Position Paper of the German Society for Interventional Radiology and Minimally Invasive Therapy (DeGIR) and the German Roentgen Society (DRG) on Structural and Professional Requirements in Interventional Oncology

Positionspapier der Deutschen Gesellschaft für Interventionelle Radiologie und minimal-invasive Therapie (DeGIR) und der Deutschen Röntgengesellschaft (DRG) zu strukturellen und fachlichen Anforderungen in der Interventionelle Onkologie

Authors

Peter Isfort[1], Christof M Sommer[2, 3], Philipp Bruners[4], Bettina Maiwald[5], Jens-Peter Kühn[6], Christoph Georg Radosa[6], Roman Kloeckner[7], Patrick Freyhardt[8], Mareike Franke[9], Michael Moche[10], Ralf-Thorsten Hoffmann[6], Konstantin Nikolaou[11], Andreas H. Mahnken[12], Marcus Katoh[13]

Affiliations

1 Department of Diagnostic and Interventional Radiology and Neuroradiology, DIAKOVERE Friederikenstift, Hannover, Germany
2 Clinic of Diagnostic and Interventional Radiology, University Hospital Heidelberg, Heidelberg, Germany
3 Faculty of Medicine, Heidelberg University, Heidelberg, Germany
4 Department of Diagnostic and Interventional Radiology, University Hospital RWTH Aachen, Aachen, Germany
5 Diagnostic and Interventional Radiology, Hospital St. Elisabeth & St. Barbara, Halle an der Saale, Germany
6 Institute and Policlinic for Diagnostic and Interventional Radiology, University Hospital Carl Gustav Carus Dresden at the Technische Universität Dresden, Dresden, Germany
7 Institute for Interventional Radiology, University Hospital Schleswig-Holstein Campus Luebeck, Lübeck, Germany
8 Institute for Diagnostic and Interventional Radiology, HELIOS Hospital Krefeld, Krefeld, Germany
9 Radiology and Nuclear Medicine, Cantonal Hospital Lucerne, Lucerne, Switzerland
10 Department of Interventional Radiology, HELIOS Park Hospital Leipzig, Leipzig, Germany
11 Department of Radiology, University Hospitals Tubingen, Tubingen, Germany
12 Diagnostic and Interventional Radiology, Philipps University of Marburg, Marburg, Germany
13 Institute for Diagnostic and Interventional Radiology, HELIOS Hospital Krefeld, Krefeld, Germany

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Correspondence
Peter Isfort
Department of Diagnostic and Interventional Radiology and Neuroradiology, DIAKOVERE Friederikenstift, Hannover, Germany
peter.isfort@diakovere.de
isfort@me.com

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ABSTRACT

Background Interventional oncology (IO) employs various techniques to enable minimally invasive, image-guided treatment of tumor diseases with both curative and palliative goals. Additionally, it significantly contributes to managing tumor-related and perioperative complications, offering diverse supportive procedures for patients at all stages of their diseases. The execution of IO procedures places unique demands on the equipment, personnel, and structural organization of radiological clinics, necessitating specific expertise from interventional radiologists.

Methods This position paper aims to comprehensively outline the multifaceted aspects of IO and discuss the requisite criteria for hospitals, radiological clinics, and interventional radiologists (IRs). Furthermore, it underscores overarching consid-

erations of quality assurance that clinics and professional societies should prioritize.

Conclusion The requirements for hospitals, radiological clinics, and IRs are varied and demand not only a high level of proficiency in performing IO procedures but also in-depth knowledge of the differential therapy for various tumor diseases. This expertise is essential for effectively serving as clinical partners in the interdisciplinary treatment of oncologic patients. Additionally, a thorough understanding and safe handling of ionizing radiation technologies, along with proficiency in radiation protection methods, which are fundamental aspects of radiological specialist training, is crucial for ensuring the safety of IO procedures for both patients and staff. The Deutsche Gesellschaft für Interventionelle Radiologie und minimal-invasive Therapie (DeGIR) and the Cardiovascular and Interventional Radiological Society of Europe (CIRSE) have long-established dedicated quality management programs, accrediting radiology clinics and certifying IRs. These initiatives aim to uphold the highest standards of care and meet the quality expectations set by politics in healthcare system, particularly in the realm of interventional radiology.

Key Points

- The various procedures in the field of interventional oncology (IO) are complex medical interventions that require not only the most advanced technical equipment but also adequate human resources, particularly specialized expertise in interventional radiology, diagnostic imaging, oncology, and radiation protection.
- This expertise is an integral part of the specialized medical training in radiology and is certified by professional societies such as the German Society for Interventional Radiology (DeGIR) and the Cardiovascular and Interventional Radiological Society of Europe (CIRSE).
- Professional societies like DeGIR, CIRSE, and the American Society of Interventional Radiology (SIR) establish the necessary quality assurance framework for comprehensive, high-quality IO therapy through quality assurance (QA) registries, standard operating procedure (SOP) documents, and participation in guideline development.
- Currently, radiology is the only discipline that provides physicians with the theoretical and practical knowledge, skills, and competencies required to perform the demanding procedures in the field of IO through specialized training programs and tailored certification processes.

