

MEETING ABSTRACTS

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## ORAL PRESENTATIONS

01

### Global challenges in oncologic imaging

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Even as many cancers have been transformed from fatal to chronic diseases in developed countries, global cancer incidence and mortality have been rising [1]. While imaging is an essential tool in cancer care, the guidelines for its use are neither sufficient nor widely recognized. The needs for imaging equipment and training vary around the globe but are generally vast. Addressing these needs will require increased international cooperation. Conferences such as this, donation of equipment, "teach the teachers" programs, and ongoing education and consultation with experts via the Internet can all help. Most importantly, to have a long-lasting impact, cooperation must be tailored to local needs, engage local healthcare leaders, and build new generations of local leaders in oncologic imaging. With few exceptions (most notably the United Kingdom), oncologic imaging has yet to mature as a subspecialty around the world. In the United States, only a handful of oncologic imaging fellowships exist, and radiologists in most hospitals are still organized around modalities or organ systems.

Just as pediatric radiology is not simply general radiology for small adults, oncologic imaging is not simply the identification of masses added to general body imaging. Sub-specialized expertise is required for optimal, clinically relevant interpretation. Oncologic imagers must understand all imaging modalities, even those they do not interpret primarily, to be full partners in multidisciplinary disease management teams. Yet oncologic imaging is not recognized as a separate section in board examinations, and most radiology residents do not perceive it as a potential career path. Formal acknowledgment of the value provided by dedicated oncologic imagers would help raise the visibility of this critical subspecialty.

Another challenge facing oncologic imaging is the need to standardize reports to ensure all key points are covered clearly for each specific kind of cancer [2]. As part of this effort, radiologists must learn to utilize quantitative rather than qualitative terms as much as possible. Not only should they use numerical scales to express diagnostic certainty, they must also learn to interpret an ever-growing array of quantitative imaging parameters [3].

Finally, while state-of-the-art equipment is widely available in the United States, the approval and dissemination of new molecular imaging probes has been frustratingly slow. To realize the true potential of oncologic imaging and assure its contribution to precision medicine, we need to

expedite the validation, regulatory approval and dissemination of new tracers—particularly PET tracers, which have unparalleled molecular specificity. Radionuclide tracers are critical for characterizing tumor heterogeneity in vivo and are powerful predictive, prognostic and early response biomarkers. They can be used as companion diagnostics for targeted therapies and to assess pharmacodynamics/pharmacokinetics. Moreover, they can be integrated into theranostic agents that allow simultaneous diagnosis, treatment and treatment monitoring [4,5].

All these challenges may seem formidable, but as Alfred Einstein said, "in the middle of difficulty lies opportunity." Despite its lack of recognition, oncologic imaging is poised to be part of a revolution in cancer care. With dedication, imagination and cooperation, there is no limit to what we can accomplish.

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02

### Challenges of cancer imaging in Africa

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Africa as a continent is subdivided into different regions, Northern, Eastern, Western, Middle and Southern Africa. Sub-Saharan Africa refers to the combined Eastern, Middle, Southern, and Western regions. These subdivisions are important as the disease and cancer spectrum found in specific regions is quite different. Similar to the differences found between Africa and the developed world, cancer incidence and mortality patterns vary remarkably across regions within Africa because of the

substantial differences in economic development, and social, cultural and other environmental factors, including major known risk factors [1]. The occurrence of cancer in Africa varies remarkably by type of major cancer, stage at diagnosis, survival, incidence and mortality rates. This is largely due to differences in exposure to major risk factors, detection practices (availability of diagnostic and screening services), awareness of early signs and symptoms, and availability of treatment [1].

The cancer burden of each region will be discussed and some of the factors related to cancer imaging and the challenges faced will be highlighted.

Recent statistics and data for some parts of Africa are lacking, relatively representative in other parts, however more available for sub-Saharan Africa, which will probably be the greater focus of the discussion.

There are many significant global organisations that are constantly working to alleviate the cancer burden, and conduct research. There is significant vendor interest and investment in imaging equipment, and therapeutic modalities in scattered parts of Africa, although more focused in certain parts of Africa.

There is major local and international focus in establishing cancer centres in Africa, yet the predicted increase in the cancer burden, is phenomenal.

Collaborative and novel solutions are being explored through initiatives that involve international, regional and local organisations. These programmes include the procurement, installation, and maintenance of diagnostic and therapeutic imaging equipment.

There is much to be done, in the realm of screening, diagnosis, training, teaching, treatment and research, and this has to be an on-going, focused, enthusiastic effort by all countries in sub-Saharan Africa, the entire continent of Africa and key global cancer bodies. Much has been done in the last few years however much more still has to be done. As Victor Kgomoewana highlights in his book "Africa is open for business", Africa needs investment.

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### 03

#### Global challenges of cancer imaging: perspective from different parts of the world: Asia

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Asia accounts for about 60% of the world's population and half the global burden of cancer [1]. Due to the diverse economic development across the Asian continent, countries have highly variable health services development and healthcare infrastructure. Thus, there is disparity in access to services, especially resource intensive cancer management. All countries in Asia, except Japan are defined by the UN as 'less developed regions' and this reflects the limited resources in general. This presentation aims to describe the demographic characteristics of cancer in Asia, and highlight the challenges and main advancements of cancer imaging across this region. Lung cancer is the most common cancer in men (35.2/100,000 persons) and breast cancer the most common cancer in women (29.1/100,000 women) in Asia.

The incidence rate of breast cancer in Asia is about 1/3 compared to North America (NA) and Western Europe (WE), although it is on a steady rise. However, the five year prevalence rate is manifold lower indicating that in proportion, there are fewer cancer survivors in Asia. With the exceptions of Japan, South Korea and Taiwan, resources in most countries are inadequate for population-based organised screening mammography programmes. However, it is less clear if organised screening would be a cost-effective programme in Asia, due to the lower incidence rate as well as reduced sensitivity of mammography in Asian women with higher density breast tissue [2], and there is evidence that supplemental ultrasound screening increases the sensitivity for cancer detection in women with dense breasts [3].

Notably, in South East Asia (SEA) and East Asia (EA) compared to the rest of the world, the incidences of liver cancer, oesophageal cancer, stomach cancer and nasopharyngeal cancer are relatively high, although on the

decline. Liver cancer is the second and third most common cancer in men in SEA and EA respectively, and fifth most common cancer in women. More than 70% of the new cases of liver cancer are from Asia, of which 50% are from China. Recent studies have advanced the use of gadolinium ethoxybenzyl dimeglumine (Gd-EOB-DTPA) enhanced MRI for its superior sensitivity for the detection of hepatocellular carcinoma, especially small tumors [4], and 11C-acetate PET imaging for detection of well-differentiated tumors [5]. Oesophageal cancer is the fifth most common cancer in EA men. Asia accounts to about 75% of new cases, specifically the 'asian oesophageal cancer belt' that extends from Turkey to Mongolia and Western/Northern China. The majority of these are squamous cell carcinoma in histology. Studies have found 18F-Fluorodeoxyglucose (FDG) PET to be useful in disease staging (particularly upstaging), and predictive of outcome of neo-adjuvant chemotherapy and disease survival [6]. Nasopharyngeal carcinoma is the sixth and fourteenth most common cancer in men across SEA and EA respectively. 80% of new cases are from this region, and are focussed around Southern China, Taiwan and SEA. Current research has evaluated the roles of diffusion MRI for tissue characterisation [7] and 18F-FDG PET for prognostication [8].

In recent years the cancer burden in Asia and its developing countries has surged, and is forecasted to continue to rise. Resources for the provision and development of diagnostic imaging which plays an essential role in early detection and management of cancer must be supported and strengthened across the region.

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### 04

#### Biliary tract neoplasms: detection and staging CT and Ultrasound

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Most biliary tract neoplasms are malignant and have been traditionally divided into cancers of the gallbladder, the extrahepatic bile ducts, and ampulla of Vater. Although infrequent, bile duct carcinomas and cancer of the gallbladder are not rare. In the United States, an estimated 6,000 to 7,000 new cases of carcinoma of the gallbladder and 3,000 to 4,000 new cases of carcinoma of the bile ducts are diagnosed annually. Familiarity with the imaging characteristics of gallbladder and bile duct neoplasms is important to expedite diagnosis and appropriate treatment of patients who often present with nonspecific symptoms of right upper quadrant pain, jaundice, and weight loss. This workshop presents the CT and ultrasound features of biliary tract neoplasms important for early diagnosis, staging, and follow-up of these often lethal neoplasms

## O5

### MR imaging

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Biliary tract neoplasms are commonly accounted for by cholangiocarcinoma and biliary cystadenoma/carcinoma and other less common tumors including papillary neoplasms, lymphoma and metastases. Although cholangiocarcinoma is a rare tumour (<2% of all cancer), it is the second most common primary hepatobiliary malignant tumour after hepatocellular carcinoma (HCC). This tumour actually encompasses a diverse group of tumours varying greatly in location, growth pattern and histology resulting in a gamut of imaging manifestations. It is important to be familiar with those diverse manifestations to provide accurate detection and characterization. Since only surgery can provide curative therapy, accurate resectability assessment is critical. Defining an optimal MRI protocol which includes precontrast MR imaging along with high resolution MRCP sequences and Dynamic contrast acquisitions/MR angiography is necessary to ensure accurate results. MRI offers unique advantages via its ability to provide information noninvasively in a single test regards tumour size, extent, vascular involvement, nodes and extrahepatic spread. MRCP can superbly display bile ducts upstream to an obstruction. According to its anatomic origin cholangiocarcinoma is usually classified as intrahepatic, perihilar, or extrahepatic distal or based on growth pattern as mass forming, infiltrating or polypoidal. Staging systems have been designed for anatomical location precise for surgical planning and to establish prognosis after surgery. MRI is not without limitations. In some cases other disease process may mimic cholangiocarcinoma and these will be discussed. At times MRI may not be able to confidently detect or stage the tumor and correlative imaging with Ultrasonography, CT and PET needs to be considered. Biliary cystic tumors, such as biliary cystadenoma (BCA) and cystadenocarcinoma (BCAC) constitute <5% of all liver cysts. BCA occurs predominantly in women (90%) with mean age of 45 years while BCAC can occur equally in men and women with mean age of around 55 years. Biliary cystic tumors are commonly multilocular with thick walls and enhancing septations on MRI. The differential diagnosis includes hydatid cyst, liver abscess, embryonal sarcoma, primary or metastatic necrotic neoplasm, and biliary intraductal papillary mucinous neoplasm (IPMN). Lymphoma involving bile ducts is secondary to systemic lymphoma but can result in biliary obstruction that mimics klatskin tumor or inflammatory cholangitic processes. Intrahepatic metastases are most commonly due to colorectal carcinoma metastases and also occasionally secondary to lung and breast carcinoma. Intrahepatic metastases can be mistaken for cholangiocarcinoma in the absence of knowledge of a primary malignancy.

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## O6

### Staging of lung cancer CT and PET

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Lung cancer is the leading cause of cancer related deaths in the United States with a 5 year survival of only 15%. [1] The International Association for the Study of Lung Cancer (IASLC) issued a 7<sup>th</sup> edition of the TNM staging system for lung cancer in 2007. [2] It includes several revisions which better align TNM staging with prognosis and in some cases with treatment.

There have been revisions in the TNM descriptors. In the T or tumor category, the T1 and T2 categories include now subcategorization of size with new T1a, T1b, T2a and T2b subdescriptors. One of the important changes is that tumors larger than 7 cm are now considered Stage T3 tumors. Stage IV tumors include separate tumor nodules in the same lung but not in the same lobe as the primary lesion which were previously considered metastatic (M1). Stage T4 disease is now downgraded to Stage III when satellite nodules are present in the same lobe as the primary lesion. The presence of malignant pleural effusion, pleural dissemination or pericardial disease is now considered metastatic disease, specifically stage M1a for local intrathoracic disease rather than Stage IV disease [3-5].

Although the IASLC has proposed a new lymph node map there are no changes to the end descriptors in the 7<sup>th</sup> edition of the TNM staging system [3-5].

Nearly one half of newly diagnosed lung cancers already demonstrate metastases within the lung, brain, liver, and bony structures. Any metastatic disease is automatically designated Stage IV disease and with few exceptions is considered surgically unresectable. The M category is now subcategorized into intra-thoracic metastasis M1a and extra-thoracic metastatic M1b with the former having a better prognosis [4].

Contrast enhanced CT remains the mainstay for staging of lung cancer. However, PET has particular value in nodal staging of lung cancer and also in determining the presence of distant metastatic disease. In a study by Gould et al, the sensitivity of PET CT for metastasis was 85% and the specificity was 95% as compared with a CT sensitivity of 61% and specificity of 79% [6]. PET CT does have a high false positive rate so it cannot replace invasive sampling, but it may be used to direct invasive staging. PET scanning is particularly useful in M staging of non-small cell lung cancer. PET can replace the use of bone scintigraphy and it is now widely used for determination of distant metastasis throughout the body. However, it is limited in the assessment of brain metastases. In the PLUS Trial, 188 patients with potentially resectable non-small cell lung cancer were randomized to either conventional work up or PET CT. Addition of the PET CT to the conventional work up prevented future surgery in 1 out of 5 patients [7].

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## O7

### Imaging as a guide to tissue sampling

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When assessing a patient with lung cancer, it is important to stage the tumor in order to determine prognosis and direct appropriate therapy. Although imaging findings, particularly with CT and PET, can suggest the correct tumor stage, imaging is imperfect in this regard; enlarged and/or hypermetabolic lymph nodes may require sampling for confirmation of presumed tumor stage. A major role for imaging is to direct the most optimal method of tissue sampling in order to establish the highest possible tumor stage, so that proper therapy may be instituted [1]. Lymph node biopsies may be performed using mediastinoscopy for lymph nodes that are adjacent to the trachea or carina; bronchoscopy with endobronchial ultrasound for lymph nodes adjacent to the trachea, carina, mainstem bronchi and more peripheral airways; video assisted thorascopic surgery (VATS) for lesions adjacent to the pleural surfaces; Chamberlain procedure for lymph nodes in the aortopulmonary window and anterior paraaortic regions; endoscopic ultrasound (EUS) for nodes adjacent to the esophagus; ultrasonography for nodes in the neck and supraclavicular regions; and CT biopsy for large, accessible nodes. Selection of the best method for obtaining a tissue sample necessitates consideration of various factors, including the location of the lesion, the need for sampling of single vs. multiple lymph node stations, the amount of tissue that is necessary to make a confident diagnosis, the expected diagnostic yield and accuracy of the technique, the cost and availability of the procedure at the patient's institution, the expertise of the physicians, and the safety and risks involved.

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## O8

### Screening & staging of colorectal cancer

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In Europe, colorectal cancer (CRC) is the second most common cancer, and the second most common cause of death from cancer [1]. The vast majority of CRC develop from benign precursor lesions, so-called adenomatous polyps, which via the adenoma-carcinoma pathway may eventually transform into colon cancer. It has been shown that endoscopic removal of adenomas interrupts this pathway and subsequently reduces CRC incidence and cancer-related mortality. Thus endoscopic CRC screening programs have been instituted in many countries to reduced CRC cancer mortality. However, limited availability of colonoscopy and limited adherence of the population to colonoscopy-based screening programs is well documented. CT colonography (CTC) has evolved as an effective tool to detect small colorectal polyps, with a high sensitivity to diagnose adenomas  $\geq 10$  mm and advanced adenomas (with dysplasia) [2]. After negative screening CTC, clinically presenting CRC is rare in the 5 years following CTC [3].

Guidelines for staging of CRC have been developed by the European Society of Medical Oncology (ESMO) [4], which recommend MRI and/or endorectal ultrasound for local staging of rectal cancer (in order to decide which patients need neoadjuvant therapy). MRI is preferred in stenotic tumors or cancers in the upper third of the rectum. In patients with colon cancer, local staging (by CT) primarily seeks to exclude T4 disease with infiltration into other organs. Variability exists in different European countries regarding the use of contrast-enhanced MDCT of the abdomen and chest (to be preferred over chest X-ray) for evaluation of nodal disease and distant metastases. Assessment of lymph nodes based on size criteria alone has some limitations, because metastases can be found even in normal-sized lymph nodes [5,6]. FDG-PET is not recommended for staging [4]. It might be used for staging of patients with CT-detected synchronous liver metastases scheduled for liver surgery. However, a recent study showed that PET/CT in patients with potentially resectable liver metastases did not result in frequent change of management and did not improve overall survival [7]. CTC screening for CRC will be presented and CRC staging by MDCT and MRI will be highlighted.

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## O9

### MRI for managing intermediate & low risk prostate cancer

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**Intermediate risk disease:** Pathological status: PSA 10–20 ng/mL, or biopsy Gleason score 7, or clinical stage T2b or T2c

**Clinical note:** Heterogeneous group with a wide incidence of biochemical relapse & numerous curative therapy options.

**Problems with categorization:** Detection of unfavourable subgroup includes Gleason  $\geq 4+3$  and/or  $>50\%$  positive biopsies and/or  $>1$  intermediate risk factors [1,2]

**Role of MRI in practice:**

- If initial active surveillance is considered, then it is important not to underestimate tumor grade/ volume/stage
- For external beam radiotherapy, the presence of unfavourable disease affects duration of adjuvant hormonal therapy.
- For focal therapy, index lesion localization is needed
- For surgery, accurate staging to enable curative treatment with negative margins & nerve sparing if possible

**Type of MRI [3]:**

- Lesion detection and localisation protocol with T2W, DW-MRI and DCE-MRI  $\pm$  MRSI for low ADC lesions to assess aggressiveness

- Staging with multi-planar T2W, DW-MRI ± DCE-MRI for ECE/SVI

**High risk disease:** Pathological status: PSA >20 ng/mL, **or** Gleason score 8–10, **or** clinical stage >T2c

Clinical note: Highest risk of biochemical recurrence and cancer specific mortality but substantial population heterogeneity  
Prognostic subgroups [4]:

- Good prognosis subgroup: one single risk factor (any)
- Intermediate prognosis subgroup: two risk factors (PSA >20 ng/ml and stage cT3–4); **No** Gleason 8+ disease
- Poor prognosis subgroup: GS >7 and stage cT3–4 and/or PSA >20 ng/ml

Clinical sub-groups: localized, locally advanced & metastatic

Problems with categorization: Local staging accuracy & the detection of metastatic disease

Role of MRI in practice

1. local and nodal staging: to detect extensive ECE/SVI that would preclude radical surgery with negative margins. Nerve sparing rarely undertaken.
2. To detect nodal and bone metastases

Type of MRI [3,5]:

- Accurate local staging and pelvic nodal assessments
- Bone scan + CT abdomen or WB-MRI

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#### O10

##### PSMA ligands for diagnosis and therapy of prostate cancer

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Since the prostate-specific membrane antigen (PSMA) is frequently over-expressed in prostate cancer (PCa) several PSMA-targeting molecules are under development to detect and treat metastatic castration resistant prostate cancer (mCRPC).

We investigated 319 patients who received a <sup>68</sup>Ga-PSMA<sup>HBED</sup>-PET/CT. In 82.8% of the patients at least one lesion indicative for PCa was detected. Tumor detection was positively associated with PSA level and androgen deprivation therapy (ADT). Mean SUV<sub>max</sub> of analyzed tumor lesions was 13.3 ± 14.6. Amongst lesions investigated by histology, 30 were false-negative in <sup>68</sup>Ga-PSMA<sup>HBED</sup>-PET/CT (one local relapse in one patient and 29 lymph nodes in another patient), all other lesions (n=416) were diagnosed true-positive or -negative. Fifty of 116 patients available for follow-up received local therapy after <sup>68</sup>Ga-PSMA<sup>HBED</sup>-PET/CT.

In thirty-seven patients with biochemical relapse of PC a comparison was done between <sup>18</sup>F-fluoromethylcholine- and <sup>68</sup>Ga-PSMA-PET/CT within a time window of 30 days. Radiotracer uptake that was visually considered as

PC lesion was subsequently semi-quantitatively analyzed by measuring the SUV<sub>max</sub> values of the scans acquired 1 hour p.i. of <sup>68</sup>Ga-PSMA complex solution (59 - 263 MBq, median of 132 MBq) and <sup>18</sup>F-fluoromethylcholine (114 - 374 MBq, median of 237 MBq) respectively. In addition tumor to background ratios were calculated. 78 PC-suspicious lesions were detected in 32 patients using <sup>68</sup>Ga-PSMA-PET/CT and 56 lesions were detected in 26 patients using Choline-PET/CT. The higher detection rate in <sup>68</sup>Ga-PSMA-PET/CT concerning PC-suspicious lesions was significant (p=0.04). In 5 patients no lesion was found. All lesions detected by <sup>18</sup>F-fluoromethylcholine-PET/CT were also seen by <sup>68</sup>Ga-PSMA-PET/CT. In <sup>68</sup>Ga-PSMA-PET/CT SUV<sub>max</sub> was clearly (>10%) higher in 62 of 78 lesions (79.1%) and tumor-to-background ratio was clearly (>10%) higher in 73 of 78 lesions (93.6%) when compared to <sup>18</sup>F-fluoromethylcholine-PET/CT.

