replacing many conventional surgical procedures and at the same time developing new possible interventions.

IR is a clinical subspeciality of radiology, in which practitioners must accept responsibility for patient care and work in an optimal environment. Performing IR needs competence in image interpretation, familiarity with the use of image-guided techniques for endovascular navigation and other interventional procedures, an excellent clinical background and knowledge, dedicated environment and equipments/materials similar to an operating theatre [6]. The IR team is capable of taking in charge patients candidates for interventional procedures following a comprehensive multidisciplinary discussion.

**REFERENCES**