Citation Format

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ZUSAMMENFASSUNG

Hintergrund Die interventionelle Onkologie (IO) mit ihren unterschiedlichen Verfahren ermöglicht die minimal-invasive, bildgesteuerte Behandlung von Tumorerkrankungen in kurativer und palliativer Intention. Zudem leistet sie einen wertvollen Beitrag zur Behandlung tumorbedingter und perioperativer Komplikationen und unterstützt mit vielseitigen, supportiven Verfahren Patientinnen und Patienten in allen Stadien ihrer Erkrankung. Die Durchführung der IO-Eingriffe stellt besondere Anforderungen an die apparative und personelle Ausstattung sowie strukturell-organisatorische Voraussetzungen der radiologischen Kliniken aber auch spezielle Anforderungen an die Interventionellen Radiologen selbst.

Methoden Ziel dieses Positionspapiers ist es, die zahlreichen Facetten der IO darzustellen und die dafür notwendigen Anforderungen an Krankenhäuser, radiologische Kliniken und an interventionelle Radiologinnen und Radiologen (IR) zu erörtern. Ferner werden übergeordnete Aspekte der Qualitätssicherung, die von Kliniken und Fachgesellschaften implementiert werden sollten, aufgezeigt.

Schlussfolgerung Die Anforderungen an Krankenhäuser, radiologische Kliniken und an die/den IR sind vielfältig und erfordern neben einer hohen Expertise in der Durchführung der IO-Verfahren auch profunde Kenntnisse in der Differentialtherapie der unterschiedlichen (Tumor-)Erkrankungen, um als adäquater klinischer Partner in der interdisziplinären Behandlung onkologisch erkrankter Patienten. Ferner sind der sichere Umgang mit ionisierenden Strahlenquellen und die Kenntnis von Methoden des Strahlenschutzes – beide Aspekte sind integraler Bestandteil der radiologischen Facharztausbildung – eine unabdingbare Voraussetzung, um die IO-Eingriffe für Erkrankte und Mitarbeitende sicher zu gestalten. Die Deutsche Gesellschaft für Interventionelle Radiologie und minimalinvasive Therapie (DeGIR) und die Cardiovascular and Interventional Radiological Society of Europe (CIRSE) haben seit geraumer Zeit – einmalig in der Medizin – dedizierte Qualitätsmanagementprogramme implementiert, die sowohl radiologische Kliniken akkreditieren als auch IR zertifizieren, um eine möglichst hohe Qualität der Versorgung sicherzustellen und die von der Politik geforderte Qualität im deutschen Gesundheitswesen für den Bereich der Interventionsradiologie zu gewährleisten.

Kernaussagen

- Die unterschiedlichen Verfahren auf dem Gebiet der IO sind komplexe medizinische Eingriffe und erfordern neben modernster technischer Ausstattung, adäquate personelle Ressourcen, insbesondere spezialisierte Expertise in der Interventionsradiologie, in der bildgebenden Diagnostik, in der Onkologie sowie im Strahlenschutz.
- Diese Expertise ist integraler Bestandteil der Facharztweiterbildung Radiologie erworben und durch die Fachgesellschaften wie DeGIR und CIRSE zertifiziert.
- Die Fachgesellschaften DeGIR, CIRSE und die amerikanische Society of Interventional Radiology (SIR) schaffen mittels Qualitäts-Sicherungs- (QS)-Register, SOP-Dokumenten und Beteiligung bei der Leitlinien-Erstellung den notwendigen Qualitätssicherungs-Rahmen für die flächendeckende, hoch-qualitative IO-Therapie.

- Die Radiologie ist derzeit das einzige Fachgebiet, das Ärztinnen und Ärzten im Rahmen der Facharztweiterbildung und maßgeschneiderter Zertifizierungsprogramme die erforderlichen Kenntnisse, Fähigkeiten und Fertigkeiten zur Durchführung der anspruchsvollen Verfahren im Bereich der IO theoretisch und praktisch vermittelt.

Abbreviations

AWMF	Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften [Association of the Scientific Medical Societies in Germany]
CM	Case management
CT	Computed tomography
CIRSE	Cardiovascular and Interventional Radiological Society of Europe
DeGIR	Deutsche Gesellschaft für Interventionelle Radiologie [German Society for Interventional Radiology and Minimally Invasive Therapy]
DGMTR	Deutsche Gesellschaft für Medizinische Technolog:innen für Radiologie [German Society of Medical Technologists for Radiology]
DKG/GCS	Deutsche Krebsgesellschaft [German Cancer Society]
DRG	Deutsche Röntgengesellschaft [German Roentgen Society]
EASL	European Association for the Study of the Liver
ECT	Electrochemotherapy
EPR	Electronic patient record
HDBT	High-dose brachytherapy
ITB	Interdisciplinary tumor board
IO	Interventional oncology/ interventional-oncological
IR	Interventional radiologist
IRE	Irreversible electroporation
MRI	Magnetic resonance imaging
MTR	Medical technologist for radiology
MWA	Microwave ablation
ÖGIR	Österreichische Gesellschaft für Interventionelle Radiologie
PEG	Percutaneous gastrostomy
PEJ	Percutaneous jejunostomy
PICC	Peripherally inserted central catheter
PTCD	Percutaneous transhepatic cholangio-drainage
PVE	Portal vein embolization
TARE	Transarterial radioembolization
RFA	Radiofrequency ablation
SIR	Society of Interventional Radiology
SSVIR	Swiss Society of Vascular and Interventional Radiology
TACE	Transarterial chemoembolization
TAE	Transarterial embolization
CVC*	Central venous catheter