Since the ligand bound to PSMA is internalized, the target may also be used for endoradiotherapy. We investigated the tissue kinetics of a small molecule inhibitor of PSMA ((S)-2-(3-((S)-1-carboxy-5-(3-(4-[<sup>124</sup>I]iodophenyl)ureido)pentyl)ureido)pentanedioic acid; MIP-1095) using PET/CT to estimate radiation dosimetry for the potential therapeutic use of <sup>131</sup>I-MIP-1095 in men with mCRPC. We also report preliminary safety and efficacy of the first 28 consecutive patients treated under a compassionate use protocol with a single cycle of <sup>131</sup>I-MIP-1095.

I-124-MIP-1095 PET/CT images showed excellent tumor uptake and moderate uptake in liver, proximal intestine and within a few hours post-injection also in the kidneys. High uptake values were observed only in salivary and lacrimal glands. Dosimetry estimates for I-131-MIP-1095 revealed that the highest absorbed doses were delivered to the salivary glands (3.8 mSv/MBq, liver (1.7 mSv/MBq) and kidneys (1.4 mSv/MBq). The absorbed dose calculated for the red marrow was 0.37 mSv/MBq. PSA values decreased by >50% in 60.7% of the men treated. 84.6% of men with bone pain showed complete or moderate reduction in pain. Hematological toxicities were mild. 25% of men treated had a transient slight to moderate dry mouth. No adverse effects on renal function were observed.

Based on the biodistribution and dose calculations of the PSMA-targeted small molecule <sup>124</sup>I-MIP-1095 therapy with the authentic analog <sup>131</sup>I-MIP-1095 enables a targeted tumor therapy with unprecedented doses delivered to the tumor lesions. Involved lymph node and bone metastases were exposed to estimated absorbed doses upwards of 300 Gy.

#### O11

##### Clinical management of patients with complicated multifocal disease

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Deferent to the indication for surgical resection of liver metastases in previous years number, location and size are not the main targets to define resectability any more but the volume of the so called liver remnant, which has to have adequate inflow, outflow and biliary drainage. The magnitude of the remnant is dependent upon the function of the liver which nowadays is not only hampered by a potential underlying liver disease but very often damaged by previous extensive chemotherapy [1]. Liver surgery has become a safe procedure as a result of improved techniques, interdisciplinary management in radiologic assessment, oncological understanding, perioperative care and surgical specialisation. When a patient is newly diagnosed with metastatic colorectal cancer (mCRC) the following issues should be discussed primarily in a multidisciplinary meeting: timing of metastatic diagnosis (metachronous/synchronous), primary insitu (yes/no; clinically symptomatic: y/n), affected organs, comorbidities, resectability status. Especially the last point has no general rules and is dependent upon the experience of the team and the specialised surgeon.

Initial resectability is categorized into three groups: resectable, potentially resectable (after downsizing through chemotherapy), unresectable [2]; the belonging of each patient to one of these groups can change within its course of disease and should therefore be rediscussed routinely every two months.

Every newly diagnosed mCRC patient should receive at least a short course of systemic chemotherapy (e.g. two months) to estimate his/her aggressiveness of disease and thereby define the right surgical candidate (the responding patient). Chemotherapy has become very effective with response rates (defined as complete or partial radiological response) in liver

limited disease approaching 80% with very small percentage numbers of progressive disease (<5%) [3].

If a patient's disease has demonstrated to respond to chemotherapy every attempt should be made to perform resection with potential curative intent in a fit patient who can tolerate major surgery. The technical options are various and range from a simple removal of half of the liver to the addition of resection of lesions in the remaining lobe or their destruction by thermal energy. This can be done after an increase of the initially too small remnant by using portal vein embolization (PVE) or by the use of a so called two stage procedure where one lobe is cleared of metastases at the first operation and the other lobe is resected secondarily after hypertrophy of the initially treated lobe (mostly with the addition of PVE). The resection itself is nowadays a bloodless procedure especially if sophisticated methods are used (e.g. CUSA technique) with the requirement of transfusions in less than 10% of patients in experienced centres [4].

Postoperative care is essential for the outcome of the patients and should include specialised anesthesiological surveillance and medical oncology advice after pathological work up of the resected metastases.

With this multidisciplinary approach to mCRC patients overall outcome has improved and reached median survival figures of 5 years [5].

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#### O12

##### The do's and don'ts of liver CT and MR imaging

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Contrast enhanced multi-detector CT (MD CT) is now the most commonly used imaging modality for detection of liver metastases and work-up of equivocal lesions found at ultrasound. MR imaging is an established technique for non-invasive characterisation of liver masses and for preoperative potentially resectable liver tumours. Diagnostic value of each modality strongly depends on the scan technique. With MDCT, the role of thin slice imaging has been well established, with slice thicknesses of 5-7.5 mm being inferior to thinner slices in terms of lesion detection [1]. The amount of contrast material as well as the flow rate influence enhancement of hypervascular lesions in the arterial phase and the magnitude of liver parenchyma enhancement in the venous phase, respectively [2,3]. The number of CT scans varies with the local indication, with single-phasic venous scans to 4-phasic scans, as recommended by European and US guidelines for HCC detection and characterisation.

For MR imaging, a multi-point DIXON technique has replaced conventional T1-weighted GRE pulse sequences; with this technique in one breathhold in-phase, opposed-phase, fat-suppressed, and water-suppressed images can be obtained, without any spatial misregistration. Diffusion-weighted pulse sequences significantly improve detection of metastases [4,5]. As a black-blood technique with T2-weighted image impression, it demonstrates small lesions without any blurring by an adjacent high signal intensity of vessels of bile ducts [6]. Administration of contrast agents is mandatory for liver

MRI, with the choice of either non-specific gadolinium chelates or liver specific contrast agents. Indications for liver-specific contrast agents include preoperative evaluation of liver metastases and characterisation of hepatocellular lesions (FNH, adenoma), whereas non-specific gadolinium chelates are used for characterisation of haemangiomas, after liver resection or tumour ablation. The choice of the imaging techniques and the scan or contrast agent protocol should be tailored according to the clinical question.

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#### O13

##### Prospects and challenges of US and CEUS

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Ultrasound is already a major technique to study focal liver lesions. Particularly since the arrival of the ultrasound contrast agents which allows a sensitivity greater than 90% for characterizing incidentally detected focal liver lesions in adults in whom an unenhanced ultrasound scan is inconclusive or with inconclusive MRI/CT. However the role of ultrasound will probably rise even more in the near future because of rapid software and hardware developments.

Future prospects are:

- 1) The development of image fusion and navigation technology combining US and CT or MRI to improve the possibility to perform difficult percutaneous ultrasound guided biopsy or thermo ablation procedures with a higher rate of success.
  - 2) The development of 3D imaging technology in ultrasound to improve liver tumour response assessment particularly by means of a combination with ultrasound contrast agents. The challenge will be to be able to reach a real time 3D imaging through matrix technologies also capable of handling contrast agents enhanced modes in order to get enhancement curves of the whole tumour with a adapted temporal resolution.
  - 3) The development of targeted imaging through targeted microbubbles against a variety of targets located on the vessel wall. Indeed contrast enhanced ultrasound is probably the second more sensitive technique to the presence of a small amount of targeted contrast compound after PET. Many feasibility studies on animal models have already been conducted and currently a hypo allergenic targeted microbubble that includes in its membrane a heterodimer peptide having a high affinity to VEGFR2 (BR55) is being tested in humans.
- Beside CT and MRI, US must be also considered as a major technique that has much to offer particularly in liver imaging and the near future of ultrasound is undoubtedly exciting.

#### O14

##### Pediatric tumours: pseudotumour or a tumour?

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Differentiation between tumours and pseudo-tumours is essential for planning adequate treatment and for estimating outcome and future prognosis. Per definition, tumour and pseudo-tumours are lesions that look alike on ultrasound (US), computer tomography (CT) or magnetic resonance imaging (MRI) studies. Misinterpretation may lead to a significant delay of adequate treatment for malignant tumours or on the contrary may result in over-treatment of a tumour-like, benign lesion. The essential question is how does a radiologist reliably differentiate between both entities? Typically, he will use anatomical imaging studies like US, CT or MRI. A tumour is suspected when a focal density or signal alteration is seen displacing or infiltrating adjacent structures with or without a matching contrast enhancement and possibly surrounded by vasogenic edema. Unfortunately, many pseudo-tumours including abscesses, resolving hematomas, vascular malformations, benign cysts, and even metabolic disorders may have similar imaging features. In addition, a frequent, difficult question is the differentiation between postsurgical changes and residual tumour after recent tumour surgery or between radiation induced lesions and recurrent or residual tumour. The recent development of functional MRI sequences like diffusion tensor imaging (DTI), perfusion weighted imaging (PWI), <sup>1</sup>H magnetic resonance spectroscopy (MRS), susceptibility weighted imaging (SWI) and dynamic contrast enhanced MRI sequences facilitates the differentiation between tumours and pseudo-tumours.

It is impossible to present a complete list of pseudo-tumours, however the current presentation will discuss how a multidisciplinary, multi-imaging and multi-sequence approach may facilitate differentiation between tumors and pseudo-tumours.

## O15

### Neuroblastoma and nephroblastoma: an overview and comparison

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Neuroblastoma (NBL) is the most common extra-cranial tumour in childhood [1] and commonly presents as an abdominal mass. Nephroblastoma, also more commonly known as a Wilms' tumour, is the commonest renal tumour in childhood and also typically presents as abdominal pathology. The natural histories and typical clinical courses of these tumours are very different, thus early distinction is important. Both occur in early childhood, with Wilms' having a slightly older peak incidence at between 3 – 4 years. Histologically, they are different diseases with NBLs arising from primordial neural crest cells [1] and Wilms' being undifferentiated mesodermal tumours [2]. The heterogeneity of NBLs and their biological characteristics mean the prognosis is highly variable; tumour stage, patient age, tumour oncogenes and DNA content are all known to be implicated [3]. Wilms' have two distinct histopathological types, favorable and unfavorable, with differing outcomes. NBLs are most commonly located within the adrenal gland, so typically present as palpable abdominal masses causing pain and distension [1,4]. Well described paraneoplastic syndromes include opsomyoclonus and excessive vasoactive intestinal peptide (VIP) production [1]. Metastatic disease is common on presentation [1]. Wilms' usually present as a large, painless abdominal mass with few constitutional symptoms [2]. On ultrasound (US), NBLs are solid, heterogeneous masses with calcification and are rarely cystic [4]. With Wilms', US also evaluates whether the mass is intra- or extra-renal, solid or cystic, and for the presence of vascular invasion [2]. MRI effectively assesses the extent of primary NBL disease, being superior to CT in assessing metastatic marrow disease, chest wall invasion and spinal canal involvement. On CT, NBLs are poorly marginated, heterogeneous masses that can cross the midline and enter adjacent body cavities. A key-defining feature is calcification, but this can have a variable appearance [4]. NBLs tend to encase and displace structures rather than invade them. Over 90% are MIBG-sensitive, but for primaries that are not, <sup>99m</sup>Tc-diphosphonate bone scintigraphy is currently recommended to look for metastatic bony disease [1,3]. MRI is also useful at Wilms' diagnosis, with contrast-enhanced sequences clearly demonstrating the 'claw' of normal renal tissue around the tumour. Tumours return low signal on T1W, with variable/high signal intensity on T2W. The non-cystic components typically restrict on diffusion sequences. In contrast to NBL, vessels are displaced rather than encased and vascular invasion occurs in approximately 5-10% of cases [4]. NBL staging

has evolved with the simpler International Neuroblastoma Risk Group (INRG) system [3,5]. Imaging significantly contributes to this system. To enable consistent reporting, imaging defined risk factors have been identified by the INRG [3]. Unlike with NBL, chest CT is routinely done for Wilms' staging. Management strategies for NBL include surgery, chemotherapy and radiotherapy, with additional myeloablative therapy and recently also immunotherapy for high-risk disease. A unilateral Wilms' tumour is treated with nephrectomy and chemotherapy. With bilateral disease, pre-operative chemotherapy is vital as each kidney is staged separately, but the surgical approach is to preserve normal renal parenchyma.

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## O16

### Pediatric tumours: liver tumours

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Pediatric liver tumors account for approximately 1% of all liver tumors and up to 2% of all pediatric malignancies [1,2]. While the overall incidence of liver tumors is rare, the liver remains the third most common organ of origin for solid abdominal tumors in the pediatric population [3]. The majority of pediatric liver tumors, both benign and malignant, occur (almost) exclusively in children.

Benign tumors account for one-third of all pediatric hepatic neoplasms and include infantile hepatic hemangioma, focal nodular hyperplasia, mesenchymal hamartoma, and hepatic adenoma [2-5]. Malignant neoplasms account for the remaining two-thirds of pediatric liver tumors. The most common malignancies are hepatoblastoma, hepatocellular carcinoma, fibrolamellar hepatocellular carcinoma, undifferentiated embryonal sarcoma, and biliary rhabdomyosarcoma [4-6]. While the majority of these tumors are unique to children, focal nodular hyperplasia, hepatocellular adenomas, and hepatocellular carcinoma have counterparts in adults. The presentation, risk factors, and imaging appearance of these overlapping tumors differs in the pediatric population as compared to adults [7,8].

Even though there are a number of different liver tumors, the radiologist can often make a confident diagnosis based on the clinical information and imaging appearance of the mass [9,10]. The purpose of this lecture is to describe the imaging work-up for pediatric liver masses and then discuss each tumor, focusing on its unique clinical and imaging features.

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## O17

### ICIS workshop on adnexal mass characterization

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Ovarian cancer is predominantly diagnosed at a late stage due to a relative lack of symptoms in the early stages of disease. The published screening trials have not demonstrated any benefit to screening for disease. However, with relatively widespread use of pelvic ultrasound for abdominal or pelvic symptoms, adnexal masses are commonly identified. The majority of such adnexal masses are benign and the majority can be readily triaged into benign or malignant categories using standardized systems, such as the IOTA simple rules. However, a number of cases are difficult to categorise and remain indeterminate on ultrasound. It is important to categorise each lesion as accurately as possible to direct the appropriate management, ensuring cytoreductive surgery in cases that are highly likely to be cancer whilst allowing a more conservative approach in benign cases, particularly when fertility preservation is of concern to the patient. There is a body of evidence now to support the role of MRI in the assessment of this cohort of “difficult to classify” adnexal masses. The T2 signal intensity characteristics and the presence of enhancement are important classifiers. Very low T2 signal intensity and lack of enhancement are markers of benignity. More recently, the role of diffusion weighted imaging (DWI) and dynamic contrast enhancement (DCE) has been closely evaluated. The enhancement curves generated from DCE can be a strong pointer to benignity or malignancy, using the myometrial enhancement as an internal comparator. Where the solid component enhances more rapidly and more intensely than the myometrium, invasive malignancy is highly likely. In lesions that retain no high signal intensity on the high b value DWI, benignity is highly likely. A proposed scoring system, the AdnexMR score, has been developed and is currently being prospectively tested throughout Europe and several centres in the United States. This workshop will review the key features for characterizing adnexal masses, review the proposed scoring system, and give practice examples for scoring by the audience.

## O18

### Ovarian cancer: imaging in treatment selection and planning with FIGO update

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The International Federation of Gynecologists and Obstetricians (FIGO) has recently revised the staging of ovarian cancer [1]. It includes a revision of the stage III patients and allotment to stage IIIA1 is based on spread to the retroperitoneal lymph nodes without intraperitoneal dissemination, because an analysis of these patients indicates that their survival is significantly better than those who have intraperitoneal dissemination [1]. The FIGO staging system for ovarian cancer is surgically based. It does not formally include imaging but the FIGO committee encourages the use of imaging techniques if available to assess the important prognostic factors such as disease resectability and lymph node status.

The standard of care for patients with newly diagnosed advanced ovarian cancer has been comprehensive staging laparotomy and primary optimal surgical cytoreduction followed by adjuvant chemotherapy. However, the use of neoadjuvant chemotherapy followed by interval debulking surgery (IDS) as a suitable alternative is supported by multicenter randomized controlled trials [2]. Imaging is therefore of paramount importance in helping triage patients for appropriate management by accurately evaluating the extent and anatomical location of peritoneal spread, which in turn dictates the feasibility of cytoreductive surgery and predicts the likelihood of optimal primary cytoreduction. Optimal cytoreductive surgery (residual disease <1 cm) is a very strong predictor of survival, and even after the threshold for optimal cytoreduction has been reached, it is important to remove as much of the residual tumor as possible.

CT is the primary imaging modality used to stage ovarian cancer. It is complimentary to surgical staging identifying possible sites of unsuspected disease such as pelvic peritoneum, paraaortic nodes, diaphragm and chest [3,4]. The thorax frequently harbors undiagnosed pleural disease at the time of the initial diagnosis which is likely to affect survival even in cases of optimal debulking [5,6]. Accurate imaging helps guide the surgeon to areas of disease that may be difficult to identify surgically. Relative criteria for non-optimally resectable disease have been developed [7]. They include lymph node enlargement above the renal hilum, presence of abdominal wall invasion, parenchymal liver and subcapsular liver metastases, peritoneal implants of >2 cm along the diaphragm, lesser sac, porta hepatis, intersegmental fissure, gall bladder fossa, gastrosplenic, gastrohepatic ligament and small bowel mesentery. However, it is important to realize that these criteria may vary and will depend on the aggressiveness of the surgical procedure and on the performance status of the patient. Therefore, they should only be used as a basis for a multidisciplinary consensus. It is important to note that upper abdominal disease and pleural metastases can be surgically resected, but this requires careful planning as it involves a team of surgeons (e.g. liver surgeons for hepatic resection). There has been a growing awareness of the potential of diffusion weighted magnetic resonance imaging (DW-MRI) in improving the mapping of the extent of ovarian cancer [8,9]. There is also growing evidence that FDG-PET/CT may play a role in pre-operative staging of patients with advanced ovarian cancer [10].

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## O19

### Metastasis: imaging shows the way

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Metastasis, the life threatening aspect of cancer, is a systemic disease process. Considerable progress has been made in recent years regarding how tumor cells circulating in the blood and lymphatic systems interact with and extravasate into secondary sites, and what determines whether these disseminated tumor cells survive, remain dormant or go on to form macrometastases. New insights into the routes that tumor cells take once leaving the primary tumor have emerged. Novel concepts regarding early seeding of metastases coupled to parallel progression, self-seeding of primary tumors by circulating tumor cells, and the induction of pre-metastatic niches in distant organs by primary tumors have come to the fore. In our presentations we will review these and other paradigm shifts that have taken place over recent years, placing a particular focus on how the use of intravital and other imaging techniques have played a major role in these developments.

## O20

### Locoregional therapy of renal cancer

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This lecture aims to provide an overview of renal cell carcinoma (RCC) and insights into this rapidly evolving treatment – image guided thermal ablative (IGA) therapy. RCC is the commonest kidney cancer and the detection of RCC has increased over the past decade. There are over 8000 and 50,000 new cases/year in the UK and USA respectively [1,2]. The increased detection is due to wider usage of radiology (e.g. ultrasound or computed tomography) and this usually results in the detection of smaller RCC with earlier stage disease [3,4]. In addition, this is also related to the rise in incidence in the general population as a result of smoking and obesity [5-7].

The historical classical clinical triad where patients presented with flank pain, abdominal mass and haematuria is now a rarity and nowadays the majority of the incidentally detected RCCs are smaller and at an earlier stage –T1 stage. However, historical data has suggested that 60% of these small incidentally detected tumours will grow gradually over a period of time [8]. Therefore, there remains a clinical risk with adopting a 'watchful waiting' approach for younger patients as these tumours may become symptomatic or metastasize [9].

Open radical nephrectomy (RN) was the gold standard treatment for RCC since it was introduced in 1869 and Robson et al had popularized this treatment over the last 50 years [10]. Over the past 10 years, laparoscopic RN is becoming the standard of care with better cosmetic results and shorter recovery time [11]. More recently for locally confined (T1 disease) RCC treatment with nephron sparing surgery (NSS) e.g. open/ laparoscopic PN has demonstrated similar oncological durability to that of the gold standard RN [12,13]. RN is now largely considered an overtreatment for T1a (<4cm) RCC because it is associated with greater nephron loss and earlier onset of chronic kidney disease and also associated with increased cardiovascular events after RN [14,15].

Therefore, the current consensus is that RCC at stage T1a (<4 cm), should be treated with minimally invasive techniques in order to preserve renal function. Nephron sparing surgery (NSS) with either laparoscopic/open PN is advised whenever it is deemed technically possible [16]. Although, the NSS has similar recurrence free and long term survival outcomes as those with RN, NSS remains technically challenging and associated with significant morbidity even in expert hands [14,15].

Given the surgical challenges and the quest to preserve renal function, IGA treatment of the smaller RCC with radiofrequency ablation (RFA), cryoablation (CRYO) and microwave (MWA) has evolved rapidly over the last decade. Today, IGA of RCC has proven to be a safe and effective treatment option and good oncological outcome data is emerging for RFA [17-22] and CRYO [23,24]. In the hands of an experienced interventional oncologist, the primary technical success is now approaching >95% for both IGA with RFA and CRYO. As RFA was introduced earlier, the emerging larger RFA series have demonstrated cancer specific survival of 97-100% with a follow up of 61-78 months [17-22].

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## O21

### Complications following locoregional therapy of renal cancer

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Renal locoregional therapy or local ablation therapy, offers a valid solution for patients with small renal tumours that are not suitable surgical candidates.

Local ablation techniques are usually performed under imaging guidance and are minimal invasive. However, complications may occur even with this minimal invasive treatment.

The most frequent complication of ablation treatment is bleeding. Patients with renal cancer are often on antiplatelet or anticoagulant treatment for other reasons therefore at high risk of bleeding. The formation of a perirenal haematoma is reported in up to 30% from various authors [1-3]. Among the ablation methods cryotherapy appears to be leading to the formation of perirenal bleeding, probably due to the fact that a higher number of probes are usually required. Larger scale bleeding that would require transfusion and embolization is less frequent and is reported in up to 2% in various series [1,4]. Bleeding in such cases may be taking origin from the intercostal arteries or from the ablation site of the renal parenchyma. Bleeding may also be expressed in the form of haematuria in up to 2.5% of the cases particularly when central lesions are treated [5-7]. However, haematuria may be transitional and urine may clear up after 24-48 hours.

Further reported complications may be adjacent organ thermal injury, particularly of the colon, that is reported in up to 1% in the various series [8]. In such cases thermal injury perforation and peritonitis may occur. Hydrodissection with glucose for RFA or CO<sub>2</sub> dissection for cryoablation may prevent this complication.

Furthermore, thermal injury of the renal tract may occur and lead to the formation of a urinoma. Cold solution through an antegrade ureteric stent would protect the ureter from thermal injury when central lesions are treated.

Pain post treatment may also occur, however it is usually limited within the first two days. If persistent pain occurs then nerve injury needs to be suspected. Infection in up to 2% has been reported [9] however antibiotics are not routinely administered.

For the treatment of renal cancer surgical resection remains the standard treatment modality. Locoregional therapy has been frequently used to treat renal cancer in patients not suitable for surgical resection. This approach is minimally invasive, however it is not free of complications that need to be recognized and avoided.

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## O22

### Whole-body DWI in patients with lymphoma: imaging findings, pitfalls, and limitations

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Whole body (WB) imaging plays an essential role in the management of lymphoma patients, including defining the full extent of the disease at baseline, allowing for an accurate staging and therefore an adapted treatment strategy, assessing treatment response and detecting relapse. Contrast-enhanced computed tomography (CT) has long been the imaging technique most commonly used for staging and follow up of malignant lymphoma, using International Working Group (IWG) criteria [1]. However, CT lacks functional and metabolic information, compromising identification of disease in non-enlarged lymph nodes or other organs, as well as sufficient contrast in certain organs as for example the spleen or bone marrow. In 2007, IWG response criteria were revised, incorporating Positron Emission Tomography (PET) with 18-fluorodeoxyglucose (FDG) information [2], thus combining metabolic information and anatomical data of the CT resulting in a higher accuracy than the both imaging modalities taken separately [3].

Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) probes noninvasively the random microscopic motion of water molecules in the body, reflecting cellularity and cell membrane integrity. Because of their high cellularity and high nuclear-to-cytoplasm ratio, lymphomas have a lower apparent diffusion coefficient (ADC) than other tumors [4]. WB-DW-MRI allows both anatomical information, as well as functional and quantitative evaluation of tumor sites, thanks to the extraction of the

apparent diffusion coefficient (ADC). At staging, lymphoma lesions have low ADC value except necrotic areas.

Recent studies comparing whole-body DWI to PET-CT have demonstrated the potential role of whole-body DWI in routine lymphoma patient care but included only a small number of patients. Using the DWIBS technique (diffusion weighted imaging with background body signal suppression), Abdulqadhr et al. compared whole-body DWI and PET/CT at staging with an agreement in the Ann Arbor stage for 90.3% of patients [5]. Based on ADC analysis, Lin et al showed an agreement at baseline in 93% of patients [4]. Response assessment is necessary during therapy to readapt treatment strategy if necessary, and to document a complete remission at the end of treatment. After treatment, an increase in ADC value of residual masses has been demonstrated [6]. Recent technical breakthroughs in MRI technology such as echo-planar imaging (EPI), high gradient amplitudes, combined phased-array surface coils covering the patient, and parallel imaging, have drastically improved patient comfort and acceptance for whole body MRI [7,8], making this technique feasible in clinical routine, illustrating the need for radiologists to get familiar with this technique. As a result, WB-DW-MRI with ADC mapping has become a promising tool for lymphoma staging and re-staging, and response assessment.

Based on our 4-years experience with WB-DW-MRI applied in Hodgkin and diffuse large B-cell lymphoma patients together with 18FDG-PET/CT, our objective is to offer radiologists the information required to optimize acquisition whole body DWI parameters on both 1.5 and 3T MR systems. We will expose the spectrum of imaging findings and discuss the pitfalls, limitations, and potential challenges of WB-DW-MRI in caring for lymphoma patients.

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#### O23

##### FDG-PET in lymphoma

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FDG-PET has changed lymphoma management at staging and for response assessment due to its capability to improve disease characterization and treatment selection. New recommendations have been made by the ICML working group in 2014. FDG-PET is now recommended for staging in the vast majority of lymphoma since almost all types of lymphoma are FDG-avid. It has been shown recently that FDG-PET due to its high sensitivity for

bone marrow involvement in Hodgkin lymphoma can obviate the bone marrow biopsy. In addition FDG PET may be used to target biopsy and based on the local SUVmax to detect transformation.

For response assessment after treatment or during chemotherapy the HIP2007 criteria have now been replaced by the Deauville criteria using a 5-point scale. Initially proposed for the evaluation of interim PET these criteria are now extended for end treatment evaluation. The residual activity observed after treatment is scored against different levels of background i.e: 1.no uptake, 2. uptake uptake  $\leq$  mediastinum but  $\leq$  liver, 3. uptake  $>$  mediastinum, 4. uptake moderately higher than liver, 5. uptake markedly higher than liver and/or new lesions. A score 4 has been chosen as the threshold for positivity both at interim and end treatment. The value of this choice has been demonstrated in validation studies. Using these criteria FDG PET has demonstrated its prognostic value early in the course of the treatment or at end treatment in Hodgkin lymphoma, Diffuse large B cell lymphoma and Follicular Lymphoma. A tailored therapy based on interim PET is under study in many ongoing trials but at the present time it is not recommended to change therapy on the basis of the results of an interim FDG-PET. Quantitative analysis of metabolic volume at staging or  $\Delta$  SUVmax response assessment and their prognostic values and various trends in the future will be discussed.

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#### O24

##### Management of solid and sub-solid lung nodules

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**Introduction:** Pulmonary nodules present a unique challenge for radiologists which includes the detection of malignancy and identification of benign disease, recommending the appropriate procedures to avoid unnecessary thoracotomy, and ensuring that excessive radiation from follow-up computed tomography (CT) examinations is kept to a minimum. Although seasoned radiologists can use an approach based on their extensive experience, in this era of evidence-based medicine, guidelines have been established that include both radiologic and clinical factors in an integrated fashion. Such guidelines have been developed by the Fleischner Society, first in 2005, for the management of small pulmonary nodules detected on CT scans, and then, in 2013, for the management of sub-solid nodules [1].

For incidentally detected solitary nodules, these guidelines integrate elements as individual risk factors (via pre-test probability), with lesion size, growth rate, and morphology, based on imaging characteristics. Relevant risk factors to consider in the evaluation of pulmonary nodules are smoking history and patient age. Patients with a substantial smoking history and over 40 years of age are defined as high-risk patients, whereas low-risk patients are those with a negligible smoking history and no other known risk factors, and who are below 40 years of age.

Based on the Fleischner Society recommendation [1], lesions less than 4 mm do not require any further invasive or non-invasive measures or evaluations. However, lesions with a diameter of more than 8mm should be evaluated with either follow-up CT scans, including dynamic, contrast-enhanced scans, positron emission tomography (PET)-CT, and biopsy. For lesions that fall between the 4 mm and 8 mm size, CT follow-up with a limited number of scans is recommended.

Sub-solid nodules are often found during screening studies or incidentally on CT scans. They are characterized by their appearance as rounded areas of increased attenuation, and a homogeneous or heterogeneous texture. Sub-solid nodules can be subdivided according to their composition: non-solid lesions that consist of ground-glass opacity only; and part solid lesions that contain both ground-glass and soft tissue elements.

Sub-solid nodules can regress, persist, or grow. Small persistent non-solid nodules are often atypical adenomatous hyperplasia (AAH) and focal fibrosis, whereas non-solid and part-solid nodules that increase in size typically indicate malignancy, which can include adenocarcinoma in situ (AIS), minimally invasive adenocarcinoma (MIA), and invasive adenocarcinoma, as well as lympho-proliferative disease. How these lesions develop has not been entirely elucidated as yet, but it seems that a small percentage of ground-glass opacities (AAH) develop into larger lesions that can eventually comprise solid components due to invasion and alveolar collapse [2]. In any case, radiologically, an increase in lesion density, growth, or the development of solid portions are all indicative of malignancy.

CT analysis and surveillance of sub-solid nodules is the modality of choice for the identification of malignant lesions. The primary factor is nodule size. While lesions less than 5 mm in diameter are usually AAHs, lesions greater than 15 mm in size are malignant, and are typically MIAs and invasive adenocarcinomas. Generally, a diameter of more than 8 mm is indicative of malignancy. Another important indicator of malignancy is lesion growth. The growth of the lesion may affect either the ground-glass or the solid components, or both. Volume doubling times of AIS and MIAs are much longer, compared to invasive adenocarcinomas and squamous cell lesions. Morphologically, the presence of lobulated borders, air bronchograms and bubble-like lucencies, and the development of solid portions in pure ground-glass abnormalities are all indicative of malignancy. Lesion morphology is closely related to prognosis. Nodules with an increasing percentage of solid components represent a poorer prognosis, but, for patients with pure ground-glass abnormalities or those with only a small area of a solid component, the survival rate after lesion resection is 100%.

The Fleischner Society management guidelines [2] for sub-solid lesions recommend that part solid nodules, especially those that persist or grow in size, mandate further evaluation and monitoring, and typically, require surgical resection. Smaller lesions, with a negligible area of solid components, can be managed with follow-up CT scans.

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#### O25

##### Session: Evaluation of lung nodules: role of PET/CT

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Computed Tomographic (CT) screening for lung cancer remains controversial, although the National Lung Screening Trial (NLST) found that low dose CT (LDCT) reduced lung cancer mortality by about 20% [1], the high rate of indeterminate and false positive lung nodules was worrying.

The diagnostic work-up of CT nodules considers size (diameter or volume), characteristics (density, morphology, homogeneity) and volume doubling time (VDT), but several studies have investigated the ability of positron emission tomography (PET) to characterize nodules, although its role in diagnostic algorithms for screening-detected nodules has not been defined.

The first PET study with [<sup>18</sup>F]fluorodeoxyglucose to characterize indeterminate nodules outside screening was published in 2001 [2]. In a previous study on PET-CT at baseline screening, we found an overall sensitivity of 88% for diagnosing malignancy, while for solid nodules >10 mm, sensitivity was 100%, suggesting PET-CT as an alternative to invasive procedures in the screening setting [3]. When assessing the ability of PET-CT to diagnose indeterminate nodules detected during the subsequent years of the screening and analyzing 383 PET-CT examinations performed over 6 study years of screening, the sensitivity, specificity and accuracy of visually evaluated PET-CT, in distinguishing benign from malignant nodules, were 64%, 89% and 76% respectively. PET performance varied with nodule

diameter (accuracy increased from 70% for nodules <10 mm to 82% for nodules ≥15 mm) and nodule type (accuracy ranged from 88% for solid nodules to 46% for non-solid nodules).

We do not use FNAB routinely in our screening protocol. Typically we proceed to surgery when nodule characteristics, including VDT, often backed up by PET-CT, indicate malignancy. The disadvantage is that a preoperative pathological diagnosis is not available and a wedge resection with frozen section examination is required before radical surgery.

Nodules on PET-CT are commonly evaluated by semi-quantitative SUV<sub>max</sub>, which is operator independent, as well as by visual assessment of uptake by the nuclear medicine physician, whose experience can markedly influence the result. In our study we evaluated both methods and found visual assessment afforded higher accuracy (76%) than any SUV threshold with a good compromise between sensitivity (64%) and specificity (89%); while increasing the threshold from 1.5 to 2.5 decreased sensitivity (67% to 51%) and increased specificity (80% to 91%).

To conclude, PET-CT has high NPV for solid nodules ≥15 mm, and high PPV for sub-solid nodules <10 mm, justifying its inclusion in the diagnostic work-up of indeterminate nodules identified on LDCT screening. It is more useful for nodules detected at baseline, while sensitivity is low for sub-solid nodules and nodules discovered after baseline: for these other diagnostic modalities, particularly VDT, are more useful.

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#### O26

##### Characterization and management of cystic pancreatic neoplasms communicating lesions (IPMN)

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**Introduction:** Intraductal papillary mucinous neoplasms (IPMNs) are a group of exocrine mucin-producing tumors, diagnosed at a mean age of 60 years, with a male prevalence [1].

Improvements in imaging techniques have led to an increasing incidental detection of IPMNs: the prevalence of incidental cystic pancreatic lesions can be observed in up to 19.6% of imaging studies [2].

Three types of IPMNs have been described [1]: the main duct type; the branch-duct type and the mixed type, which meet the criteria for both MD-IPMN and BD-IPMN, with significant differences in frequencies of malignancy in IPMNs according to the morphological types, higher for MD-type (mean 61.6%) and lower for BD-type (25.5%)(3).

**Imaging-pathologic correlations: Pathologic features:** IPMNs appear with a cystic dilation of the involved segment, either main duct and branch duct. Some findings can be suggestive of the behavior of the IPMN, according to the presence of high risk stigmata or worrisome features [3].

High risk stigmata suggest the high possibility that the lesion is malignant, thus requiring resection if the patient is surgically fit: main duct diameter > 10 mm for MD-IPMN, the presence of solid enhancing nodules within the cyst in BD-IPMN, or obstructive jaundice in presence of a cystic lesion of the pancreatic head.

Worrisome features suggest the possibility that the lesion could evolve as malignant, thus requiring further workup by EUS, to better risk-stratify the lesion, and a strict follow-up: cyst > 3 cm, thickened enhanced cyst walls, MPD size of 5-9 mm, non-enhancing mural nodules, abrupt change in the MPD caliber with distal pancreatic atrophy, and lymphadenopathy.

**Imaging features:** MR with MRCP has the highest capacity to assess the presence of communication with main pancreatic duct, with a sensitivity of 91.4-100% [4].

The proliferating nodule is characterized by the capacity to enhance after contrast media administration, which can be appreciated with all imaging technique (CEUS; CT; MRI), after administration of contrast media.

In case of IPMN, MDCT has a sensitivity of 70% in the diagnosis of benignity vs malignancy according to some worrisome features (nodules, main pancreatic duct > 10 mm, thick septa, calcifications) [5].

MR with MRCP has a sensitivity, specificity and accuracy of 70%, 92% and 80%, respectively in the diagnosis of benignity vs malignancy according to some worrisome features (nodules, main pancreatic duct > 10 mm, thick septa, calcifications)[5].

**Management:** International consensus guidelines [3] recommend resection in presence of high-risk stigmata, while in presence of "worrisome features" the lesion should be evaluated by EUS to further risk-stratify the lesion. Age, status of the patient can have influence on the decision management.

**Conclusions:** Age, clinical, laboratory and imaging findings are accurate in stratifying these lesions, and imaging plays a pivotal role in their management.

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#### O27

##### Noncommunicating cystic pancreatic lesions (i.e. serous and mucinous cystadenoma + rare lesions)

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**Mucinous cystic neoplasm (MCN)** occurs predominantly in women (>95%) with a mean age of approximately 45 years and most commonly is located in the pancreatic body or tail. The mass is lined by mucin-producing columnar epithelium with a fibrous ovarian-type stroma. The epithelial lining can contain various degrees of atypia, ranging from adenoma to invasive carcinoma. The CT and MR appearance is that of a thick walled cystic mass with septa and/or mural nodules. The contour of the mass is smooth, and the wall or septa may contain calcification. Endoscopic ultrasound with fine needle aspiration of the cyst fluid to assess CEA level may be helpful in distinguishing MCN from serous cystadenoma. CEA <5 ng/mL favors serous cystadenoma, whereas CEA >192 ng/mL favors MCN, with an accuracy of approximately 80% [1]. The overall risk of malignancy in one series was 17.5%, and all malignant tumors were either >4 cm or contained mural nodules [2]. Treatment of MCN is surgical resection, and patients without extracapsular or diffuse intracapsular infiltration have an excellent prognosis [2].

**Serous cystadenoma (SCA)** also occurs predominantly in women (approximately 75%), but the mean age is older (mid 50s to early 60s). It is lined by glycogen-rich cuboidal epithelium and is considered a benign neoplasm, although rare cases of malignant SCA have been reported. The typical appearance is that of a lobulated mass consisting of numerous tiny cysts which give it a honeycomb appearance. Larger lesions may contain a central stellate scar and calcifications. Oligocystic or macrocystic SCA is an uncommon variant comprised of a small number of larger

cysts. Distinction between macrocystic SCA and MCN can be made based on the lobulated contour of SCA, its multiple clustered cyst configuration and homogeneity of each locule on T1 weighted MR images [3]. Surgical resection generally is reserved for symptomatic patients, although some authors recommend periodic imaging to assess the rate of growth, with consideration given to surgical resection of lesions with doubling time of <6 years [4].

**Solid pseudopapillary neoplasm (SPN)** is a rare low-grade malignancy that predominantly affects younger women (>80%), with a median age 30-38 years [5,6]. It is not a true cystic neoplasm in that the cystic component lacks an epithelial lining. Rather, the cystic component represents necrotic degeneration of the mass, with various amounts of internal blood and debris. SPN appears as a well-circumscribed round or oval thick-walled mass with solid and cystic components, but it can appear completely solid or completely cystic. CT demonstrates calcification in nearly half of SPNs [6]. MR often demonstrates a thick T2 hypointense or enhancing rim and internal blood products. Treatment is surgical resection, and the prognosis is excellent, with metastases developing in <5% of patients [6]. **Cystic neuroendocrine neoplasm** of the pancreas most commonly occurs in patients with multiple endocrine neoplasia type I and usually is nonfunctional [7]. It generally appears as a cystic mass with an enhancing rim and may contain septa or a solid component. Treatment usually is surgical resection, although observation may be a viable alternative approach [8].

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#### O28

##### Imaging neuroendocrine tumours of the pancreas: role of CT and MRI

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Pancreatic neuroendocrine tumours (pNETs) are a part of a heterogeneous group of tumors, neuroendocrine gastroenteropancreatic tumors (GEP-NETs), with their origin in neuroendocrine cells of the embryological gut. Most commonly, primary lesions are located in gastric mucosa, small and large intestine, rectum and pancreas. The overall incidence of all GEP-NETs has increased over the past decade, with pNET incidence of 0.32/100 000/year. Patients with multiple endocrine neoplasia type 1 (MEN-1) or von Hippel-Lindau's disease (VHL), have pNETs 15–20 years earlier than patients with sporadic pNETs [1].

CT and MRI are typically the first line imaging modalities of choice in the evaluation of most patients with suspected pNETs. The role of cross

sectional imaging is complementary to somatostatin receptor based imaging and PET CT. CT and MRI are essential in the detection of primary tumours, which is challenging in small secretory insulinomas and gastrinomas. Meticulous care must be taken in cross sectional imaging technique to maximize the sensitivity for detection of the small and frequently multiple lesions. CT imaging should include triphasic imaging. No one sequence detects all pNETS on MRI and multiple sequences including T1, T2, fat saturated images are required. Over the last few years the use of diffusion weighted imaging (DWI) has also improved primary lesion detection in the pancreas [2] and detection of small metastatic liver and bone lesions.

Surgery is the only curative treatment for pNETS. The role of CT and MRI also extends to staging and planning surgical resection. Excellent anatomical detail can be accurately provided with CT and multi-planar and thin section imaging. The staging for pNETS is based on recommendations from European Neuroendocrine Tumour Society [3] and WHO staging which will be outlined with imaging and pathological illustrations.

Larger pNETS, usually have low or no secretory activity and characteristic features on CT and MRI, which provide an indication to their histopathology. Punctate calcifications, lack of biliary obstruction and vascular invasion despite large tumour volume are features that allow the radiologist to make the initial working diagnosis of a pNET. In these patients the role of imaging is to provide tissue diagnosis and staging by biopsy, assess tumour bulk, detect distant metastases and assess disease response following therapy. A large number, close to 50%, of non-secretory pNETS present with distant disease. These are offered radiolabelled therapies but increasingly radiological embolization techniques and radiofrequency is available for local control. Targeted therapies with vascular endothelial growth factor receptor-tyrosine kinase inhibitor (VEGFR-TKI), Sunitinib and the mammalian target of rapamycin (mTOR) inhibitor, Everolimus for medical management of locally advanced and metastatic disease sees the role of CT and MRI now extending to evaluation of disease response in phase II and III trials. The imaging techniques again require scan phase precision and consistency to ensure accuracy for tumour response assessment which is based on RECIST criteria.