Introduction

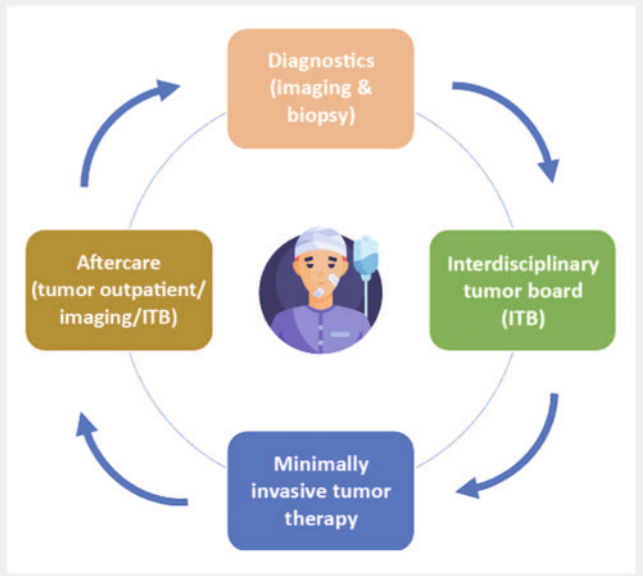
Interventional oncology (IO) is a special field of interventional radiology that aims to treat tumors and tumor-related diseases using minimally invasive and image-guided interventions. IO is the fastest growing and most innovative field in interventional radiology, and it has quickly established itself as an independent fourth pillar of oncological therapy – alongside oncological surgery, medical oncology, and radiotherapy [1].

Interventional radiologists (IRs) actively participate in the treatment process and support patients during the entire course of the disease through the following activities ("patient journey" – see also ▶ **Fig. 1**):

- Performing initial imaging diagnostics, including, if necessary, image-guided biopsy findings
- Demonstrating imaging and interdisciplinary decisions on oncological treatment in conjunction with the treating physicians on the interdisciplinary tumor board (ITB)
- Carrying out IO treatments
- Providing care for the patients on the ward
- Providing clinical and radiological aftercare for patients

One of the strengths of IO is that it is directly involved in all the stages of oncology therapy – diagnostics, therapy, and aftercare. This means that referring doctors and patients have consistent contact persons with proven specialist expertise. IRs can also be the primary treating physicians.

However, this does not mean that patients are treated in IO without taking into account related oncological disciplines. On the contrary, because IRs are, to a large extent, accustomed to working in an interdisciplinary manner in routine clinical practice, it makes sense to coordinate treatment pathways for oncological



▶ **Fig. 1** Roles of Interventional Radiology in the Treatment of Oncology Patients

patients with other oncological disciplines when reviewing findings or as part of the ITB, and to discuss and decide on the relevant indications for interventional oncological procedures.

IO procedures can now be provided anywhere in Germany, although specialized procedures (e. g. electrochemotherapy or chemosaturation) are provided mainly at centers [2].

This position paper aims to address the special requirements for IO that are necessary to enable safe and effective oncological therapy. These requirements are related to the equipment and personnel of the hospital, to the structural and organizational issues, but also to the specialist staff and their training and expertise, and they are monitored systematically using quality management tools (e. g. the quality register of the German Society for Interventional Radiology and Minimally Invasive Therapy (DeGIR-QS-Register)). In fact, these are prerequisites for certification as an oncology center.

Description of sub-areas

IO provides a versatile toolbox of curative and palliative treatment options for tumors and tumor-associated phenomena (▶ **Fig. 2**). These procedures can be divided into (tumor) therapeutic procedures and *supportive procedures*. In addition, there are procedures for *complication management* as well as *peri-interventional and follow-up imaging*.

IO procedures are used for both primary tumors and metastases, depending on the tumor entity, tumor location, and the clinical situation of the patient. Procedures commonly focus on the treatment of liver, kidneys, lungs and bones. The procedures can be divided into *vascular* or *percutaneous* and, depending on the intention, into *curative* and *palliative* procedures. The *curative* procedures include, as probably the only vascular therapy, radioembolization (TARE) with curative intent, in the form of radiation segmentectomy [3].

All forms of percutaneous tumor ablation are mainly *curative percutaneous* procedures. These are used for the local treatment of tumors, as a supplement or alternative to surgical resection. The different modalities use the following methods to achieve the desired tumor therapy: heat (e. g. microwave ablation (MWA) or radiofrequency ablation (RFA)); cold (e. g. cryoablation (Cryo)); cell membrane-destabilizing voltage pulses (e. g. irreversible electroporation (IRE) or electrochemotherapy (ECT)); and local radiation (e. g. interstitial brachytherapy (HDBT)). Regional interventions such as transarterial chemoembolization (TACE) and local interventions such as MWA are also used together for curative intent: after targeted devascularization of the liver tumor to be treated, ablation can be performed even more effectively, since there is no heat loss via vessels with this approach [4]. In ECT, IRE is combined with intravenous chemotherapy, resulting in increased intracellular chemotherapy concentration in the treatment area [5]. In addition, tumor ablations can also be used less frequently with a *palliative* intent, e. g. with the aim of delaying tumor progression [6].

Most vascular interventions are performed primarily with a *palliative* intent. These are procedures for *regional* treatment of liver and lung tumors that use TACE, TARE, and chemoperfusion/ chemosaturation. The first two procedures, in particular, have a solid place in the guideline-based treatment of hepatocellular carcinoma [7]. This category also includes tumor embolizations for bleeding control in the palliative setting, which are generally performed on all organs and body regions. Furthermore, stent (graft) implantation is a palliative vascular procedure in cases of malignant arterial and venous vascular stenosis (e. g. malignant superior venous congestion).

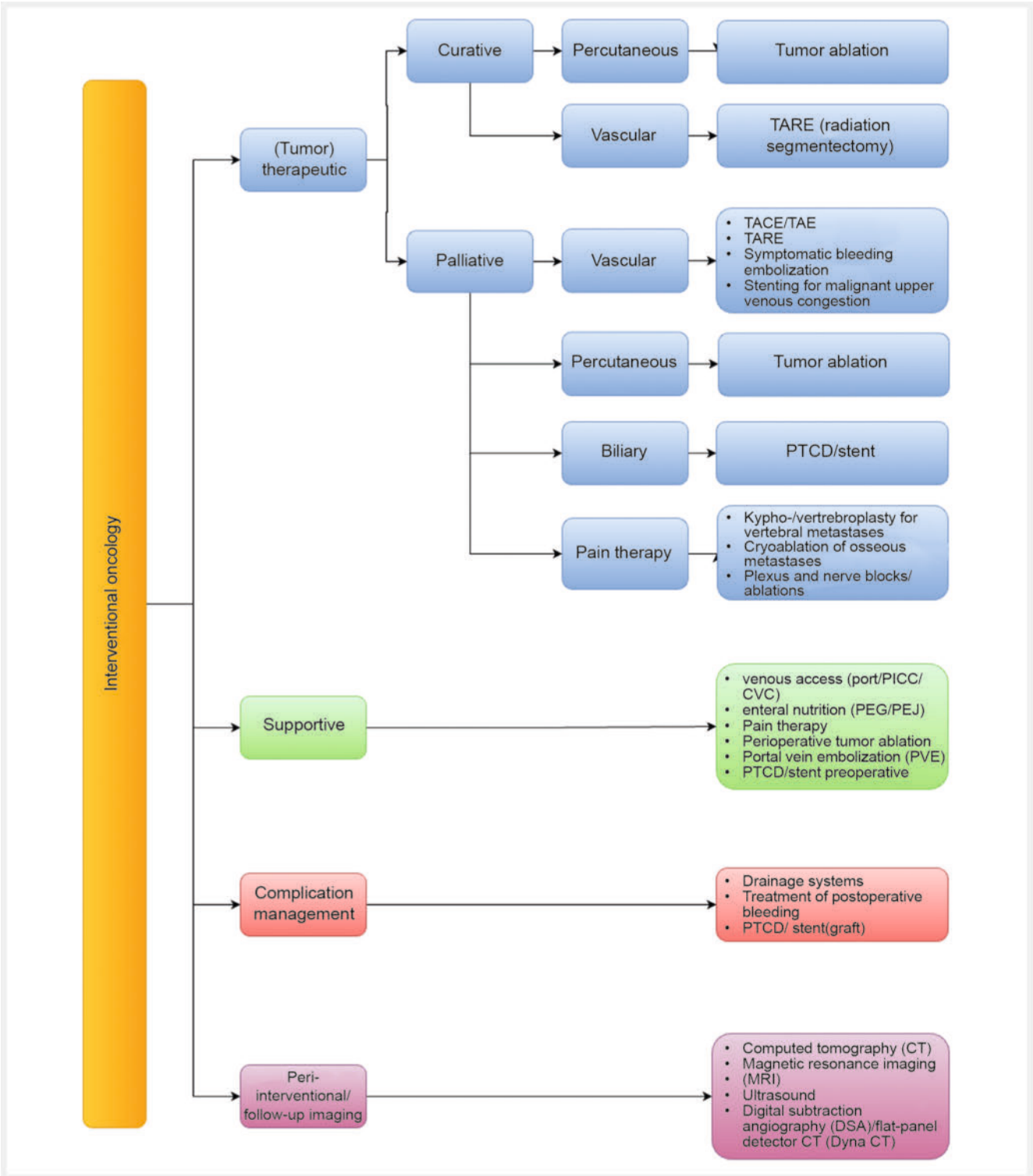
Additional palliative therapeutic procedures include biliary interventions, such as the placement of a percutaneous transhepatic cholangio-drainage (PTCD) and biliary stent implantation, as well as all interventional procedures for pain therapy, such as (cryo-)ablation of painful tumors, plexus and nerve blocks/ablations, and kypho-/ vertebroplasty for vertebral metastases.