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#### O29

##### Role of molecular imaging in the detection of neuroendocrine tumour

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Neuroendocrine tumours (NETs) have distinct biological and clinical characteristics, in particular a high density of somatostatin receptors at the cell membrane [1]. It is this property that allows the use of radiolabelled somatostatin analogues for imaging of these tumours. Importantly, somatostatin receptor PET/CT imaging (e.g. <sup>68</sup>Ga-DOTATOC, <sup>68</sup>Ga-DOTATATE, <sup>68</sup>Ga-DOTANOC) is superior to somatostatin receptor scintigraphy including SPECT/CT [2] and <sup>18</sup>F-DOPA PET/CT [3] in the detection of gastroenteropancreatic neuroendocrine tumours (GEP NETs).

NETs, however, have a wide range of cellular differentiation. <sup>18</sup>F-FDG PET/CT is of limited value in well-differentiated NETs but of high value in poorly differentiated NETs. Somatostatin receptor PET/CT shows contrary results [4]. As both <sup>18</sup>F-FDG PET/CT and somatostatin receptor PET/CT exploit distinct tumour characteristics they are complementary for tumour staging.

Small insulinomas are difficult to detect with <sup>18</sup>F-FDG PET/CT, somatostatin receptor PET/CT, <sup>18</sup>F-DOPA PET/CT and morphological

imaging. Targeting of Glucagon-like peptide-1 receptors using radiolabelled exendin-4 has shown to be highly effective in the detection of these tumours [5].

Clinical studies have shown higher tumour uptake of radiolabelled somatostatin receptor antagonists than somatostatin receptor agonists [6]. As a result radiolabelled somatostatin receptor antagonists may have a significant impact on imaging of NETs.

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#### O30

##### Cancer imaging in the era of precision treatment: present and future

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The landscape of cancer imaging is being shaped by advances in oncological treatment. As the genetic and molecular aberration of cancers and cancer subtypes are being elucidated, specific cellular pathways and associated molecular receptors are recognized as potential pharmacological targets to modify or arrest cancer growth. In the past two decades, such targeted therapies are being developed and are progressively being introduced into the clinics. Broadly, they include monoclonal antibodies (-abs) targeted against circulating molecules or membrane receptors; and small molecules (-ibs) which act intracellularly on biochemical pathways.

A number of molecular targets have been identified in the past decade in a range of tumours (including prostate, gastrointestinal stromal, colorectal, melanoma, chronic myeloid leukaemia, renal, lymphoma and myeloma) for which there are now approved and effective drugs directed at specific molecular receptors or cellular pathways. Many of these act by inhibiting signal transduction, blocking the signal between receptor activation and cellular proliferation; while others modify signalling proteins that regulate cellular functions. Another common mode of action is inhibiting neovascularization (antiangiogenic or antivascular), which in turn arrests tumour growth. There are also tumour vaccines and immunotherapies which stimulate cytotoxic response to cancer cells.

Although target therapies have been employed with varying success in cancers, the complexity of tumour escape pathways and the recognition that monotherapy alone may not be effective, means that it has not been possible to fully individualise treatment for patients. This remains the ultimate goal of cancer management. However, accurate genetic and molecular tumour profiling is already helping to identify tumour subgroups enabling more precise treatment to be prescribed.

Precision treatment aims to give the right drug (or combination of drugs) to the right patient at the right time to optimise tumour cell kill and minimise drug toxicity. In a wider context, precision treatment is also evolving in surgery and radiotherapy. The advent of robotic surgery allows more precise control of surgical dissection in some anatomical areas. In radiotherapy, the evolution from simple external beam treatment to state-of-the-art stereotactic body radiotherapy and cyberknife treatment means that

high-dose or hypo-fractionated radiation can be delivered precisely to small target volumes thereby maximizing cell kill and reducing peri-tumoural complications.

Cancer imaging remains at the heart of this approach, as precision treatment mandates precision imaging. In the era of targeted therapy and precision treatment, cancer imaging aims to accurately depict disease burden, provide the roadmap for treatment planning, enable novel assessment of treatment response and yield prognostic information. Although conventional imaging remains important; molecular, functional and hybrid/multiplex imaging are being developed and utilised.

The depiction of disease sites and metastatic burden has implications for disease staging and prognostication. Body diffusion-weighted MRI (DWI) is now widely used as a contrast mechanism to improve disease detection at initial diagnosis and at disease relapse; especially for liver, peritoneal and bone metastases. State-of-the-art high spatial resolution CT and MRI provide detailed anatomical roadmaps for surgical and radiotherapy planning. The deployment of functional and molecular imaging yield additional biological information that can be used to define biological target volumes for precise radiotherapy planning. The portfolio of current imaging techniques also enables us to observe treatment induced changes or complications; and advance our knowledge in the effects of radiation, cytotoxic and targeted therapies on normal tissues.

As many targeted treatments may be effective without significant tumour shrinkage, conventional size-based measurement criteria are often inadequate for determining treatment effectiveness. Not surprisingly, quantitative CT, MRI and radiotracer techniques are being used to provide objective measurements of tumour properties such as tumour perfusion, water diffusion, metabolism, hypoxia, cellular proliferation and cell death. As these techniques become standardised and more widely adopted, they can provide both unique and corroborative information about tumour behaviour.

Nonetheless, there are significant challenges and opportunities ahead. First, better understanding of heterogeneity within and between tumours remains an unmet need. Repeated lines of treatment result in differential tumour clonal evolution, leading to sub-fractions of tumour cells which become refractory to treatment. A better understand of the onset and nature of resistant phenotypes is likely to contribute to the design of more effective future treatment regimes. Second, there is a huge opportunity to develop multiplex imaging on hybrid imaging systems (e.g. PET-MRI) to improve our understanding of intra- and inter-tumour variations, and the identification of imaging phenotypes associated with treatment resistance and poor prognosis. Such information can be combined with genomics and other molecular profiles on a common informatics platform to provide a rich matrix for data mining and hypothesis testing. Third, more translational research using human analogous animal models, where available, would make a significant contribution to the understanding of the disease and treatment by providing histological and molecular validation for both mechanistic and therapeutic drug studies. Fourth, it is necessary to align future workforce and imaging practices between the historical domains of radiology and nuclear medicine. The development of an integrated research and service strategy between these disciplines would be critical for the future success of multimodal multiplex imaging. Last but not least, in an age where imaging sciences are being increasingly commoditized, it is important for imaging specialists to add value by active engagement in clinical decision-making and management discussions, so that our practice remains current and relevant to the rapidly changing oncological practice.

### O31

#### Whole-body MRI and diffusion MRI

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Metastatic bone disease is a common manifestation of advanced cancers with a very high prevalence in breast, prostate and lung cancers. In order to effectively manage patients with metastatic bony disease it is essential to have consistent, reproducible and validated methods for detecting and assessing the response to therapy. In response assessments, confident categorization of response is needed to enable therapeutic strategies to be tailored to individual patient's benefit. Commonly used methods such as

x-rays, bone and CT scans do not always enable the positive assessment of therapeutic benefit to be made but instead provide an evaluation of progression, which then guides therapy decisions in the clinic.

Whole body MRI incorporating DW imaging (WB-DWI) has emerged as a promising bone marrow assessment tool [1] for detection [2,3] and therapy monitoring of bone metastases [4]. On WB-DWI, lytic/infiltrative skeletal metastases appear as focal or diffuse areas of high-signal intensity on high b-values on a background of lower signal intensity of the normal bone marrow [4,5]. Metastasis detection with DWI should be done with anatomical MRI [1,4,5]; a recent meta-analysis demonstrated high sensitivity of WB-DWI to detect metastases at the expense of specificity [2]. Causes for false-positive findings on WB-DWI include bone marrow oedema, vertebral haemangioma, isolated bone marrow islands and bone marrow hyperplasia. False-negative findings occur when there are low levels of bone marrow infiltration or when background bone marrow hyperplasia obscures metastases. Detection of skeletal metastases may be impaired in areas of body movement and the visibility of skull base infiltrations is impaired because of the adjacent high signal of the brain. False-negative findings also include treated malignant disease and sclerotic deposits. WB-DWI when combined with emerging "wet" biomarkers can improve the classification of therapy response in patients with metastatic bone disease. Both high b-value image signal intensity and ADC value changes are needed for therapeutic assessments [4,5]. A range of imaging findings can be seen depending on the type of therapy and duration of treatment [4]. Morphologic and diffusion MRI therapy response criteria need to be tested in prospective studies in order to address current, unmet clinical and pharmaceutical needs for reliable measures of tumor response in metastatic bone disease [5].

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### O32

#### Hybrid imaging with PET/CT and PET/MR

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Hybrid PET/MRI systems have recently become commercially available with potential to change medical imaging by providing combined anatomical-metabolic image information. Especially in cancer patients, this may be of benefit.

PET itself is widely used in everyday routine due to its capability of providing molecular information used mainly for the non-invasive characterization of tumors and metastases [1,2], as well as for monitoring effect of cancer therapy [3]. However, PET images contain no detailed anatomical information and, therefore benefits from fusion with morphological image information from CT. Accordingly, since PET/CT systems became available oncological PET examinations have mainly been performed as combined PET/CT which has been proven of higher diagnostic value than separate PET or CT imaging in a number of clinical indications [4]. Recently, hybrid PET/MRI scanners were introduced and made available. However, PET/MRI is more costly and with a lower throughput than PET/CT. Accordingly, the question arises when and if PET/MRI should be used in cancer patients. MRI has the advantages compared to CT, that it may also be considered a

functional imaging technique in addition to its anatomical capabilities. This may be of particular relevance in cancer patients in view of need for planning tailored therapy and for monitoring response to treatment [5,6]. Compared to CT, also the anatomical capabilities of MRI are often superior due to better soft-tissue contrast.

The knowledge obtained from molecular imaging-guided therapies e.g. using FDG-PET for predicting therapy response in lymphomas [7], could quickly be transferred to PET/MRI, for a combined multi-parametric strategy. Accordingly, hybrid PET/MRI scanners might become game-changers for how MRI is used in clinical routine.

At the Department of Clinical Physiology, Nuclear Medicine & PET at Rigshospitalet in Copenhagen we have currently PET/MRI scanned more than 1,200 patients and our experience so far will be presented and discussed with focus on whether PET/MRI fulfills a real clinical need within oncology or should (still) be considered an expensive research tool and the challenges of PET/MRI [8,9].

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#### O33

##### Beyond the image : sense and non-sense in imaging biomarkers

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A biomarker or biological marker is defined as an indicator of a biological state or existence in the past of a particular type of organism. Biomarkers are *objectively measured and evaluated* as indicators of normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention. Over the last two decades such biomarkers have been developed in many fields of medicine : such as in cell biology where a molecule is used as a biomarker to detect and isolate a particular cell type, in genetics where a DNA sequence is associated with the cause of or susceptibility to a disease, in pharmacology where biomarkers provide a molecular impression of a biological system (cell, animal or human) such as a blood PSA protein as an indicator of prostate cancer or blood cholesterol as a risk indicator of vascular disease etc. A recent analysis on biomarker innovation shows a huge gap between the discovery of biomarkers on one hand and the development into diagnostic application on the other. Very few biomarkers progress after initial discovery and publication to clinical validation, confirmation and at the end diagnostic application due to many

complex factors such as limited confirmation of initial findings by other laboratories, rare quantitative clinical validation of biomarkers by single test and multi laboratory research and very limited progress of validated biomarker to applicable molecular diagnostic tests. In pharmacology a biomarker definition working group was initiated in 2001. Ten years later several initiatives to further develop uniformity in terminology, data acquisition, data processing and post processing etc have been integrated in the QIBA group which works its way through this enormous field of developing Imaging biomarkers [1]. An Imaging Biomarker can be defined as a single quantitative unit acquired by an imaging modality and expressing morphology or function of a cell, tissue or organ, which objectively measured and evaluated as a prognostic indicator of normal, physiological and pathogenic processes. This definition should be distinguished from an image phenotype which is a set of multiple acquired quantitative measurements obtained from digital imaging data as parameters for personalized characterization of the subject examined. An imaging biomarker should be accurate, reproducible, objective, quantitative, standardizable and robust. For successful implementation an imaging biomarker has to be fast applicable, widely available and cheap. Furthermore an imaging biomarker should deliver a single parameter on which clinical decisions can be taken. In this manner imaging biomarkers can be directly compared to other non imaging biomarkers in any diagnostic management algorithm. For imaging biomarkers there is the same long development road as for non-imaging biomarkers with the same huge innovation gap. Many candidates but very few which reach the maturity to clinical application. Each imaging modality has its specific strengths and weaknesses from which in a further analysis the candidates with the best chances can be deducted and selected for further development to clinical implementation. Only in systematic development pathways this goal can be reached and imaging can come to another era beyond the image.

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#### O34

##### PET / MR as tool for "precision medicine"

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With the advent of multimodality imaging, molecular information by tracer techniques can be combined with high resolution structural and functional imaging by MRI. Specific tracers address biological processes of the oncogenic process, which allow not only early detection of malignant tissue, but may also provide prognostic information of oncological diseases. Most importantly, imaging biomarkers can be used to select patients for a given therapy (companion diagnostics) and to monitor response in order to optimize therapeutic strategies tailored to the needs of the individual patient. Examples of new molecular tracers are Gallium-68 labeled peptides targeting integrins, ligands of the chemokine CXCR4 and somatostatin receptors. These tracers do not only address cell surface proteins (receptors), but also the interaction of cells as well as cell migration, which have been linked to angiogenesis and metastasis. Since FDG is not very useful in patients with prostate cancer, the recent introduction of Gallium-68-PSMA has added excellent diagnostic sensitivity and specificity for PET diagnosis of prostate cancer, especially in patients with recurrent disease. The combination of molecular targeting of prostate cancer with measurements of regional perfusion (DCE) and cellularity (DWI) provided by MRI offers a comprehensive and innovative multimodality diagnostic approach. Regional phenotyping of malignant tissue addresses the spatial as well as dynamic heterogeneity of cancer, which may provide unique insights into mechanisms of therapeutic response and resistance. It can be hypothesized, that multimodality molecular imaging and radionuclide therapy will be an important part of the emerging concepts of "theranostics" and further strengthen the role of Nuclear Medicine in precision medicine evaluating cancer patients.

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### O35

#### Response assessment in daily practice: RECIST and its modifications

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Response Evaluation Criteria for Solid Tumours (RECIST) were introduced in 2000 to provide a standardized method for assessing response to treatments in the clinical trial setting [1]. The RECIST Working Group has updated RECIST to version 1.1 [2]. The revised version has maintained assessment of tumour burden using sum of the diameters and continues to use uni-dimensional measurements. The response categories are still those of complete response, partial response (30% decrease in sum from baseline), stable disease and progressive disease (20% increase in sum from nadir). The revision addressed issues that had arisen related to the use of the criteria in practice.

Though the RECIST criteria are intended for use in the clinical trial setting, oncologists increasingly rely on RECIST based measurements to make clinical management and therapeutic decisions in daily clinical practice. The reasons for this include the clinician's application of trial data into routine clinical practice but most importantly RECIST offers a simple way of measuring and communicating response assessment. The terms such as measurable disease, tumour burden, target lesions, and response categories are now used and understood universally. RECIST criteria also provide guidance on technique as well as measuring lesions and application to assessing sites of disease, eg lymph node and bones. This allows for a more robust and reproducible way of gauging response. The limitations of RECIST are also well known thereby allowing the clinician to understand the pitfalls in those cases. Therefore the radiologist has to understand and use "RECIST" in their daily practice.

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### O36

#### Imaging tumour response: beyond RECIST

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One of the most widely employed quantitative measurements for assessing tumour response to treatment is the tumour diameter (RECIST criteria), usually determined on cross-sectional CT or MRI. This simple measurement is relatively reproducible and reduction in the maximum tumour diameter by 30% or more following therapy is taken as a sign of effective treatment. However, new targeted therapies may be effective without significantly reducing tumour size and other quantitative response criteria are being evaluated.

Some of the response criteria being evaluated combine tumour diameter measurement with other quantitative assessment (e.g. CT density). These have been applied towards the evaluation of gastrointestinal stromal tumours (CHOI criteria) and renal cell carcinoma (modified or revised CHOI criteria) undergoing multi-kinase inhibitor treatment; and hepatocellular carcinoma (modified RECIST criteria) treated with novel therapeutics or chemoembolization. In these clinical settings, the applications of such criteria for tumour response assessment have shown better correlation with clinical outcome compared with conventional RECIST criteria. When immunotherapy is administered, conventional RECIST criteria may erroneously ascribe the appearance of new lesions to disease progression; whereas this phenomenon is given due consideration within the immune-related response criteria (irRC).

As quantitative imaging becomes increasingly important in oncology, quantitative indices are being applied and developed in CT, MRI and PET imaging for tumour response assessment. Using perfusion CT technique, the change in CT attenuation value with time resulting from the passage of

contrast through tissue can be used to calculate quantitative vascular parameters such as permeability surface area product (PS), blood flow (F) and mean transit time (MTT). Using dual energy CT, it is possible to obtain quantitative iodine contrast distribution in soft tissue.

MRI is a powerful multiplex imaging technique because depending on how the scans are performed, it can yield different quantitative information. Two of the most widely employed quantitative techniques for tumour assessment are dynamic contrast enhanced MRI (DCE-MRI) and diffusion-weighted MRI (DW-MRI). The former has been used in early phase trials for the assessment of antivascular/ antiangiogenic therapies. The latter has shown potential as an early response biomarker to a range of effective treatments including chemotherapy, radiotherapy, chemoembolization treatment and novel therapeutics. Other clinical MR techniques include intrinsic susceptible contrast imaging and magnetic resonance spectroscopy (MRS). However, these have currently limited value for assessing tumour response to treatment.

PET imaging using <sup>18</sup>F-DG tracer enables the semi-quantitative standardised uptake value (SUV) to be derived. PET imaging is increasingly utilized for tumour response assessment, and forms the basis of standard criteria for assessment of tumour response in lymphoma. By performing dynamic imaging, it is also possible to calculate the quantitative tracer uptake in tissues. The strength of PET imaging is the range of radiolabelled tracers that are now available clinically to probe a range of tissue properties.

In early phase trials, quantitative imaging other than tumour size measurements using CT, MRI or PET can provide mechanistic information about drug action, and also therapeutic effects on specific aspects of tumour biology (e.g. vascularity, cellularity). By using multimodality imaging, there is also an opportunity to corroborate imaging measurements made using one technique with another. However, quantitative techniques require a process of quality control and quality assurance; as well as knowledge of their measurement reproducibility so that they can be applied with confidence in clinical practice.

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### O37

#### Abdominal and pelvic complications of molecular targeted therapy

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Traditional chemotherapy is cytotoxic in nature and acts primarily by eliminating neoplastic cells. Change in tumor size, which is an indicator of change in the number of neoplastic cells, evolved into the radiologic biomarker of treatment response. The infectious, inflammatory, hemorrhagic and neoplastic complications of these therapies have been well described. Significant advances in molecular cytogenetics has led to the development of molecular targeted therapy which selectively acts on tumor cells and modifies their biologic characteristics, by affecting various cellular targets: growth factor receptors, signaling molecules, cell-cycle proteins, molecules that direct apoptosis and angiogenesis. This has required new means of assessing tumor response to therapy. Additionally, a variety of expected and unusual complications can develop in the abdomen and pelvis in these patients. This presentation highlights the imaging features of these complications which may be confusing both radiologically and clinically.

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### O38

#### Lung, CNS and musculo-skeletal targeted therapy-induced toxicity: imaging features

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By focusing on molecular and cellular changes that are up regulated in cancer, targeted agents may have less severe side effects compared with conventional chemotherapy. However, many of these signaling pathways

also exist in healthy cells and targeted therapies can therefore result in specific complications [1-3].

The spectrum of toxicity encountered with the targeted agents includes fatigue, skin rash and mucositis, eye, cardiac and muscle toxicity, drug-induced interstitial lung disease (DILD), posterior reversible encephalopathy syndrome (PRES) and a wide spectrum of gastrointestinal complications. Nephrotoxic effects such as proteinuria, nephrotic syndrome or hypertension are also seen with agents such as VEGFR or mTOR inhibitors.

The DILD imaging appearances encompass a range of patterns including nonspecific ground-glass opacity with and without interlobular septal thickening, multifocal consolidations with or without traction bronchiectasis, flitting subcentimetre nodules with or without ground glass halo, bronchiolitis and pulmonary fibrosis or pleural effusions [4]. Acute respiratory distress syndrome (ARDS) has also been described. The EGFR inhibitors related DILD is an important challenge for their use in lung carcinoma especially in patients with preexisting pulmonary fibrosis. Up to one-sixth of patients taking mammalian target of rapamycin (mTOR) inhibitors get a reversible interstitial pneumonitis [5].

Posterior reversible encephalopathy syndrome (PRES) is an uncommon complication (incidence < 0.1%) of VEGF/VEGFR pathway therapy. Most patients recover fully with discontinuation of the causative agent and supportive management of hypertension and seizures [6]. Intra-cerebral bleeding has also been described with anti-VEGF agents, especially in tumours with a strong hemorrhagic tendency, such as renal-cell carcinoma. On imaging, there is usually symmetrical vasogenic oedema in the occipital and parietal regions. However, PRES can be found in a non-posterior distribution, occurring at watershed areas of vascular territories, including the frontal, inferior temporal, cerebellar and brainstem areas.