For the *supportive procedures* there are methodologies, on the one hand, that are involved directly in the diagnosis. These include image-guided percutaneous or transvascular biopsies. On the other hand, preoperative procedures are used to enable operations with greater safety (e. g. portal vein embolization (PVE) or preoperative tumor embolization to minimize intraoperative blood loss, percutaneous bile duct diversion, and stenting of vascular stenoses). Finally, the installation of port systems or PICC lines serves to provide permanent vascular access and the insertion of feeding tubes (PEG/PEJ tubes) serves to ensure nutrition.

Interventional radiology also plays an important role in the treatment of postoperative complications. These include, for example, inflammatory conditions, which are treated by means of image-guided drainage, perioperative bleeding, which is treated by means of embolization or implantation of vascular prostheses, or insufficiencies of biliodigestive anastomoses, which are treated by means of a PTCD system, a target drainage or the implantation of a bile duct stent (graft).

In contrast to surgical resection, IO relies primarily on imaging (and not on pathological workup) to assess local response – feedback from pathology as to whether a tumor has been completely or incompletely removed is not possible. This task falls to imaging. Accordingly, the performance and interpretation of peri-interventional and follow-up imaging after IO procedures are very important. This imaging should be subject to as few subjective influences as possible and should be standardized and reproducible. CT and MRI, in particular, meet these criteria.

▶ **Fig. 3** illustrates the many facets of IO using the example of a patient with colorectal liver metastases: after initial imaging, an image-guided biopsy of a liver metastasis was performed. Following a good response to the administered systemic therapy, an in situ split was performed in preparation for a right liver resection and MWA of a metastasis in the left liver lobe. In case of insufficient hypertrophy, PVE was performed on the right to induce further hypertrophy of the left liver lobe in order to finally enable successful extended right liver resection. Finally, CT-guided percutaneous MWA of a remaining left metastasis was performed.



▶ **Fig. 2** Interventional Radiology "Toolbox"

Structural requirements

Technical equipment

IO requires different imaging techniques to guide the interventions. These include non-invasive cross-sectional imaging techniques such as ultrasound, computed tomography, and magnetic resonance therapy, which are used not only to guide interventions but also for diagnostics before and after the actual intervention. In addition, angiography systems with the option of X-ray fluoroscopy and digital subtraction angiography (DSA) are available as systems for intervention control in transvascular and biliary proce-

▶ **Fig. 3** 48-year-old patient with a history of rectal cancer and newly developed multiple liver metastases. **A**: Liver MRI showing newly developed metastases in both liver lobes. **B/C**: CT-guided biopsy to obtain histological confirmation of the liver metastases. **D**: CT after chemotherapy, showing a good response and planning for a right hemihepatectomy. **E/F**: Microwave ablation (MWA) of a non-resectable metastasis in segment IVa after in-situ split for liver hypertrophy and atypical resection in segment II. **G/H/I**: Right portal vein embolization (PVE) due to insufficient hypertrophy of the left liver. **J**: Repeated MWA of a remaining metastasis in the left liver lobe with normal post-interventional findings.

dures. The additional production of cone beam CTs and multimodal image fusion have proven further to be useful techniques, particularly for guiding selective embolizations, e. g. when performing TACE on hepatocellular carcinoma (HCC) [8]. Hybrid systems, which bring together imaging modalities such as CT and angiography in the same physical space, are helpful for complex interventions that combine, for example, transvascular and percutaneous access routes. However, these systems are not yet available widely or cost-effective. Essential functions required for IO include roadmap functionality and image data fusion.

The equipment used should be based on the type of interventions carried out on site.

The constant technical progress with developments on the hardware and software side (e. g. cone beam CT with 3 D naviga-

tion, etc.) leads to improvements in patient safety, as well as in the feasibility of interventions, and reduces the overall radiation exposure of patients and IRs. Against this background, it is necessary to regularly replace or update large imaging devices in order to keep pace with the rapidly evolving equipment technology [9].

Large devices such as angiography systems are often used jointly by radiology, neuroradiology, or occasionally cardiology. Since IO interventions are often planned elective procedures, reliable access to the relevant angiography and CT systems is important. Repeatedly canceling and postponing procedures for people being treated is unacceptable, in part, due to potential disease progression but also because doing so adds considerable organizational effort. As a result, a concept has to be developed on site together with users of the relevant large imaging devices, which defines usage times and alternative concepts for emergencies in order to be able to reliably plan for and perform IO services.

Because a large proportion of IO interventions require image control with ionizing radiation, it is important to ensure that radiation protection is provided. In addition to providing state-of-the-art equipment technology with adequate instrumental and structural radiation protection (under-table tube with comprehensive protection by lead slats and lead glass panes) and adequate personal radiation protection (including lead apron, thyroid protection, X-ray protective goggles) in sufficient quantity and high quality, focus on the procedural aspects of radiation protection is just as critical. Also highly relevant in this context are protective measures that include not only minimizing fluoroscopy time, but also the application of basic measures such as minimizing the DSA series, the use of other technologies for dose reduction (including pulsed fluoroscopy and low image acquisition rates in DSA; reducing the patient-detector distance; use of apertures), additional mobile radiation protection walls and state-of-the-art systems for personal dose recording, including real-time dosimetry [10]. The physical background, practical implementation, and legal aspects of radiation protection are an integral part of training and continuing education in radiology, an integral part of the subject catalog for the specialist examination in radiology, and these topics are also implemented in the curriculum for the personal certifications from DeGIR and CIRSE.

The performance and interpretation of pre- and post-interventional imaging is also part of IO's range of tasks and should be carried out according to the hospital/department's internal standards. Pre-interventional diagnostics serve, on the one hand, to determine the indication and, on the other hand, to subsequently plan the intervention. Post-interventionally, imaging provides the basis for assessing the outcome of the intervention, as well as for detecting intervention-related complications. Ideally, the IR should be involved not only in assessing the immediate post-interventional studies but also in interpreting the aftercare imaging. In this context, the use of software solutions that enable quantitative, semi-automatic tumor detection is of major importance. This is found, on the one hand, in good pre-therapeutic tumor detection and, on the other hand, in an objective assessment of the tumor response to the (interventional) therapy [11]. Because different employees often perform the interventional and diagnostic parts of radiology in radiology clinics, at least the diagnosis should generally be performed based on the four-eyes principle.

Outpatient clinic and inpatient ward

Running an interventional radiological/oncological outpatient clinic or consultation hours is a basic building block for a high-quality IO clinic. Such an outpatient clinic is a reliable point of contact for patients and referring physicians. In addition to planning the interventions (including organizing inpatient beds and, if necessary, anesthesia), the core activity is arranging the planning and aftercare imaging, as well as the related discussions of findings. The outpatient clinic works particularly closely with angiography, interventional CT and, if necessary, the doctors on the ward [12]. Offering dedicated consultation hours based on the procedure (e. g. transarterial procedures or percutaneous tumor ablation) or oncological disease can be helpful in structuring an outpatient clinic. Another challenge is correctly coding and billing outpatient services.

Access to interventional radiology beds can be provided in various constellations, each with different implications [12, 13]. Ultimately, these concepts provide services from a single source, minimize the loss of information at interfaces, and strengthen the position of interventional radiology as an independent clinical discipline [14].

Physical requirements

When it comes to physical requirements, in addition to the operating rooms (angiography and CT, MRI, and ultrasound, if necessary), ancillary rooms must also be taken into account, which are useful for patient preparation/ induction of anesthesia and as a recovery room or holding/ recovery area for monitoring the patient after the procedure.

In addition, rooms have to be created for meetings with sick patients and their relatives, ideally in the vicinity of the outpatient clinic.

The rooms of the patient ward will not be discussed further due to the different usage concepts (managed entirely radiologically vs. occupied beds).

Personnel requirements

Department staffing depends largely on the level of integration of interventional radiology in the radiology clinic. If the interventional department is integrated in radiology as a section, medical and technical staff can be provided to the section as needed. If interventional radiology is organized as a completely self-sufficient unit, personnel planning is usually carried out independently of the sister radiology clinic.

In this case, a needs assessment makes more sense. To operate a state-of-the-art interventional radiology department, full 24/7 availability has to be ensured, which, depending on the working hours model, requires at least 3–6 IRs on duty. The availability of specialized MTRs or nursing staff also has to be ensured. Whether additional MTRs, operating room nurses, MFAs or others are used to assist with the procedures varies depending on the location and profile.

It is also important to consider the additional tasks for the interventional procedures: specialist doctors have to be available the various ITBs and for the outpatient clinic. Caring for inpatients is also part of the doctor's duties. However, the specific personnel requirements vary greatly from clinic to clinic.

Outpatient care and treatment in day clinics

Increasing cost pressure in the healthcare system, especially in the inpatient sector, has led to a broad discussion in recent months about outpatient treatment for interventional oncology procedures. The latter have so far been performed predominantly in an inpatient setting. In this context, it is important to consider, from a medical perspective, which oncological interventions can be performed on an outpatient or day-patient basis due to their degree of complexity and side effect profile, taking into account individual patient factors (age, performance status, comorbidities, home environment, etc.). Yet cost-covering reimbursement for outpatient interventions also has to be ensured through the relevant billing channels. However, public policy on this topic is still in the process of being decided.

Organizational framework for performance of IO therapies

IO is an essential component in the interdisciplinary treatment of oncological patients. This is reflected, among other things, in the certification criteria from the German Cancer Society (GCS). A prerequisite for a GCS-certified visceral oncology center (pancreas center, liver center) is the availability of an IR certified by the DeGIR at level 2 and a 24/7 on-call service for emergency procedures. In addition, an IR has to participate in the multidisciplinary tumor boards in order to have a role in interdisciplinary treatment decisions. Consensus SOPs should be available at the site for all the relevant interventional therapies, as well as peri- and follow-up imaging.