Increases of creatine kinase (CK) are amongst the most common grade 3-4 toxicity treatment-related adverse events of the Mitogen-activated protein kinase (MEK) inhibitors, although most patients are asymptomatic. Symptoms of CK increase include muscle weakness and myalgia. The true significance especially of asymptomatic CK increases is still unknown. An association between CK elevation and skin rash of novel targeted agents in phase I trials, possibly due to increased CK-BB (brain and skin) expression of keratinocytes was reported by Moreno Garcia et al [7].

With the continuous increase in the use of anti-cancer targeted therapies, it is important for the radiologist to be familiar with the clinical and treatment history and associated complications that may occur, in order to accurately identify drug-related complications and differentiate them from disease progression.

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#### 039

##### Comprehensive breast MRI: an update

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With increasing use of clinical breast MRI and a plethora of novel techniques and sequences for lesion characterisation, a standardised approach to lesion description and reporting is increasingly important. This facilitates meaningful research and audit, particularly in the context of multicentre studies.

To this end the American College of Radiology has recently published the 5<sup>th</sup> edition of the BI-RADS lexicon, with revision of the MRI section including addition of new descriptors, modification of others and deletion of some that were rarely helpful in practice, such as 'stippled' enhancement [1]. Categories for fibroglandular volume are now a to d, in line with the descriptors for mammography, thus avoiding confusion with assessment category. The degree of background parenchymal enhancement is now purely descriptive, from none/minimal to marked. A new descriptor is clustered rim enhancement (usually indicating DCIS). Non mass-like enhancement becomes non mass enhancement, whereas 'ductal' enhancement becomes linear. Overall the effect is of simplification and consistency with the mammography and ultrasound lexicons.

The lexicon highlights the importance of a structured report, including the indication, scan technique, salient findings and critically, an overall assessment with a clear recommendation for further management. This approach has been validated in a number of studies correlating the assessment category with histopathological findings and/or long-term follow-up [2,3].

Use of a standardised lexicon, modified in the light of available evidence, has obviated some of the interpretative challenges of breast MRI. Use of supplemental diffusion weighted imaging may also be helpful [4]. Nonetheless, technical and clinical challenges remain. Artefacts are problematic, especially at 3T [5], and medical physics support is essential for good quality diagnostic scans, especially at higher field strength.

Most importantly, it should be remembered that to date, despite the recognised superiority of breast MRI over any other modality for breast cancer detection and local staging, there is no hard evidence for improved patient outcomes. Two randomised controlled trials and seven comparative cohort studies have not shown any benefit for preoperative MRI in terms of re-excision rates; rather, there is a trend to higher mastectomy rates [6]. No convincing beneficial effects have been demonstrated in terms of in-breast tumour recurrence rates, disease-free survival or overall survival. Regarding assessment of response to neoadjuvant chemotherapy, MRI correlates better than mammography or ultrasound with final pathology, but false positive and negative studies are frequent, with underestimation of the amount of residual disease in up to 30% and overestimation in around 20% of cases [7,8]. Though evidence is accruing that MRI may be helpful in early response assessment, this is by no means standardised and is heavily dependent on many factors, not least tumour immunophenotype. Finally, though screening breast MRI for women at high risk has approximately double the sensitivity of mammography with encouraging stage shift and high rates of node negativity, there is as yet no evidence of a reduction in breast cancer mortality [9,10].

This workshop will provide an update on the BI-RADS lexicon and indications for breast MRI, with expert tuition in hands-on analysis of case studies.

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#### O40

##### Contributions of multimodal imaging

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Imaging for radiotherapy is indicated during all phases of diagnosis and treatment: for staging, radiotherapy planning, therapy response monitoring and prediction, follow-up and relapse detection. Besides conventional CT imaging, functional (e.g. MRI) and molecular (e.g. PET) imaging modalities are increasingly used in patients before, during and after radiotherapy.

**Staging and radiotherapy planning:** Given the limitations of CT for adequate detection of lesions in many tumor types, functional and molecular imaging is used for improved detection of lesions and assessment of loco-regional disease that should be included in the radiation treatment plan [1,2]. This may result in an increase as well as a decrease of the gross tumor volume (GTV). Increasing the GTV with lesions suspicious of malignancy enhances the likelihood of optimal tumor control. Conversely, exclusion of lesions detected on CT, but with a low likelihood of malignancy on MRI or PET decreases the GTV and thus the side effects associated with larger fields while maintaining optimal loco-regional control of the cancer [3].

**Therapy response prediction and monitoring:** In case radiotherapy is indicated after previous systemic therapy (e.g. in malignant lymphoma), molecular imaging is increasingly used to assess areas of viable tumor, which may prevent the need to irradiate large areas of residual abnormalities which contain no viable tumor [4].

Furthermore, adaptation of treatment during radiotherapy (before the full radiation dose has been administered) offers the chance to increase the dose to radioresistant areas in solid tumor, while the dose to areas that respond very well may be decreased [5]. The clinical impact of this paradigm is currently the subject of many clinical trials, which will make radiation therapy a much more dynamic treatment by a more or less continuous evaluation of tumors by functional and molecular imaging and subsequent adaptation of radiotherapy plans. This concept will be largely facilitated by the use of MRI-Linac and maybe in future PET-Linac.

**Follow-up and relapse detection:** In case of suspicion of relapse, advanced imaging may preselect those patients who are potentially eligible for salvage therapy, but require invasive diagnostic procedures to establish a histological diagnosis. With an increasing number of local and systemic treatment options becoming available for many tumor types, the demands for optimal follow-up becomes increasingly important [6]. The choice for the optimal imaging modality and the timing of imaging are crucial for adequately restaging patients. The impact of radiotherapy-related effects such as radiation-induced inflammation and fibrosis on the accuracy of imaging procedures has to be considered. When considering imaging during follow-up of patients, the clinical need for early detection and the availability of meaningful subsequent treatment should be weighed against the increasing costs associated with the frequent use of advanced imaging techniques (i.e. appropriate use).

**Conclusions:** Multimodal advanced functional and molecular imaging is increasingly used before, during and after radiotherapy. The evidence for many indications is rapidly evolving. This offers great potential for optimized, individualized treatment of patients, providing better chances for loco-regional tumor control and less treatment-associated side effects.

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#### O41

##### Pleura and lung

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Incidental pulmonary nodules in patients that are imaged for staging purposes or during follow-up may represent metastases, second primary tumours (lung cancer) or benign nodules.

The probability of pulmonary metastases or primary lung cancer differs depending on the number, size, size distribution and morphology of the nodules as well as the histologic type, stage, grade and other features of the known malignancy. A large proportion of pulmonary nodules in patients with known cancer are benign. Thus, an unconfounded diagnosis of pulmonary metastases has to be avoided in order not to falsely preclude potentially curative therapy of the primary tumour.

Synchronous or metachronous second primary lung cancers in a patient with a known lung cancer have to be differentiated from pulmonary satellite nodules representing either advanced tumour stages or metastatic disease as they may be amenable to curative surgery.

Pulmonary consolidation or ground glass attenuation most often represents infection and other non-malignant pathology but may occasionally be due to malignant lesions.

Pleural effusions and focal or diffuse pleural thickening from benign causes need to be differentiated from lesions representing pleural carcinomatosis which represents metastatic disease.

During this course examples of different incidental pulmonary and pleural lesions will be demonstrated and recommendations and guidelines for the management of the findings will be presented.

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#### O42

##### Incidental findings in the oncology patient: liver

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Technical advances in ultrasound, multi-detector computed tomography (MDCT) and magnetic resonance imaging (MRI) have increased our ability to detect small-sized hepatic lesions and low-contrast lesions, which would have escaped detection some years ago [1,2]. Prevalence of small lesions found at CT ranges from 12.7% to 29.4% in cancer patients [1-3]. Only a minority of these lesions will eventually turn out to be malignant. However, these incidental findings (or "incidentalomas", as they are called) detected in an oncologic patient pose a particular challenge for both the reporting radiologist and the referring clinician. Contrast-enhanced MRI has additional value in characterization of small lesions indeterminate at CT [4,5], but it has to be justified in terms of cost and resources in an individual patient. Management strategies are being developed to address these lesions, whether aggressive further evaluation (including contrast-enhanced MRI and/or biopsy) or imaging follow-up is sought [6]. Seeking a "100%-certainty strategy" may result in unnecessarily costly and invasive work-up of many patients. Decisions on further management should depend on the imaging appearance of incidentalomas, the history of the patients, risk assessment, taking into account further treatment options.

Imaging appearance of focal fatty infiltration and focal sparing of fat, which may mimic malignant disease, is presented. Small benign lesions, such as flash-filling hemangiomas, FNH, biliary hamartomas, or solitary necrotizing nodules can be difficult to diagnose in the setting of primary tumors with either hypervascular or hypovascular metastases, respectively. Strategies to approach these lesions and guide further management are presented.

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#### O43

##### Incidental findings in the oncology patient: pancreas and spleen

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Recent advances in multidetector CT, magnetic resonance imaging, and ultrasound have led to the detection of incidental pancreatic and splenic lesions that in the past remained undiscovered. These incidentalomas are unexpected, asymptomatic abnormalities discovered serendipitously while searching for other pathology. These incidental lesions have created a management dilemma for both clinicians and radiologists, particularly in the oncology patient in whom any mass, clinical or subclinical, warrants further evaluation.

Strategies for optimizing patient management have emerged in terms of deciding which of these incidentalomas can be ignored, which can simply be monitored over time, and which lesions require more aggressive workup. Subjecting the patient to unnecessary testing and treatment carries its own set of risks that can result in an injurious and expensive cascade of imaging and intervention. The exhaustive evaluation performed in some patients reflects the unwillingness of many physicians to accept uncertainty even in the case of a very rare diagnosis. This unwillingness is in part driven by varying algorithms with regard to diagnostic and treatment strategies, fear of potential malpractice liability, and/or anxiety of the patient. In this review, guidelines concerning the approach to some of the more common incidental cystic pancreatic lesions including IPMN, SPT (SPEN), serous cystadenoma, mucinous cystic tumor, as well as primary and secondary cystic splenic lesions will be presented.

#### O44

##### Incidental lesion in oncology patients: kidneys

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The increasing use of cross-sectional imaging has led to greater detection of incidental lesions in oncology and non-oncology patients. These incidental lesions are unexpected and usually asymptomatic abnormalities that are identified when imaging for other purposes. These incidental lesions create a diagnostic and management challenge for radiologists and clinicians [1]. They may result in patients having unnecessary investigations and treatment, which is not without risks or expense. The American College of Radiologists has developed guidelines and recommendations for incidentally detected lesions on abdominal imaging [2]. The guidance developed addresses incidental findings in the kidney, liver, adrenal glands and pancreas but does not deal specifically with cancer patients.

In the case of an incidentally detected renal lesion in a cancer patient, the incidental abnormality may represent metastatic disease, a second primary malignancy or a benign lesion. The diagnosis and management of such incidental findings will depend in part on the clinical setting, the pathology and stage of underlying primary malignancy and the imaging features of the incidental abnormality [3-6].

In terms of imaging characterisation many incidental kidney lesions can be fully characterised using ultrasound, CT or MRI. In characterising a renal mass, in general it is important to first ensure that the mass is not the result of non-neoplastic conditions that may mimic a tumour. For example focal bacterial pyelonephritis, pseudotumours such as columns of Bertin, hypertrophied tissue adjacent to scars, vascular anomalies, aneurysms and infarcts.

Further imaging characterisation may suggest that the lesion is a benign cystic renal tumour, i.e. Bosniak I or II lesions. If the lesion is solid, unless there are features in keeping with an angiomyolipoma (AML), it is usually not possible to differentiate benign from malignant primary tumour or metastases to the kidney. Therefore either cystic lesions or solid lesions in which malignancy cannot be excluded may need further assessment and this is an indication for a renal biopsy.

Metastases to the kidney are very uncommon. Renal metastases frequently do not present clinical symptoms and many patients have no haematuria. Traditionally, metastases to the kidney are thought to be multiple and bilateral, however descriptions are limited to case reports. The most common malignancies metastasizing to the kidney are lung and breast cancer. Previous imaging or history is also useful in evaluating metastases to the kidney as there is often widespread metastatic disease with renal involvement. Isolated metastasis is very rare and may need a biopsy in order to distinguish it from primary renal neoplasm.

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## O45

### Adrenal masses in oncology patients

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In the general population, adrenal masses are demonstrated in 2-9% of CT scans. Eighty per cent of these are benign cortical adenomas. However, in patients with cancer, over 50% of detected adrenal masses prove to be metastases. Despite this the techniques for the evaluation of adrenal masses in patients with cancer should be similar to patients without cancer and incidentally discovered adrenal masses. Extensive published material is now available on the diagnostic performance of CT, MRI and PET in the characterization of adrenal masses. It must be borne in mind, however, that these techniques are usually evaluated for their ability to positively identify adenomas. Other adrenal pathology also occurs incidentally and it is essential that the radiologist should be familiar with the range of appearances of this pathology. Examples of this include pheochromocytomas, cysts, myelolipomas, haemorrhage and granulomatous infections. Furthermore, although cross-sectional imaging techniques, particularly when modified specifically to evaluate indeterminate adrenal masses, can prove to have an excellent diagnostic performance (with remarkably high specificity), all have limitations. It is a consideration of the relative comparative strengths and weaknesses of each of these imaging modalities that informs the choice of technique and interpretation of the findings. This short presentation outlines the key points relating to the most widely used techniques for evaluating the adrenal mass in patients with cancer and the evidence for their role in patient management.

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## O46

### Incidental findings in the oncology patient: ovaries

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Ovarian incidentalomas are reported in 5-18% of asymptomatic females in cross sectional imaging. Even in oncologic patients the majority of these lesions will be benign, with hydrosalpinx and ovarian cysts as leading diagnoses. Special emphasis should be given to adnexal lesions in patients with history of primaries from the GI tract or breast cancer, both of which have a propensity to metastasize to the ovaries. Patients with hereditary cancer syndromes, e. g BRCA1 or 2, are at a higher risk to develop ovarian cancer. Guidelines for the management of adnexal incidentalomas have recently been developed. Multiparametric MRI aids in further characterization of a complex adnexal lesion and thus assists in patient management in a multidisciplinary setting.

## O47

### Whole-body DWI in practice

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Whole-body diffusion-weighted imaging (WB-DWI) can be used to assess malignancy throughout the body for tumour staging and is being applied for the assessment of treatment response. One of the current unmet needs in oncology is the assessment of metastatic bone disease and diffuse bone marrow involvement, for which WB-DWI appears highly promising. For WB-DWI to be deployed successfully, meticulous data acquisition is necessary to obtain the highest quality images possible. Image post-processing is required to display images in a manner that is easy for referring clinicians to understand, especially on serial follow-up studies. Image interpretation requires knowledge on what is being displayed on WB-DWI. Key to the establishment of WB-DWI in clinical practice is the recognition of interpretative pitfalls, which will be discussed in detail including false-positive and false-negative cases. The potential clinical applications for WB-DWI are illustrated with case examples.

## POSTER PRESENTATIONS

### P1

#### How accurate is 18F-FDG-PET-CT in determining local cartilaginous/bony involvement by head & neck malignancy?

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**Aims:** 18F-FDG-PET-CT plays an important role in the management of head and neck cancers (HNC). In particular, presence/absence of local osseous invasion is an important factor in T-staging and determining treatment options. This study aimed to determine the accuracy of PET-CT in prediction of local osseous invasion by head and neck cancers.

**Methods:** A 6-year-period retrospective analysis of 771 PET-CT scans of HNC (oral/nasal cavity, pharynx, larynx) was performed. Final diagnosis of osseous involvement was determined by histopathology, clinical and imaging follow-up.

**Results:** PET-CT scans demonstrated increased abnormal osseous uptake in 63 cases, of which 52 were true osseous invasion, but 11 were false-positive (4 due to osteoradionecrosis, 4 benign dental infection/inflammation, 3 over-staging due to intense FDG-uptake nearby the bone). 708 cases were reported as 'no osseous uptake', of which 704 were true-negative, but 4 were false-negative (2 due to intrinsically low FDG-avid primary disease and bony lesions were not significantly FDG-avid, 2 due to bony necrosis of tumour with no significant FDG-uptake).

Sensitivity, specificity, PPV, NPV and accuracy of PET-CT in detecting local osseous invasion are 93, 98, 83, 99 and 98% respectively.

**Conclusion:** 18F-FDG-PET-CT plays an important role in detecting local osseous invasion by HNC, with an accuracy of 98%. Important false-positives are due to benign causes such as infection and osteoradionecrosis, and due to intense FDG-uptake nearby the bone. If there is clinical doubt further investigations including MRI and biopsy should be performed.

## P2

### Can we save our resources with half-body-18F-FDG-PET-CT rather than whole-body, in the management of head & neck cancers?

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**Introduction:** 18F-FDG PET-CT plays a significant role in the management of head and neck (H&N) malignancies. There have been recent suggestions that half-body (above diaphragm) PET-CT may be sufficient for the management of H&N cancer patients. This study aims to determine if half-body PET-CT is a safe practice option, or should we stick to whole-body PET-CT.

**Methods:** A 6-year-period retrospective analysis of 729 consecutive PET-CT scans of H&N cancer patients was performed in order to record the incidence of below-diaphragm metastases and below-diaphragm synchronous primary malignancies. The four main indications of PET-CT in H&N cancers are; pre-treatment staging of high-risk of disseminated disease, metastatic cervical lymphadenopathy with unknown primary, assessment of therapeutic response and detection of recurrence/relapse.

**Results:** A total of 664 squamous cell carcinoma (SCC) and 65 nasopharyngeal carcinoma (NPC) cases were studied. 35/729 (4.8%) of cases showed below-diaphragm metastases (liver, renal, adrenal, retroperitoneal and lumbar vertebral metastases), 24/664 (3.3%) by SCC and 11/65 (16.9%) by NPC.

52/729 (7.1%) cases showed synchronous primary malignancies, of which 32 (4.4%) were below-diaphragm (colonic, pancreatic, bladder cancers and retroperitoneal lymphoma).

In total, 84/729 (11.5%) H&N cases had either below-diaphragm metastases or below-diaphragm synchronous primary malignancies.

**Conclusion:** A significant proportion of H&N patients, over 10%, have either below-diaphragm metastases or below-diaphragm synchronous primary malignancies. Half-body (above diaphragm) PET-CT would have missed these lesions, leading to mis-staging of disease and mis-management of patients. It is important to keep whole-body PET-CT in practice in the management of H&N cancers. This is more so in the management of NPC compared to SCC.

## P3

### Prevalence of osteoradionecrosis demonstrated in 18F-FDG PET-CT of post-high-dose-radiotherapy head and neck cancer patients

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**Introduction:** Osteoradionecrosis (ORN) is one of the complications after high-dose-radiotherapy due to damage to normal bony tissues. ORN may occur years after radiotherapy and clinical manifestation may mimic disease recurrence. This study aimed to determine the incidence of ORN shown in 18F-FDG-PET-CT of post-radiotherapy head and neck cancer (HNC) patients.

**Methods:** Retrospective analysis of 386 PET-CT scans of post-radiotherapy HNC was performed. Total dose of radiotherapy, time duration after radiotherapy and SUVmax were recorded. Final diagnosis was reached by biopsy, clinical and imaging follow-up.

**Results:** Out of 386 scans, 41 cases demonstrated abnormal increased bony/cartilaginous uptake. Of which 22 were confirmed as residual local osseous involvement of pre-existing bony disease, 8 due to disease recurrence at new sites of bone/cartilage, 7 due to benign causes such as dental infection, and 4 due to ORN with no previous local osseous involvement. The incidence of ORN is 1.0% (4/136) of total PET-CT scans and 9.8% (4/41) of increased osseous FDG-uptake. Average occurrence of ORN was 6 months after radiotherapy (range 2 months to 3 years), all received over 60 Gray of radiation dose. Mean-SUVmax of ORN was 6.6, not significantly different from disease recurrence (mean-SUVmax=8.2, P=0.23).

**Conclusion:** ORN is a rare complication after high-dose radiotherapy seen in PET-CT (1.0%), but when abnormal increased osseous FDG-uptake is

seen within the previous radiotherapy field then ORN should be considered as a differential diagnosis (9.8% of increased osseous uptake). ORN may occur years after treatment and symptoms mimic disease recurrence. There is no significant difference in SUVmax values between ORN and recurrence.

## P4

### Prevalence of malignancy in patients with fever of unknown origin (FUO) demonstrated in 18F-FDG PET-CT – prospective multi-centre study

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**Purpose:** 18F-FDG PET-CT plays an important role in the management of fever of unknown origin. FUO is defined as "body core temperature <38.3°C on several occasions lasting for <3 weeks but no cause found despite routine clinical investigations for <1 week in hospital". Malignancy is an important cause of FUO, and the aim of this study is to demonstrate prevalence of malignancy as a cause of FUO demonstrated in PET-CT.

**Methods:** A total of 231 patients with FUO were prospectively studied using PET-CT after negative conventional investigations. Final diagnosis was based on biopsy, microbiological tests and imaging follow-up.

**Results:** The cause of FUO was identified only in 129/231 (56%) patients, of which 27 (12%) were due to malignancy and 102 were due to benign causes.

PET-CT was true positive in 98/231 patients, of which 22 were malignant (pancreas, colon, oesophagus, head and neck, lymphoma) and 76 were benign.

False positive in 18/231 patients, due to increased FDG-uptake in reactive nodes.

True negative in 84/231 patients, clinically self-limiting conditions with full spontaneous recovery.

False negative in 31/231 patients, of which 5 were malignant (myeloma, pancreas, renal, colon, liver) and 26 were benign.

PET-CT identified malignancy in 22/27 (81%). PET-CT misses poorly-FDG-avid malignancy or lesions embedded within normal physiological uptake.

**Conclusion:** In this study 12% (27/231) of FUO are caused by malignancy. PET-CT demonstrated the site of malignancy in 81% (22/27). Although PET-CT plays an important role in the management of FUO, some malignancy may be missed (19%) so further investigations are still required if spontaneous recovery is not achieved.

## P5

### Incidence of sarcoid-like reaction demonstrated on 18F-FDG PET-CT in head and neck cancer patients

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**Aim:** Sarcoid-like reaction (SLR) is a well-known benign cause of nodal FDG-uptake in cancer patients and needs to be differentiated from active nodal metastatic disease. This study aimed to demonstrate the prevalence of sarcoid-like reaction in head and neck cancer (HNC) patients demonstrated on 18F-FDG-PET-CT.

**Methods:** A 6-year-period (2008-2013) retrospective analysis of 729 PET-CT scans (308 patients) of HNC was performed. Pre and post-treatment scans were compared and cases with persistent mediastinal/hilar nodal uptake despite therapeutic response elsewhere were further analysed and clinically followed up. Final diagnosis was reached by biopsy, clinical and imaging follow-up.

**Results:** SLR was diagnosed in 8/308 (2.6%) HNC patients. Of which 3 had mediastinal nodal uptake only, 2 had bilateral hilar nodal uptake only and 3 had both mediastinal and hilar uptake. All the 8 patients had primary HNC and deep cervical lymphadenopathy but no distant metastases, hence misinterpretation of SLR would have upstaged as M1 (metastasis positive). 4 cases were identified on scan for restaging of suspected

recurrence, and 4 were for primary tumour staging. The mean SUVmax of SLR was 6.9 (range 2.4-9.6), and the mean SLR nodal size was 1.6cm in short axis (range 0.6-2.4cm), with no significant difference compared to active nodal diseases ( $P=0.33$  and  $0.23$ ).

**Conclusion:** SLR was seen in 2.6% of HNC patients at 18F-FDG PET-CT examinations. 18F-FDG PET-CT plays a significant role in the management of HNC, and it is important to be aware of a possibility of SLR in order to avoid false-positive interpretation of metastasis.

## P6

### What is the importance of solitary focal bony FDG-uptake on 18F-FDG PET-CT of known cancer patients?

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**Aim:** 18F-FDG-PET-CT plays an important role in oncology staging. While the presence of multiple FDG-avid lesions on PET-CT in the context of known malignancy is generally considered metastases, the exact significance of solitary FDG-avid-lesions remains unknown. This study was undertaken to evaluate the significance of solitary bony lesions on PET-CT of oncology patients.

**Methods:** Retrospective review of 15,645 PET-CT studies was performed. Further evaluation of solitary bony FDG-avid lesions was carried out by conventional imaging, follow-up and biopsy studies. Spontaneous resolution on subsequent PET-CT without a change in therapy was considered benign while progression was considered malignant.

**Results:** 361 (3%) cases were found to have single FDG-avid skeletal lesions, of which 16 were due to uptake at the primary bony malignancy, and 42 were not further-investigated/passed away, hence excluded. Of the remaining 303 lesions 276 (91%) were confirmed as metastases, 27 (9%) proven benign (10 by imaging, 5 by biopsy and 12 by follow-up). Of 276 metastases (SUVmax  $9.6\pm 6.6$ ); 191 were lytic, 45 sclerotic, 21 mixed and 19 normal on CT. Of 27 benign (SUVmax  $3.8\pm 2.8$ ); 2 were lytic, 7 sclerotic, 2 mixed and 16 normal on CT. PPV of PET-CT on lytic, sclerotic, mixed and normal lesions on CT are 99%, 87%, 91% and 54% respectively. There was significant difference in SUVmax between malignant/benign lesions ( $P<0.001$ ).

PET-CT correctly upstaged in 83/303 (27%) cases, but incorrectly upstaged or suggested further investigation in 18/303 (6%) cases.

**Conclusion:** Solitary skeletal FDG-uptake on 18F-FDG-PET-CT in patients with known malignancy is just as significant as multiple skeletal FDG-uptake, carrying high risk of metastases.

## P7

### Pictorial review of appearances post lung thermal ablation: what is normal?

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Lung thermal ablation can be used to treat both primary and secondary thoracic malignancies. Evidence to support its use, particularly with metastases from colonic primary tumours, is now strong, with survival data approaching that seen after surgery. Because of this the use of ablative techniques (particularly thermal ablation) is growing and the Royal College of Radiologists (UK) predict that the number of patients who could benefit from such treatment may reach in excess of 5,000 per year. While thermal ablation is often restricted to tertiary referral units, general radiologists are frequently expected to interpret post-treatment imaging, often performed in the context of acute complications which can occur after discharge. Although ablation is generally a safe technique with a specific mortality rate of between 1 and 2.6% and a major complication rate (as defined by the Society of Interventional Radiology as one requiring remedial action or where the patient experiences significant morbidity) of 17.1%, it is important for all radiologists to be aware of the range of post-treatment appearances. This pictorial review will cover all the normal and abnormal appearances encountered after

lung ablations, based upon a review of the literature and our experience of over 200 ablations. Emphasis is given to the range of normal appearances and there will be discussion outlining when further investigation or intervention is required post ablation.

## P8

### Patient outcome after pulmonary radiofrequency ablation: a prospective analysis of results from a single centre

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**Aim:** To assess the safety of pulmonary RFA and analyse the factors which affect overall survival and disease-free survival in patients with pulmonary malignancy treated with ablation.

**Materials and methods:** 90 tumours in 45 patients who were treated between April 2009 and August 2013 during 83 separate procedures were analysed using a prospective database. Patient records and imaging was reviewed on the hospital PACS system. For each patient we recorded the histologically confirmed nature of the primary tumour, site and number of metastases and if the patient received prior chemotherapy or other treatments. On a lesion by lesion basis we recorded the site and size of the lesion, ablation details, lesional progression-free survival, complications and overall survival. Factors were compared by the log rank test and Kaplan-Meier survival analysis was performed.

**Results:** The median overall survival was 105 weeks from initial RFA, with 1, 2 and 3 years survival of 95.5%, 89.9% and 77.7% respectively. 15 lesions (17%) developed recurrence; with the mean time to recurrence being 32 weeks. 40% of those with recurrence occurred when the lesion was abutting a major vessel. Repeat RFA in 8 of these 15 lesions demonstrated no further recurrence in 7. The rate of significant complications (those requiring treatment), was 12%. Patients with 3 or more lesions ablated were found to have a mean survival of 150 weeks, compared to 195 weeks in those with a total number of lesions  $\leq 2$ . This came close to statistical significance ( $p=0.091$ ).

**Conclusion:** Three-year survival of 77.7% compares favourably with surgery. Patients with 3 or more lesions treated are likely to have reduced survival than those with 2 or fewer lesions treated.

## P9

### Diagnostic accuracy of MRI in local staging of rectal cancer, and determining the surgical resection margin status; retrospective study. The experience in Oman

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**Aims and objectives:** To retrospectively review the accuracy of magnetic resonance (MR) imaging in preoperative staging of rectal cancer and to predict surgical circumferential resection margin status, with histopathologic results

**Methods and materials:** MR images of 39 patients (15 underwent surgery without pre-operative treatment, while 24 had undergone pre-operative CRT or radiotherapy prior to MRI) with diagnosis of rectal cancer to evaluate tumour stage (T stage), involvement of mesorectal fascia (MRF), and nodal metastasis (N stage) were included in the study. Tumours were staged according to the TNM staging system (American Joint Committee on Cancer guidelines)

**Results:** We managed to correctly determine T stage in 86.6%, and 70.8%, correctly assess the status of MRF in 100%, and 70.8%, and correctly determine the N stage in 66.6%, and 54.1%, for the first and second group, respectively.

**Conclusion:** Main T staging errors contributed to desmoplastic reaction in the first group, or post-therapy changes in the second group, which also affected the MRF.

The limited accuracy of nodal size is likely to be related to the fact that 30%–50% of metastases in rectal cancer occur in nodes that are less than 5 mm.

MRI is the primary method for local staging of rectal cancer mainly due to high soft tissue resolution which makes it better in evaluating tumour extension, relation to adjacent pelvic organs, and also for the ability to assess the MRF. Results are highly dependent on the technique of the examination, which needs meticulous care and standardization.

#### P10

##### Chemotherapy response evaluation in metastatic non-small cell lung carcinoma (NSCLC) with 18F- FDG PET/CT and CT scan

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Cancer Imaging 2014, **14(Suppl 1)**:P10

**Background:** Therapeutic response assessment in NSCLC is fundamental in order to avert futile surgery and an ineffective toxic chemotherapy. This study sought to determine the potential of the PET response criteria over the RECIST Criteria 1.1 in evaluating the treatment response of the NSCLC patients.

**Materials and methods:** Eighteen patients (age: 60.16±5.39 years) with metastatic NSCLC were evaluated after 4 courses of chemotherapy and/or target therapy. [18F]-fluorodeoxyglucose with positron-emission tomography (PET) and computed tomography (CT) scans were subsequently used to assess tumour response. Discrepancies between the two procedures were evaluated after 4 courses of chemotherapy of the primary tumour lesion using the Response Evaluation Criteria in Solid Tumours (RECIST 1.1) and European Organisation for Research and Treatment of Cancer (EORTC) criteria evaluating CT and PET respectively.

**Results:** Five morphologically partial responses (PR), two morphologically stable disease (SD), one morphologically progressive disease (PD) and two morphologically complete morphological response (CR) were correlated with the PET metabolic response criteria respectively. Two (PR) were evaluated as 2 complete metabolic response (CMR). Three cases of (SD) were evaluated as 3 CMR. Three morphologically (PD) were evaluated as 1 CR, 1 PMR and 1 SMD. There were significant difference between the SUVmax changes; mean: 0.51± 0.29 g/ml versus size changes; mean 0.30± 0.24 cm,  $p < 0.05$ . Conclusion: The RECIST 1.1 and the EORTC are two discordant methods in evaluating the therapeutic response of the metastatic NSCLC with the potential of greater parametric changes of the SUV in alluding changes of the tumour metabolic landscape.

#### P11

##### Impact of three dimensional tomosynthesis on the detection and diagnosis of breast lesions

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**Objective:** To evaluate the impact of adding 3D Tomosynthesis to Full Field Digital Mammography (FFDM) in the detection and diagnosis of breast lesions.

**Subjects and methods:** The study included 166 mammograms with indeterminate findings selected from 1600 mammograms. They were classified into two groups: group 1 'Diagnostic mammograms' of symptomatic women and group 2 'Screening mammograms'. Dense breasts assigned as ACR3 and ACR4 presented 69% ( $n = 114/166$ ) of the studied cases. FFDM and 3D tomosynthesis examination was done and imaging findings were evaluated before and after the use of 3D tomosynthesis images.

**Results:** Both modalities were compared regarding detection and diagnosis, each individually assessed, using the Pearson Chi Square tests. Detection ( $P$  value: 0.006) and diagnosis ( $P$  value: 0.048) of breast lesions dramatically improved when 3D tomosynthesis images were considered in the evaluation. The sensitivity, specificity, and accuracy of digital mammography was 60%, 20.7% and 48% have significantly enhanced on applying tomosynthesis to be 94.5%, 74% and 89.7%.

**Conclusion:** Three-dimensional tomosynthesis significantly enhanced the detection and characterization of breast lesions on digital mammography especially in the context of dense breast parenchyma (ACR 3&4).

#### P12

##### Prostate-MRI: experience of the observer and technical conditions influence the cancer detection rate

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**Aim:** The prostate cancer (PCa) detection rate of MR-guided biopsy (MRGB) increased in our hospital from 36.6% in 2012 to 69% in 2013. The study analysed the values of the mpMRI-characteristics of identifiable lesions retrospectively to show the influence of the increasing experience of the observer and modified technical conditions.

**Methods:** 56 patients (pat.) with mostly at least one prior negative TRUS-guided biopsy and persistent suspicion of PCa with at least one mpMRI-defined identifiable cancer suspicious lesion were included in this study between 2012 and 2013. MpMRI: 1.5 T/e-coil/T2WI/DWI, b-values 2012: 0-1500, 2013: 100-1500/DCE-MRI. MRGB: in-bore. Characteristics of lesions (ADC, ESUR PIRADS) were statistically correlated with core needle biopsy results (ROC). A  $p$  value of  $p < 0.05$  was considered as statistically significant. Results

2012/2013: detection rate of all suspicious lesions 33%/58%; in peripheral zone 45%/50%; in transitional zone 14%/67%. The ROC curve area difference was statistically significant for 2012/2013 for ADC 0.65/0.83 ( $P=0.008$ ). The cut-off values [cut-off (sensitivity; specificity)]: 2012/2013: ADC 836 (0.58;0.58) / 651 (0.72;0.71); 2013: PIRADS DWI 3.5 (0.57;1.0), PIRADS DCE 3.5 (0.63;0.69), PIRADS T2 3.5 (0.71;0.86).

**Conclusion:** Modified DWI as to exclude microcapillary perfusion effects leads to lower cut-off value and higher diagnostic value of the ADC. The increasing experience of the observer enhances the evaluation of the transitional zone. The combination of the modified technical conditions and increasing experience of the observer leads to higher sensitivity and specificity of the overall mpMRI prostate evaluation and (PCa) detection rate.

#### P13

##### Quantitative magnetic resonance imaging of microvascular changes in KHT sarcoma

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Micromorphological changes in skeletal muscle vascular remodeling due to denervation, aging or tumour growth have been investigated recently. Naturally, quantitative imaging of the capillary bed and the determination of microstructural parameters in healthy and pathological tissue might prove beneficial for potential therapeutic interventions. Susceptibility differences of capillaries and surrounding tissue are due to paramagnetic deoxyhaemoglobin and can be used to provide a means of quantifying microstructural parameters through MRI transverse relaxation time measurements. Within a local weak field approximation and based on simple geometrical assumptions, a model is introduced that analytically derives a dependence of blood transverse relaxation rate for Carr-Purcell-Meiboom-Gill sequences on inter-pulse delay time, strength of the magnetic field, local susceptibility difference and spin diffusion constant, capillary radius and local blood volume fraction. The model is tested for healthy skeletal muscle tissue in mouse leg muscle and KHT sarcoma based on experimental *ex-vivo* experiments. Due to blood loss and increased vessel wall permeability after excision, a capillary shrinkage to about 1/10 of the typical *in-vivo* capillary diameter of 1.5  $\mu\text{m}$  is assumed, and, in a magnetic field of 0.6 T, the corresponding local diffusion constant in healthy tissue is found to be 2.2  $\mu\text{m}^2/\text{ms}$ , and for KHT sarcoma 2.6  $\mu\text{m}^2/\text{ms}$ . Therefore, the quantitative model might be used to differentiate between healthy and pathological tissue diffusion properties or, by assuming local diffusive properties, to determine differences in local microvasculature.

#### P14

##### Dynamic 18FDG PET/CT and dynamic contrast enhanced MRI of locally advanced breast cancer

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DCE-MRI provides information about the perfusion of tumours together with morphological details. Perfusion of tumour could be assessed by dynamic 18FDG PET/CT (dFDG/PET), in addition to metabolic information. This study was planned to compare the semi-quantitative parameters of DCE-MRI) and dFDG/PET in locally advanced breast cancer.

Forty patients with LABC underwent DCE-MRI and dFDG/PET study at baseline and after 2-3 cycles of neoadjuvant chemotherapy. Tumour longest diameter, spherical (SV), and angiographic volumes (AV) were recorded. Peak signal intensity (PSI), rapid and medium component of initial rise, percentage of Type I, Type II, Type III curves were calculated. Dynamic 18FDG images for the first 30 minutes and late images at second hour were recorded in the prone position, with hanging breasts and the arms above, using a special cushion. Using 18FDG dynamic data, slopes of time-activity curves for the first 2, 5 and 30 minutes were calculated. SUV max and values for 2nd, 5th and 30th minutes were measured. Metabolic tumour volume (MTV) and total glycolytic index (TLG) were calculated for primary lesion and axillary lymph nodes.

Baseline angiographic volume (AV) of DCE-MRIs and metabolic (MTV) volume of 18FDG PET/CT studies were significantly correlated. PSI had a negative correlation with 2nd minute slope of FDG dynamic curve, whereas type III enhancement percentage had positive correlation with 2/30 slope ratio. % AV change showed significant relationship with % SUVmax-bw, % SUVpeak, % MTV and % TLG.

Dynamic imaging with 18FDG provides useful information about tumour perfusion which is in relation with dynamic CE-MRI parameters.

#### P15

##### Evaluation of hepatic lesions in 30 proven cases of MEN-syndrome

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Cancer Imaging 2014, **14(Suppl 1)**:P15

**Aim:** MEN syndrome is one of the most important familial causes of neuroendocrine tumours. Radiological screening and follow-up for syndrome-related tumours play an important role in the life-long surveillance. Liver metastases (LM) from neuroendocrine tumours are common (75%) and significantly reduce the prognosis. Characterisation of liver lesions in these patients is a challenge for radiologists as LM are difficult to differentiate from benign liver lesions such as of haemangioma. In this study we aimed to give an overview of the radiological presentation of LM in MEN patients by different imaging modalities.

**Methods:** We retrospectively evaluated 30 genetically-proven cases of MEN syndrome (type 1+ 2), who had a hepatic lesion. The findings of contrast-enhanced computer tomography (CE-CT) as well as ultrasound (US) were considered for the main diagnosis. The findings of other imaging techniques such as contrast-enhanced ultrasound (CEUS), magnetic resonance imaging (MRI) as well as PET-CT were evaluated and compared individually.

**Results:** The most common liver lesions were haemangioma (40%) followed by LM (30%). The radiological findings in LM varied from hypodense lesions with low marginal contrast-enhancement to disseminated calcified lesions. The most common CT finding in early stage LM was hyperarterialised lesion with marginal contrast-enhancement in the portal venous phase as well as hyperechogenic appearance in US which mainly mimic the classic haemangioma.

**Conclusion:** Better understanding of the radiological appearance of LM in patients with MEN syndrome will help in early tumour-detection and adjusted treatment. For this purpose multimodal imaging, primarily CE-CT in addition to CEUS or CE-MRI are essential for screening as well as follow-up controls.

#### P16

##### What the radiologist needs to know about restaging of rectal carcinoma after chemoradiation therapy

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**Aim:** The purpose of this exhibit is to describe and compare the high-resolution MRI features of rectal carcinoma after chemoradiation treatment (CRT) and to correlate with the histologic findings after total mesorectal excision (TME).

**Method:** High resolution T2-W MR imaging (HRMRI) was performed in a 1.5 T unit between January 2013 and February 2014 before and immediately after CRT in the care of 25 patients with locally advanced adenocarcinoma of the rectum. After total mesorectal excision (TME) the piece was cut by the pathologist under the supervision of the radiologist, who indicated areas of residual tumour after neoadjuvant therapy or changes such as fibrosis, oedema, cellular and acellular mucin, desmoplastic reaction and pseudotumour appearance. Thus, initially we did a correlation between the macroscopic and MR imaging. Subsequently, we performed the same correlation but in this case between microscopy and MR imaging. Changes in morphologic and signal intensity features were evaluated with respect to primary tumour and nodal downstaging.

**Summary:** Emerging evidence has shown the prognostic importance of reassessing rectal cancer using HRMRI after completion of CRT. A systematic cooperation between radiologist and pathologist is essential for optimal treatment planning and patient care.

#### P17

##### Dual-energy CT for therapy monitoring: histogram analyses of iodine maps reveal typical pattern of enhancement

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**Aim:** Functional information for appropriate therapy monitoring of advanced targeted therapies is essential, but standard follow up (FU) examinations with computed tomography (CT) still focus on traditional size measurements. Iodine quantification with dual energy CT (DECT) enables additional quantitative assessment of contrast media uptake. Our purpose was to investigate patterns of contrast media enhancement under BRAF inhibitor therapy (BRAF-I) by performing histogram analyses (HA) of iodine maps based on DECT.

**Methods:** 11 stage IV melanoma patients underwent DECT at baseline and at least one FU. 8 patients were RECIST-responder to BRAF-I. Volume segmentation of in total 33 metastases was performed semi-automatically. For each lesion, iodine uptake (IU) and HA of iodine maps including maximum HU value (max), mean HU value (mean) and standard deviation (STD) was calculated.

**Results:** For BRAF-responder mean, max and STD of the iodine histograms decrease significantly ( $p < 0.05$  at FU 2). In patients with progress, 6 of 7 lesions showed increasing max and STD, while mean and IU were decreasing (4 lesions) as well as increasing (3 lesions). Analysis of the metastasis with mixed response revealed about stable values for mean, max and STD for the responding part and increasing values for the viable tumour.

**Conclusion:** For patients under BRAF-I, HA of iodine maps based on DECT revealed a typical pattern of contrast media enhancement. HA has potential to add an objective and functional criterion to traditional size measurements of standard CT examinations and can contribute to accurate response assessment for BRAF-I therapy.