This provides clear requirements for organizing interventional oncology units, particularly with regard to workflow, responsibilities, communication channels, cooperation with outpatient providers, documentation, quality management, as well as training, continuing education, and professional development.

Workflow

The aim of state-of-the-art IO is not only to carry out the intervention at the highest quality level, but also to integrate it in as many stages of the patient's treatment as possible (initial contact via outpatient clinic, imaging and clinical assessment, presentation to interdisciplinary tumor board, intervention planning, intervention execution, care or co-care during the inpatient stay, aftercare). Ideally, the entire service line can be provided in order to achieve maximum quality, efficiency, clinical perception, and cost-effectiveness with a high level of patient satisfaction [12]. Since this is implemented currently in very few clinics, or is not possible for all patients, at least the standard procedure should be defined in an interdisciplinary manner, written down in SOPs, and supported by the outpatient clinic or, if necessary, patient or case management (CM).

Responsibilities

For each work step, responsibilities have to be implemented with the corresponding redundancy and defined in SOPs that CM can reliably refer to. This one-stop organization (interventional radiology) minimizes information loss during communication and makes it easier to organize the processes for interventions. An interprofessional structure should be considered. Many tasks do not necessarily have to be performed by doctors. A qualified CM, physician assistant, or medical assistant can often perform most tasks with the same quality, better reliability, and more efficiency.

Communication channels

A central component of interdisciplinary communication in the treatment of tumor patients is the tumor board, with standardized documentation in an electronic patient record (EPR) available to all stakeholders. Beyond the tumor boards, all disciplines involved in the treatment should document their measures in the EPR. The reliable accessibility of the individual persons responsible (treating IR, MTR, MFA, outpatient clinic, ward staff, etc.) has to be ensured. For the exchange of information externally, a good option is HIM communication (communication in medicine), which is approved under data protection laws and is widely used in the outpatient sector.

Working with outpatient providers

Experience has shown that awareness of interventional radiology, in general, and its minimally invasive oncological therapy options, in particular, is rather low among outpatient providers. The reason for this is, on the one hand, that inpatients are regularly cared for in surgical or internal medicine departments, and the discharge documents are issued by these departments. On the other hand, aftercare usually takes place during the consultation hours for these disciplines. As a result, there is often hardly any communication between the actual service providers from interventional radiology and the outpatient referring physicians. Since oncological patients, in particular, often require several interventions over a longer period of time, an IO consultation is indispensable. If patients are accommodated in a separate interventional ward for the procedures, the consultation hours can be combined with those for the patient admission team.

Documentation

As mentioned above, all documentation at the clinic should be consolidated in the EPR. Follow-up examinations should also be documented and should be available to everyone involved in the therapy.

Quality management

The aim should be to record all oncological interventions in the DeGIR quality assurance register. This is mandatory anyway for certification as an interdisciplinary vascular center of the DRG and a DeGIR center for minimally invasive oncology. Such center certification and participation in the certification of (organ) tumor centers according to the GCS is strongly recommended. Regularly updated SOPs for the most common procedures and important workflows should be accessible online to everyone. See also the section below: Quality assurance measures.

Training, continuing education, and professional development

Regular attendance at conferences, as well as internal and interdisciplinary training and continuing education, ensure continuous expertise in the rapidly developing IO. MTRs should be given the opportunity to undergo further training to become specialists in interventional radiology according to the DGMTR, DRG and DeGIR. In order to promote young talent and cushion the shortage of skilled workers, coordinated training and teaching courses are needed that cover both theoretical and practical aspects. See also the section below: Quality assurance measures.

Personal requirements for interventional oncologists

If the IO wants to fully cover the fourth pillar of cancer treatment, the requirements are very extensive.

Since these are image-guided interventions, **i**n addition to the knowledge and skills required to perform the procedures, profound knowledge of diagnostic radiology also has to be present. These are necessary to correctly assess the disease and its spread, to plan therapy adequately, and to be able to properly assess the response to IO therapy using image morphology. This diagnostic knowledge is well reflected in the radiology specialist catalog and through corresponding certifications for interventional radiology (e. g. DeGIR, EBIR). The indication, therapy, and aftercare provided by the IR has far-reaching benefits:

On the one hand, the IR is very familiar with imaging and is already aware of the special features, such as vascular variants. On the other hand, the IR knows all the details of the intervention he or she has carried out and thus has a clear advantage in terms of information when assessing the follow-up examination. The treating IR is also best positioned to identify and treat potential complications in subsequent imaging.

State-of-the-art oncological therapy is characterized by interlinked multimodal therapy concepts. The IR has to be able to communicate with many disciplines on an equal footing and constructively contribute his or her highly specialized interventions to an often complex treatment concept as part of interdisciplinary tumor boards. To do this, the IR has to be well informed about alternative medicinal, endoscopic, and surgical therapies, as well as about the current data on his or her own methods and clinical guidelines. In addition, assessment of the clinical condition of patients is critical both in the preparation phase and during aftercare. This is important in order to assess the individual risk and prognosis, and to help shape the relevant follow-up treatment.