**P18**

**Diagnostic accuracy of staging of Wilms' tumour in the era of multislice CT**

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**Aim:** To assess the diagnostic accuracy of CT in local staging of Wilms' Tumour.

**Method:** Audit of radiology reports (16 slice CT), surgical notes and histopathological reports in 24 cases of unilateral non-metastatic Wilms' tumour (2012 to 2014).

**Results:** 24 patients were eligible. 12 boys, 12 girls, age range of 1-10 years (mean 3.9). 6 patients underwent upfront surgery (Group A) while 18 patients received 4 weeks of chemotherapy (Group B). The post chemotherapy scans were compared to gold standard in the latter group. Renal vein involvement: Present in 8 patients (all group B), CT had 100% sensitivity, 90% specificity, NPV 100%.

Renal sinus involvement: Present in 14 patients (4 group A, 10 group B). Sensitivity and specificity of CT was 25%, 100% for group A and 90%, 50% for group B.

Renal pelvis involvement: Present in 8 patients (1 group A, 7 group B). Sensitivity and specificity of CT was 71.4%, 81.8% for group B and specificity of 100% for group A.

Renal Capsular involvement (but not necessarily the margin) was present in 6 patients (2 group A, 4 group B). Sensitivity and specificity of CT was 50%, 100% for group A and 42.8%, 75% for group B.

Overall, CT stage matched histopathological stage in 4/6 patients in group A and in 12/18 patients in group B (66.6% in both groups).

**Conclusion:** CT staging has higher specificity in upfront surgery, probably because of the smaller tumour size. The sensitivity of CT staging with regards to renal vein, sinus and pelvic involvement is better than renal capsular involvement, where CT tends to over-stage disease in larger tumours.

**P19**

**The impact of radiologists' expertise on screen result decisions in CT lung cancer screening**

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**Aim:** To evaluate the impact of radiological expertise on screen result decisions made in a CT lung cancer screening trial.

**Methods:** In the Dutch-Belgian randomized lung cancer screening trial (NELSON), the baseline CT screen result was based on the lung nodule with largest volume. According to the protocol, nodule volume <50mm<sup>3</sup>, 50-500mm<sup>3</sup> and >500mm<sup>3</sup> led to a negative, indeterminate and positive screen result, respectively. The protocol, however, allowed radiologists to manually adjust screen result in case of high suspicion of benign or malignant nodule nature. In this study, all participants whose baseline CT result was based on a solid nodule were included. Adjustments by radiologists at baseline were evaluated. Histology was the reference for diagnosis, or, to confirm benignity, stability on subsequent CT scans.

**Results:** 3,268 participants (2,759 male, median age 58.0-years) were included. In 189 participants (5.8%) the initial baseline screen result was adjusted by the radiologist. Adjustment was downwards from positive or indeterminate to negative in two and 118 participants, respectively, and from positive to indeterminate in 64 participants. None of these nodules turned out malignant. In five participants (2.6%) the screen result was adjusted upwards from negative to indeterminate (N=1) or indeterminate to positive (N=4); two nodules (40%) were malignant.

**Conclusion:** >In about one-in-twenty cases of baseline lung cancer screening, nodules were reclassified by the radiologist (97.4% downwards), leading to reduction of false-positive and false-negative screen results.

**P20**

**Radiological characteristics of screen-detected lung cancers: predictive for histological subtype?**

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**Aim:** To evaluate CT-morphological features of lung cancers detected in a CT lung cancer screening trial, and to determine the correlation between CT-morphological features and the histopathological diagnosis of screen-detected cancers.

**Methods:** 197 solid lung cancers (192 participants) detected in all four screening rounds of the Dutch-Belgian randomized lung cancer screening trial (NELSON) were included. CT-morphological features included nodule shape, margin, location, volume, and volume-doubling time (VDT). Based on histopathology, cancers were divided into four groups: adenocarcinoma (N=114), squamous cell carcinoma (N=37), large cell carcinoma (N=28) and neuro-endocrine cancers (N=18). Data were analyzed using ANOVA, Chi-square and Fischer's exact test.

**Results:** Mean participant age was 61.3 years (95%-confidence interval [CI]: 60.5-62.2), and 160/192 (83.3%) were male. In all four histopathologic groups, the majority of cancers had a spherical nodule shape (70.6-95.8%). Margins of malignant nodules were most often lobulated (39.3-45.9%) and spiculated (22.2-35.7%), without statistically significant difference between histopathological groups. Most cancers (63.5%) were located in the upper lobes, adenocarcinomas significantly more often (71.1%) than other types of cancers (p=0.004). Adenocarcinomas had a higher mean VDT than large cell carcinomas (214.8 days, 95%-CI: 186.2-243.4 days vs 96.8 days, 95%-CI: 15.8-177.9 days [p<0.05]). VDTs of other histopathological subgroups did not differ significantly.

**Conclusion:** Only VDT and location in the upper versus lower lobes are associated with histopathological diagnosis of screen-detected lung cancers. No discrimination can be made between different histopathologic cancer types based on CT-morphological features alone.

**P21**

**Incremental diagnostic value of 18F-FDG PET/CT in the work up of adult limb and body wall sarcomas. A single centre experience**

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**Background/aim:** Soft tissue sarcomas (STS) amount to less than 1% of malignant adult tumours. There are more than 50 histological subtypes, some of which can be very aggressive and given their relative rarity, patients may pose unique diagnostic and therapeutic challenges. The aim of this exhibit is not only to share a single centre experience of the utility of [18F]FDG - PET/CT in these patients but also to offer pictorial demonstration of PET/CT appearances in some rare histological subtypes, which we feel will contribute towards the evolving role of PET/CT in this area.

**Patients and methods:** Prospectively kept database for the sarcoma multidisciplinary meeting (MDM) was reviewed and patients undergoing 18F-FDG PET/CT examination at any stage of diagnostic workup for adult limb and body wall STS between 2011 and 2014 were reviewed. Patients with GIST and skeletal sarcoma were excluded. 17 patients were identified and the histology, FNCLCC grade, cross-sectional imaging including CT and MRI findings, the indication for performing PET/CT and the impact of its findings on MDM decision-making were evaluated.

**Results:** PET/CT was utilised during initial pre-treatment staging in 10 and for assessing recurrent disease in 7 patients. The histology included 5 patients with leiomyosarcoma, 6 with various subtypes of liposarcoma, 2 with very rare extraskeletal osteosarcomas, 1 each of fibromyxoid sarcoma, solitary fibrous tumour, synovial sarcoma and undifferentiated sarcoma. By FNCLCC grading system, nine were grade 3, five were grade 2 and three patients had grade 1 tumours. PET/CT upstaged disease in 3/17 patients (identifying the true extent of local invasion in 1 patient and demonstrating subsequently proven metastases not detected on CT in 2 patients), refuted the suspicion of distant metastases on conventional imaging in 4/17, confirmed morphological findings in 5/17 and was inconclusive in 4/17 cases. In one patient with a chest wall leiomyosarcoma, a small paravertebral lesion was not evident on PET, likely due to its small size. High grade tumours (grades 2 and 3) were unequivocally hypermetabolic on PET, whilst grade 1 tumours and those with prominent a myxoid component were less FDG avid.

**Conclusion:** In our single centre experience, PET/CT was found to be of significant incremental value in patients with high grade STS, by virtue of identifying occult foci of disease, detecting extent of loco-regional disease, and also by providing metabolic evidence in support or against equivocal findings on conventional imaging. This information contributed to confident decision making, particularly in patients in whom radical extremity amputations were under consideration.

## P22

### Fast venous return in inferior mesenteric vein: a new sign for rectosigmoid carcinoma on CT

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**Purpose:** Diagnosis of colorectal carcinoma on contrast-enhanced CT relies on demonstration of rectosigmoid wall thickening, perirectal fat stranding, and perirectal lymph nodes. Wall thickening may be the only sign in early carcinoma, and may be mimicked by spasm or adherent faecal matter. Rectosigmoid carcinoma may result in earlier venous return in inferior mesenteric vein (IMV) compared to superior mesenteric vein (SMV). This study evaluates faster venous return of intravenous contrast agent in IMV as a diagnostic sign for colorectal carcinoma.

**Material and methods:** CT of 35 patients with colorectal carcinoma and 35 control patients have been reviewed in consensus by two experienced blinded radiologists, who reviewed CT for rectosigmoid wall thickening, lymph nodes and earlier venous return in IMV (positive IMV sign). IMV diameter and the IMV/SMV enhancement ratio have been measured and compared in the two groups by the Student's T-test.

**Results:** Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the IMV sign for diagnosis of carcinoma have been 83, 100, 100, 89, and 93% respectively as compared to 100, 84, 81, 100, and 91% for rectal wall thickening and 40, 98, 93, 70, and 74 % for nodal enlargement respectively. IMV/SMV enhancement ratio on the arterial phase has been significantly higher in the carcinoma group (1.38±0.42) compared to the control group (0.68±0.25) (p<0.05).

**Conclusion:** The IMV sign is a useful sign for the diagnosis of colorectal carcinoma, particularly in early tumours manifested only by subtle rectosigmoid wall thickening.

## P23

### Use of textural analysis of tumour vascular heterogeneity as a biomarker of response to anti-angiogenic treatment in patients with nasopharyngeal carcinoma

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**Objectives:** This study aims to evaluate the impact of tumour vascular heterogeneity, derived from textural analysis of dynamic contrast-enhanced computed tomography (DCE-CT) perfusion characteristics in patients with NPC treated with the anti-angiogenic drug, pazopanib.

**Materials and methods:** DCE-CT images of 33 patients, with recurrent/metastatic NPC treated with pazopanib, were analyzed to derive tumour blood flow, fractional intravascular blood volume, fractional extracellular-extravascular volume, and permeability surface area product. To each parametric map, textural analysis using multiple parameters based on co-occurrence matrix, neighbourhood gray tone difference, run-length matrix, gray level size-zone matrix and histogram statistics were applied to characterize its heterogeneity. Reproducible and important textures, were selected by a cut-off on the coefficient of variation and variable importance determined by random forest analysis, respectively. These textures are summarized by principal components analysis and their relationship to outcomes evaluated using Cox proportional hazards, receiver-operating characteristics, Kaplan-Meier and logistics regression analysis.

**Results:** The first principal component of the reproducible and important textural features of pre-treatment fractional intravascular blood volume (PC1) was related to survival outcomes. Using Kaplan Meier analysis, overall survival was significantly higher for patients with PC1 values greater than the median (p=0.002). There was no statistically significant association between DCE-textures and overall response.

**Conclusion:** Heterogeneity of tumour intravascular blood volumes may be an important biomarker for predicting overall survival in patients with NPC treated with anti-angiogenic therapy.

## P24

### Utility of dual time point 18 FDG PET-CT

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The Standardized Uptake Value (SUV) from FDG PET-CT is a simplified quantitative measure used for characterization of tissues suspected for malignancy. Its rationale is based in augmented glucose consumption of oncologic cells although, many other benign pathologies, could show elevated values leading to error.

The purpose of this presentation is to demonstrate that SUV value continues elevating in malignant pathology while in benign disease will decrease over time.

We prospectively acquired delayed images in patients with focal increase of metabolic activity without clear morphologic pathology, or failing to show increase metabolic activity in sites with morphological findings of probable oncologic origin. We have acquired delayed evaluation in 45 patients with suspicious lesions.

The most prominent findings were: 11 patients with focal hypermetabolic sites in gastrointestinal tract who demonstrate significant SUV decline on delayed images, avoiding unnecessary colonoscopies, while another 17 patients have significantly increased SUV on delayed images, correlated with polypoid lesions at colonoscopy. 7 patients with falling SUV on delayed images in adnexal hypermetabolic foci proved to be of functional origin at ultrasound follow-up, 5 patients with descending SUV at delayed images in hypermetabolic foci in the neck proved to be inflammatory on follow-up and 5 patients that SUV value continues elevating on delayed images, secondary or primary origin was confirmed. Dual time point PET-CT has proven to be an important tool for proper characterization of questionable lesions that would lead to costly mistakes or unnecessary diagnostic studies.

## P25

### Acute presentation of oncologic disease

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The number of complicated oncologic patients is increasing accordingly to the high overall prevalence of cancer and the improved survival rate due to advances in cancer treatments. Progression disease and treatment-related complications are the most common causes. In this presentation, we review the pathophysiology of selected oncologic emergencies in which radiologists play a critical role in timely diagnosis and thus have a significant impact on patients' care.

We selected patients who attended the emergency department of our hospital between 2010 to 2014 with different acute symptoms.

Of the oncological emergencies presented we found most commonly: compression of the spinal cord (4.5%), carcinomatous meningitis (13.6%); obstruction of the central airway (9%), oesophageal fistula (9%), pulmonary embolism (9%), superior vena cava syndrome (4.5%), pelvic abscess (18%), intra-abdominal haemorrhage (9.5%) and intestinal intussusception (13.6%).

Oncologic emergencies represent important causes of death in cancer patients. Radiologists should be familiar with imaging findings of acute conditions to optimize patient care. Recognition of key imaging findings allows prompt diagnosis and facilitates treatment, reducing morbidity and mortality with consequent better outcome.

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#### P26

##### Relative time-intensity curve: a new method to differentiate benign and malignant lesions on breast MRI

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**Purpose:** Benign/malignant overlap exists on time-intensity curve (TIC) of dynamic gadolinium-enhanced breast MRI. This study presents a new method for TIC generation to decrease overlap and improve accuracy.

**Material and methods:** MR images of 100 patients with enhancing breast lesions (64 malignant, 36 benign) obtained before and repeatedly after intravenous injection of Gd-DOTA were evaluated. Signal intensity of lesions (S<sub>lesion</sub>) and breast (S<sub>breast</sub>) were measured and TIC obtained. Relative signal intensity of the lesion was calculated as (S<sub>lesion</sub>-S<sub>breast</sub>)/S<sub>breast</sub> and plotted versus time to obtain relative TIC. Four parameters were evaluated for diagnosis of carcinoma: peak enhancement (PE), initial enhancement slope (S), time-to-peak (TTP), and washout ratio (WO). Comparison of parameter performance on TIC and relative TIC has been done by the Student's T test and the Receiver-Operator Curve (ROC) analysis.

**Results:** On TIC, TTP has been the only discriminating factor. When threshold for carcinoma has been set at TTP ≤ 2 min, sensitivity, specificity, positive predictive value, negative predictive value, and accuracy have been 36, 100, 100, 43, and 57% respectively. On relative TIC, accuracy of TTP has increased to 89%. Area under the ROC curve for TTP has improved from 0.77 for TIC to 0.86 for relative TIC (p < 0.05). WO ratio has become a second discriminating factor on relative TIC with more washout in malignant lesions (WO = 41 ± 32) than benign lesions (WO = 11 ± 19) (p < 0.05). PE and S were not statistically significant on TIC or relative TIC.

**Conclusion:** The use of relative TIC improves the discrimination of benign and malignant breast lesions.

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#### P27

##### CTPA for clinically suspected pulmonary emboli in oncology patients

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Cancer Imaging 2014, 14(Suppl 1):P27

**Aim:** Pulmonary embolism (PE) is a known cause of morbidity and mortality in oncology patients. Whilst much of the literature focuses on the detection of incidental PE in this cohort of patients (approximately 4%), little is written about the rate of positive CT Pulmonary Angiograms (CTPA) when PE is clinically suspected. We wanted to assess the rate of positive CTPA specifically amongst oncology patients with suspected PE in our teaching hospital.

**Methods:** We retrospectively analysed all consecutive CTPAs carried out for clinically suspected PE over a 12 month period in all patients under our oncology services.

**Results:** A total of 230 oncology patients had a CTPA to exclude PE and 40 were positive (17.4%). Of the positive CTPAs, most (31 scans, 77.5%) showed multiple PEs. The commonest cancer patients to undergo CTPA were lung (38), breast (34) and lymphoma (26) patients, and the highest incidence of positive CTPA were in breast (7/34), ovarian (2/9) and pancreatic (2/5) carcinoma. CTPAs carried out in colorectal carcinoma patients had the lowest probability of being positive (1/15).

**Conclusion:** The published rate of positive CTPA for clinically suspected PE in the general population is 15-20%. Our study shows that despite the widely held view that oncology patients are more prone to pulmonary thromboembolic disease, the incidence of positive CTPA is in fact similar to the general population. Our threshold for imaging oncology patients should therefore be the same as in the general population.

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#### P28

##### Interest of reference region models to monitor cancer treatment using dynamic contrast enhanced studies

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**Aim:** Dynamic Contrast Enhanced (DCE) imaging is an investigative tool to monitor cancer treatments such as antiangiogenic drugs. The difficulty of estimating an appropriate arterial input function in MRI or ultrasound for instance makes the reference region (RR) model very attractive. However it is not applicable to hepatic perfusion studies for which two input functions (hepatic artery and portal vein) have to be considered. A generalization of the RR approach to hepatic DCE studies was thus developed and validated on DCE-CT hepatic studies for which both input functions could be estimated.

**Methods:** Our generalization of the RR approach for hepatic studies takes into account two reference regions in addition to the region of interest (or current voxel for parametric imaging). To validate the estimation of the perfusion parameters, numerical simulations were carried out. Ten DCE-CT studies (from five patients with hepatic cancerous lesions observed twice during the course of an antiangiogenic treatment) were also retrospectively analyzed.

**Results:** The simulations demonstrated the validity of the new RR model for both noise-free and noisy data. On CT data, perfusion parameters were close when using the two input functions or the new RR model (relative variations being generally less than 10%). This experimental analysis gave also indications for the positioning of the two reference regions.

**Conclusion:** This new RR approach is well adapted to estimate perfusion parameters from hepatic DCE studies. It is thus a credible alternative when the input functions are difficult to quantify or out of the field of view.

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#### P29

##### Value of FDG PET/CT in the assessment of patients with colon cancer comparing to stand-alone CT

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**Purpose:** To evaluate the potential of FDG PET/CT vs. stand-alone CT in the assessment of histopathologically verified colon cancer in primary staging, re-staging and follow up.

**Material and methods:** 70 patients (39 men, 31 women, mean age 70.7 ± 10.7 years) were included in this retrospective study: 28 (40%) primary staging, 28 (40%) re-staging and 14 (20%) follow-up patients.

Fifty-eight (58/70) patients (83%) had a primary tumour stage of ≥ T3. Patients with a known secondary carcinoma were excluded. Diagnostic

contrast-enhanced CT was available in all patients (together with PET or in a separate setting with the same acquisition parameters).

The CT and FDG PET reports were examined for all patients. In discordant cases, images of both modalities were re-evaluated by a radiologist and a specialist in nuclear medicine separately.

All results were verified with histological findings or imaging and/or clinical follow-up studies for at least six months.

**Results:** In the preoperative setting, additional FDG PET had an influence on the staging in 11 (11/28) patients (39%) comparing to CT alone:

Nine (9/28) patients (32%) were downstaged, 6 of them with suspicious organ metastases, 3 patients with suspicious lymph node metastases and 1 patient with both suspicious organ metastases and lymph nodes metastases on CT.

Two (2/28) patients (7%) were upstaged by FDG PET/CT, one of them with an unclear lung lesion on CT and a malignant hilar lymph node. The second patient showed peritoneal carcinosis on FDG PET.

Comparing with stand-alone CT, only 3 (3/42) patients (7%) from the restaging and follow-up group were downstaged by additional FDG PET, while concordant findings were seen on both imaging modalities for the rest of the patients.

**Conclusion:** This study clearly showed that for primary staging of distant metastases in colon cancer patients FDG PET/CT is more advantageous and overcomes the lower specificity of CT alone.

Comparing both modalities in postoperative cases, FDG PET provides additional findings only in few cases.

### P30

#### Potential influence of automated volumetry on treatment response classifications in lung cancer lesions

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**Purpose:** To evaluate the potential influence of automated volumetry on treatment response classifications in lung cancer in comparison to manual unidimensional measurements.

**Material and methods:** 60 patients (41 men, 19 women, mean age 61.8 ± 9.4 years) with histopathologically verified lung cancer were included in this retrospective study.

For each patient, up to 2 target lesions were quantitatively evaluated in a baseline and two follow-up CT scans (77 lesions, 154 response classifications) by two independent radiologists. Hilar and mediastinal masses, as well as lesions surrounded by atelectasis were excluded.

For each lesion a unidimensional diameter measurement, as well as an automated CT-volumetry was performed. In the follow-up studies, the response evaluation was assessed using RECIST compared to volume equivalents of RECIST with converted thresholds (-65/+73%).

**Results:** The results of the manual one-dimensional measurements varied between the two observers by 6.34 ± 17.12%, affecting the volume to the power of 3, whereas the volumetric measurements varied only by 3.33 ± 6.66%.

In 16.9% (26/154) of the cases the volumetric assessment led to a different response classification.

In 13% (20/154) of the cases the different response classification would have an effect on therapeutic decisions.

**Conclusion:** The volumetric assessment of lung cancer lesions can reflect the tumour burden more appropriately and therefore has a significant effect on response classifications and therapeutic decisions.