Peri-interventional management of the patient is one of the core activities of IO. This includes medication management (e. g. anticoagulation, antihypertensive therapy, knowledge of the effects and side effects of the administered therapeutic agents, pain management, antiemetic therapy), knowledge of the execution and monitoring of sedation and complication management (e. g. treatment of pseudoaneurysms of the groin). The necessary knowledge and skills should be learned in a structured training course and, in the case of sedation, internalized in dedicated courses [15].

Finally, a profound knowledge is needed in the field of radiation protection during interventional procedures (specialist knowledge is an important prerequisite (see above)).

Quality assurance measures

Quality management measures are promoted and implemented by professional societies at national level (e. g. The German Society for Interventional Radiology and Minimally Invasive Therapy (DeGIR)) and at the international level (CIRSE, Society of Interventional Radiology (SIR)). These measures include:

- Certification/accreditation
- QS-Register
- Guideline documents
- Quality assurance documents for specific interventions: standards of practice (CIRSE); quality improvement standards (SIR)

IR certification is possible at national and international level. It certifies the theoretical and clinical competence to carry out interventional radiological procedures according to generally accepted standards. This personal level of quality assurance can be acquired either as a certificate from DeGIR at level 1 or level 2 (modules A to D) or as a certificate from the European Board of Interventional Radiology (EBIR) via CIRSE [16, 17]. The International Accreditation System in Interventional Oncology Services (IASIOS), on the other hand, is a new, worldwide accreditation system designed specifically for the field of interventional oncology. IASIOS offers accredited institutions not only the opportunity to present their range of services, but also to set the highest quality standards for patient care and promote established treatment procedures.

At the institutional level, the DeGIR centers for interventional vascular medicine and minimally invasive therapy are also very important with regard to standardized practical training. The DeGIR-QS-Register, which was introduced almost two decades ago and has been developed continually since then, is regularly used to publish reports on process and outcome quality [16, 18]. Such publications are important because they document the quality of the procedures performed by IR and demonstrate the strength of interventional radiology compared to other disciplines. Last but not least, the digital databases of the DeGIR-QS-Register, which now contain over 1 million entries, will be a crucial basis for the transparency offensive in the hospital sector that has been demanded for years by health insurance companies and health policy makers, and is now pending. More than 30 national societies for radiology and interventional radiology, including the ÖGIR, the SSVIR, and the DeGIR, as well as the European Cancer Organization (ECO), support and promote the abovementioned core document on quality assurance. Its stated aim is to ensure highly effective and safe interventional oncological therapies by describing the entire process of patient treatment. In the American region, the Virtex SIR data registry has been established similar to the DeGIR registry (https://www.sirweb.org/practice-resources/quality-improvement2/data-registry/).

Another aspect of quality management at this level is the personal commitment of the IR, for example, in the form of active participation in guideline committees or networking, e. g. with the German Cancer Society (GCS) or professional associations. In this regard, it is also important to highlight the consistent cooperation of the DRG and the DeGIR in the preparation of guidelines of the Association of Scientific Medical Societies in Germany (AWMF; https://www.awmf.org). At the international level, representatives of CIRSE collaborate, for example, on guideline documents of the European Association for the Study of the Liver (EASL).

The standard of practice quality assurance documents for specific interventions from CIRSE or the quality improvement standards from the SIR, both of which have been published at regular intervals for years, define the quality standards for specific treatments, for example, for thermal ablation of liver tumors [19].

Summary and conclusions

The different procedures in the field of IO are complex medical interventions that are performed in a close interdisciplinary context.

These interventions place high demands on personnel and physical resources as well as on the available equipment technology. Because the procedures are performed using imaging techniques, often using ionizing radiation, in-depth knowledge of how to use X-ray-based imaging modalities and radiation protection is an important prerequisite. These are taught in a structured manner as part of the radiology specialist training and in DeGIR and EBIR certification courses. In addition to a high level of expertise in performing interventional diagnostic and therapeutic procedures, the IR also has to have experience in peri-interventional management of patients and possess solid, up-to-date knowledge about the differential therapy for relevant tumor diseases. The assessment of pre- and post-interventional imaging is also an important prerequisite for performing IO interventions. In order to determine the indication, a high level of expertise in the execution and interpretation of cross-sectional imaging is also a necessary prerequisite. Since only the treating IR can adequately evaluate the follow-up imaging, he or she should (co-)evaluate it to ensure the best possible image interpretation.

High procedural quality standards are an important prerequisite, and they are ensured by both personal and center certifications from DeGIR and CIRSE. Quality assurance registers of the national and international professional societies (DeGIR and SIR), as well as guideline documents and quality assurance documents from the professional societies, are further cornerstones that help to ensure a high quality of treatment. These also form the basis for the creation of internal clinic SOPs and treatment pathways.

These requirements are also taken into account in the current regulations for continuing education in radiology, so that future generations of radiologists will also be well prepared to meet the challenges of state-of-the-art IO.

Conflict of Interest

The authors declare that they have no conflict of interest.

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