### P31

#### Imaging diagnostic standard in multiple endocrine neoplasia (MEN)

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**Background:** Among all hereditary cancer syndromes MEN Type 1 and 2 are characterized by the concurrent but independent appearance of benign as well as malignant tumours. Neoplasias of parathyroid glands, pancreas, pituitary gland as well as neuroendocrine tumours of the stomach and intestinal wall are typical for MEN 1. Medullary thyroid carcinomas together with parathyroid adenomas and pheochromocytomas are hallmarks of MEN 2. This presentation gives an overview about the multitude of imaging techniques that are inevitable for diagnostics and long-term follow up in MEN patients beyond molecular genetic and laboratory methods.

**Methods:** Ultrasound (US) combined with nuclear medicine techniques are the leading methods to screen for pathologies of thyroid, parathyroid glands and cervical lymph nodes. For assessing metastases of a medullary thyroid carcinoma (MEN 2) DOTA-PET/CT is useful in addition to a CT/MR scan and neck and abdominal US. To detect pheochromocytoma in MEN 2, CT and MRI are superior to US. MIBG scintigraphy can be performed in unclear cases. In primary hyperparathyroidism in MEN 1 cervical US is the leading method, supplemented by Tc-99m sestamibi scintigraphy or 11c-methionine PET/CT. DOTATOC PET/CT may supplement contrast-enhanced CT or MRI in detecting even small gastrinomas or other neuroendocrine tumours of the GI tract. In the examination of the pituitary gland, gadolinium enhanced dynamic MRI is standard.

**Conclusion:** Given the complexity of multimodal imaging, a close collaboration of clinical radiology and nuclear medicine is essential to tailor the imaging protocol for MEN patients.

### P32

#### Image directed lymph node sampling for lung cancer staging

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**Educational poster objectives:** • To display methods of regional lymph node sampling for staging bronchogenic cancer.

• To illustrate how imaging directs the optimal methods of sampling in individual patients.

**Introduction:** • Summarize the lung cancer staging system.

- Show regional lymph node stations using diagrams and CT/PET images.
- Explain the need for tissue sampling in order to establish the highest stage and direct appropriate therapy. Sampling techniques with illustrations and imaging examples of accessible lymph nodes:
- Mediastinoscopy: Gold standard; outpatient surgical technique; optimal for stations 2, 4, and 7; tissue samples from all available nodal stations.
- Transbronchial needle aspiration (TBNA) with endobronchial ultrasound (EBUS): Optimal for stations 2, 4, 7, 10-12; often only abnormal nodes sampled; cytologic sample; least invasive; not universally available.
- Chamberlain procedure: Outpatient surgical technique; historical standard for stations 5 and 6; tissue samples.
- Video assisted thoracoscopic surgery (VATS): Surgical technique; optimal for stations 2R, 4R, 5, 6, 7, 8, 9, 10, and 11; tissue samples; supplanting Chamberlain procedure; must tolerate single lung ventilation.
- Endoscopic ultrasound (EUS): Optimal for stations 3p, 4L, 7, 8, 9, and occasionally 3a, 2R, 2L, 4R; cytologic sample; not universally available.
- CT guided biopsy: not routine; different approaches (e.g. parasternal) and patient positioning; optimal for large nodes; core biopsy.

**Summary:** In patients with lung cancer, choosing a method of lymph node sampling depends on anatomy, availability of techniques, amount of tissue needed, cost, and safety. CT and PET imaging are crucial for depicting anatomical relationships and directing the appropriate sampling technique.

### P33

#### Characterization of multiple myeloma osseous lesions and diffuse infiltration pattern by 18F-FDG-PET/CT, static MRI and diffusion-weighted MR Imaging (DWI-MRI): a comparative multimodality imaging study

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**Aim:** To compare the detection rates of different imaging modalities for nodular bone marrow (BM) infiltrates and osteolyses in patients with multiple myeloma (MM).

**Methods:** 55 Patients diagnosed according to the International Myeloma Working Group criteria (2003) were referred to consecutive imaging diagnostics including 18F-FDG PET/CT, T1-weighted and short-tau inversion recovery (STIR) whole-body MRI (WB-MRI) as well as diffusion weighted MRI (DWI). Images were reviewed and matched on a lesion-by-lesion basis for the location and number of focal osseous MM lesions by two radiologists and one nuclear medicine physician, grading the conspicuity of each lesion in CT, T1w, T2 STIR, DWI and ADC-Map separately. PET/CT data were compared based on qualitative and semi-quantitative (SUV) evaluation. A scoring system was used, with a certainty score as the reference for each lesion resulting from an evaluation considering all imaging modalities simultaneously. The analysis was carried out without knowledge of the previous treatment or the stage of disease.

**Results:** In static MRI and DWI different infiltration patterns were observed and PET/CT revealed comparable patterns of tracer uptake: negative, focal, diffuse and mixed. MRI including DWI demonstrates both active as well as inactive MM lesions and displays numerous additional PET-negative lesions.

**Conclusion:** Possible reasons for lesions being PET positive or negative may be their activity or cellular density of focal BM infiltrates. Additionally, nodules may be masked by surrounding, diffuse BM infiltration. To this date, PET/CT and DWI/MRI are complementary methods, as both modalities interrogate different biophysical tissue properties (cellular density vs glucose metabolism).

### P34

#### Alteration of MR-DWI/ADC before and 24h after induction of chemotherapy in patients with lung cancer

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**Background:** Diffusion weighted MRI (MR-DWI) is frequently used in oncologic therapy monitoring as it is known to predict therapy response much earlier, than measurements of tumour size alone. In several studies the outcome of chemotherapeutic treatment of brain, soft tissue, bone, breast and prostate tumours was predicted by changes in MR-DWI. Usually, follow-up studies 2 to 4 weeks after induction of chemotherapy show an increase in the apparent diffusion coefficient (ADC), predicting size changes at the end the treatment cycle. DWI measurements in patients with NSCLC ultra early after starting chemotherapy are missing.

**Patients & methods:** 23 patients with lung cancer (aged  $63.6 \pm 7.2$  years) underwent serial MRI before and 24h after starting platin-based chemotherapeutic regimens. The MRI protocol contained a DWI sequence with 6 b-values ranging from 0 to 800. Online calculated trace images and the apparent diffusion coefficient (ADC) were used for response evaluation. In 19 patients both clinical information and RECIST evaluations at the end of the second chemotherapy cycle were available.

**Results:** 18 out of 23 patients showed a decrease in ADC maps 24h after starting treatment.

In three of the 19 patients with available follow-up data, no initial ADC reduction was observed. In all of these patients a progressive disease was observed by the time of completing the second therapy cycle. In 14 patients, initial ADC reduction was associated with tumour size reduction at the end of the chemotherapy cycle.

**Conclusion:** Chemotherapy treatment of NSCLC is regularly associated with a decrease in ADC 24h after starting chemotherapy. Initial ADC reduction may predict morphologic tumour response to CHT.

### P35

#### Evaluation of hepatic flow changes in early stages after extended hepatectomy by contrast enhanced ultrasound

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**Background:** Extended hepatectomy (EH) is the only curative procedure in patients with large or multi-nodular liver tumours. However, the alterations of the hepatic inflow (HF) after EH and the consequent complications like "small for size syndrome" (SFSS) are still challenging issues. Contrast-enhanced ultrasound (CEUS) is a non-invasive approach to evaluate liver haemodynamics with the advantages of imaging very low blood flow rates at the tissue perfusion level. The aim of this study is to detect the haemodynamic alterations after EH in early stage by CEUS in an experimental setting.

**Method:** An in vivo procaine model was studied using a low mechanical index in conjunction with single-level dynamic CEUS. A sulfur hexafluoride contrast agent (SonoVue; Bracco SpA, Milan, Italy) was applied in 5 pigs by intravenous bolus injection. Data were acquired before and after up to 75% sequential liver resections. Corresponding parameters of the time-intensity curve were measured using wash-in/wash-out curve software (Vuebox; Bracco SpA, Milan, Italy).

**Result:** Following sequential liver resection, the total HF increased gradually. In detail, the hepatic artery flow decreased 17% and portal vein flow increased around 70% after extended liver resection (75%). Also, with sequential liver resection, the PVP increased gradually up to 33% after extended liver resection (75%).

**Conclusion:** Quantitative and qualitative measurement of THF alteration in early stages is feasible by CEUS. CEUS is a suitable modality for follow-up control after EH in order to prevent postoperative complications such as SFSS, which lead to liver failure.

### P36

#### Pictorial review of cardiac sarcomas and their mimickers

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**Purpose:** This review will present a spectrum of cardiac sarcomas and mimicking conditions in order to provide tools for differentiation.

**Background:** Cardiac sarcoma remains one of the most aggressive primary cardiac tumours, which can arise from different cardiac chambers and demonstrate various features, depending on differentiation and histologic composition. In many cases the diagnosis is difficult, and consequences of incorrect diagnosis are too harmful.

We will present different types of cardiac sarcomas and their imaging features by MRI and CT in selected cases.

We will also show and discuss features of sarcomas like conditions, presenting diagnostic challenge, such as pulmonary artery thrombus mimicking angiosarcoma, fibrosing mediastinitis, infiltrative primary cardiac lymphoma, benign tumours, and thrombi.

**Summary:** This review aims to present imaging characteristics of cardiac sarcomas, their most important mimickers and benign differential diagnoses in order to avoid potential pitfalls, guide to achieve proper diagnosis, leading to timely and appropriate treatment.

### P37

#### Imaging manifestations of unusual side effects of new anticancer medications

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**Aim:** To illustrate imaging manifestations of unusual side effects of some new anti-cancer medications.

Many of the new anti-cancer medications target specific biologic pathways and are expected to cause less adverse effects on healthy tissues. Some of these agents are associated with unusual side effects, recognition of which is clinically important.

Ipilimumab is a monoclonal antibody against cytotoxic T lymphocyte-associated antigen (CTLA)-4 used for the treatment of metastatic melanoma. Though it has been shown to increase overall survival rates, it also results in various immune-related adverse effects, one of which is hypophysitis.

Crizotinib is an anaplastic lymphoma kinase (ALK) and c-ros oncogene 1 inhibitor, approved for treatment of non-small cell lung carcinoma. Its side effects include the unusual formation of complex renal cysts which mimic renal abscesses or malignancy.

In this presentation, we illustrate the imaging manifestations of Ipilimumab associated hypophysitis, early recognition of which is important as cessation of the drug in affected patients leads to resolution of hypophysitis, and also demonstrate complex renal cysts associated with the use of Crizotinib, knowledge of which is important to avoid misdiagnosis of renal abscess/ malignancy and consequent inappropriate treatment or stoppage of Crizotinib.

### P38

#### Optimising structural imaging of neuroendocrine tumours in the molecular imaging age

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**Aim:** To provide an educational update on structural imaging appearances of neuroendocrine tumours (NET), in the age of molecular imaging.

PET/CT with Ga-68 DOTA-TATE and F-18 fluorodeoxyglucose (FDG) is providing new understanding of neuroendocrine tumours including patterns and heterogeneity of disease. This is also providing new insights of structural imaging findings including CT and MRI. It is also important to be aware of the limitations of PET/CT imaging, and we outline indications where structural imaging has a high impact for patient management. These changing paradigms are translating to revised imaging protocols in our institution that are enabling personalised medicine with appropriate selection of management for an individual patient. It is also allowing us to understand the structural imaging appearances of heterogeneity within the same tumour type. A range of new targeted therapies including peptide receptor radionuclide therapy (PRRT) are now available to treat patients with non-resectable metastatic NET. New patterns of response are emerging which are important to recognise, including cystic necrosis which may initially masquerade as progressive disease due to enlargement.

We have a large population of patients with neuroendocrine tumours at Peter MacCallum Cancer Institute, providing wide experience of this spectrum of imaging findings across various subtypes of NET. We present a pictorial review of our experience.

### P39

#### Modern technology: lowering the radiation dose for lung cancer screening

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Cancer Imaging 2014, 14(Suppl 1):P39

**Purpose:** This review aims to present advances of modern technology that can be applied to lower the radiation risk for lung cancer screening.

**Background:** Lung cancer remains one of the deadliest cancers with late detection and high mortality rates. Results of the NLST trial published in 2011 demonstrated a 20% decrease in lung cancer mortality in the CT arm compared to the radiography arm. One of the biggest concerns of

wide implementation of lung cancer screening by CT, is radiation risk and radiation-induced cancer.

We present various techniques, from tube current modulation to low dose and ultra low dose CT with adaptive statistical iterative reconstruction (ASIR) and model based iterative reconstruction (MBIR), that introduce much lower radiation dose, while remain diagnostic for lung cancer screening.

We will also present our model of radiation risk estimation based on lower radiation doses used in modern studies.

**Summary:** This review will present newer currently available techniques for radiation risk reduction and our model of radiation risk estimation in comparison with available older models, based on calculations of radiation doses on population of atomic bomb survivors.

### P40

#### Batson's plexus and retrograde venous spread of malignancy – a pictorial review

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**Aim:** Batson's venous plexus is a system of paravertebral veins that connect pelvic and thoracic vessels to the intraspinal (basivertebral) veins. It was first described in 1940 to explain a route for spread of metastases and infection that was separate to the lymphatic system. Its role in the retrograde venous spread of malignancy is now well-described, but not widely demonstrated on imaging.

**Method & results:** We present a detailed pictorial review of imaging of patients from our oncology centre showing retrograde venous spread to the paravertebral vessels specifically in cases of renal, rectal and breast carcinoma.

We demonstrate expansion of the paravertebral vessels containing tumour and associated vertebral body metastases.

We also review and illustrate the spinal venous anatomy.

**Conclusion:** Radiologists should be aware of the implication of Batson's venous plexus as a route of metastatic dissemination. Our pictorial review highlights the importance of the paravertebral vessels as a review area.

### P41

#### Role of dual phase MDCT in renal cancer – beyond the renal mass

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Cancer Imaging 2014, 14(Suppl 1):P41

**Aim:** To illustrate the anatomy of renal vasculature and its variants on cross-sectional imaging.

To highlight the benefits of obtaining images in both arterial and venous phase in staging and follow-up of renal cancer.

**Content:** It is common practice to perform dual phase computed tomography (CT) in preliminary staging and subsequent follow-up of renal cancer patients in some institutions across the United Kingdom. We provide the best examples from our institution (2010-2013) with illustrations and the clinical relevance for the conditions stated below.

**Arterial phase:** We discuss the normal anatomy and variants of the renal artery including early division of artery, accessory artery and double renal artery. In addition, usual and uncommon sites (e.g. muscle, small bowel, pancreas) of hypervascular metastasis in primary renal cancer patients will be illustrated.

**Portal-venous phase:** We will highlight the normal anatomy and variants of the renal vein (e.g. aberrant, accessory renal veins) and associated tumour infiltration in unexpected veins (e.g. portal vein, gonadal vein) and solid organ metastasis.

**Conclusion:** The renal vasculature is frequently visualised on imaging but often overlooked. This exhibit will provide radiology trainee's an insight into the anatomical variants and its relevance in management of primary renal cancer. It reminds them of the common and uncommon metastasis and tumour infiltration seen in renal cancer, thus affecting the outcome.

## SCIENTIFIC SESSION PRESENTATIONS

### S1

#### Therapy response assessment with quantitative PET: evaluation of a shortened acquisition protocol with dynamic PET/CT

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**Purpose:** The results of SUV quantification for prediction of histopathological response in patients with oesophageal carcinoma show high variations with different accuracy. However, the routine use of a full dynamic PET is limited because of long acquisition times. We tested a shortened acquisition protocol for quantitative PET to overcome that limitation.

**Material and methods:** 13 patients with histopathologically proven oesophageal adenocarcinoma underwent a combined dynamic and static <sup>18</sup>F-FDG PET/CT including CT tumour perfusion (Siemens, Biograph mCT). Dynamic PET (listmode) was acquired for 60 min resulting in 38 frames from 10 to 600 sec duration for the full dynamic dataset and 2 frames each with 600 sec duration (20-30 min and 50-60 min p.i.) for dual time point PET (DTP). We evaluated the metabolic rate Ki using different models: 2-compartment irreversible model (Fit), Patlak plot and DTP (van den Hoff et al). The CT tumour perfusion protocol included the parameters blood flow, blood volume and permeability.

**Results:** The metabolic rate Ki could be reliably reproduced independent of the analytical model; we observed only slight variations of Ki with respect to the analytical model: -4,9% (Patlak vs.Fit), -10% (DTP vs.Fit) and -5,1% (DTP vs.Patlak). A linear regression revealed a strong correlation of the Ki values: R<sup>2</sup> = 0,996 (Patlak vs. Fit), R<sup>2</sup> = 0,968 (DTP vs.Fit) and R<sup>2</sup> = 0,985 (Patlak vs. DTP).

**Conclusion:** The shortened dynamic acquisition protocol of DTP-PET is a reliable method for the determination of the metabolic rate Ki and can substitute a full dynamic scan for improved quantitative assessment of therapy response.

### S2

#### Prostate-MRI: experience of the observer and technical conditions influence the cancer detection rate

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**Aim:** The prostate cancer (PCa) detection rate of MR-guided biopsy (MRGB) increased in our hospital from 36.6% in 2012 to 69% in 2013. The study analysed the values of the mpMRI-characteristics of identifiable lesions retrospectively to show the influence of the increasing experience of the observer and modified technical conditions.

**Methods:** 56 patients (pat.) with mostly at least one prior negative TRUS-guided biopsy and persistent suspicion of PCa with at least one mpMRI-defined identifiable cancer suspicious lesion were included in this study between 2012 and 2013. MpMRI: 1.5 T/e-coil/T2WI/DWI, b-values 2012: 0-1500, 2013: 100-1500/DCE-MRI. MRGB: in-bore. Characteristics of lesions (ADC, ESUR PIRADS) were statistically correlated with core needle biopsy results (ROC). A p value of p < 0.05 was considered as statistically significant.

**Results:** 2012/2013: detection rate of all suspicious lesions 33%/58%; in peripheral zone 45%/50%; in transitional zone 14%/67%. The ROC curve area difference was statistically significant for 2012/2013 for ADC 0.65/0.83 (P=0.008). The cut-off values [cut-off (sensitivity; specificity)]: 2012/2013: ADC 836 (0.58;0.58) / 651 (0.72;0.71); 2013: PIRADS DWI 3.5 (0.57;1.0), PIRADS DCE 3.5 (0.63;0.69), PIRADS T2 3.5 (0.71;0.86).

**Conclusion:** Modified DWI as to exclude microcapillary perfusion effects leads to lower cut-off value and higher diagnostic value of the ADC. The increasing experience of the observer enhances the evaluation of the

transitional zone. The combination of the modified technical conditions and increasing experience of the observer leads to higher sensitivity and specificity of the overall mpMRI prostate evaluation and (PCa) detection rate.

### S3

#### Localised prostate cancer treated with MRI-guided transurethral ultrasound ablation: phase I trial results

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**Purpose:** Purpose of this prospective, multi-institutional Phase I clinical study was to investigate whether MRI-guided transurethral ultrasound ablation (MR-TULSA), a novel minimally-invasive technology to treat organ-confined prostate cancer (PCa), is safe, feasible and effective. It employs directional plane-wave high-intensity ultrasound, which ablates prostate tissue using real-time thermometry with active temperature feedback control.

**Methods:** Enrolled were 30 patients with biopsy-proven, low-risk prostate cancer (age ≥ 65y, T1c/T2a, PSA ≤ 10ng/ml, Gleason 6 (3+3)). Whole-gland prostate ablation was performed with MR-TULSA using the PAD-105 (Profound Medical Inc., Canada) and a 3T MRI (Siemens, Germany) in one single treatment session under general anaesthesia and 3D active MR-thermometry feedback control. Contrast-enhanced MRI (CE-MRI) immediately following the ablation and at 12 months confirmed thermal coagulation.

**Results:** There were no intraoperative complications with normal micturition resuming after catheter removal. Median (range) treatment time and prostate volume were 36 (24-61) min and 44 (21- 95) ml, respectively. Maximum temperature during treatment depicted a continuous region of heating shaped accurately to the prostate within 0.1 ± 1.3 mm, with average over- and under- targeted volumes of 0.8 and 1.0 ml, respectively. Regions of acute cell kill on CE-MRI correlated well with treated volume on MR-thermometry. Successful treatment was further confirmed by a median PSA decrease from 5.35 to 0.70 ng/ml at 1 month (n=29), remaining stable to 0.65 ng/ml at 6 months (n=16).

**Conclusion:** Phase I results show that MR-TULSA represents a minimally-invasive treatment option for safe, effective and accurate whole-gland thermal ablation of organ-confined prostate cancer.

### S4

#### Agreement of diameter- and volume-based pulmonary nodule management in CT lung cancer screening

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**Aim:** To determine the agreement of manual and semi-automatic (SA) diameter and volume measurements of nodules found in low-dose computed tomography lung cancer screening.

**Methods:** Baseline data of 2,240 solid intermediate-sized nodules (volume 50-500mm<sup>3</sup>) in 1,498 Dutch-Belgian NELSON trial participants were used. Extrapolated volume based on semi-automatic (SA) maximum diameter and mean of maximum transversal and perpendicular diameter were compared

to SA volume measurements by Bland-Altman plots. Analyses were repeated by margin (smooth, lobulated, spiculated, and irregular) and shape (spherical or non-spherical). In 100 randomly selected nodules, diameters were measured manually by two independent radiologists, and compared to the SA diameters.

**Results:** Median participant age was 59-years (interquartile range:8), 14.2% were women. Compared to SA volume, volume extrapolated from SA mean or maximum diameter led to mean overestimation of 47.2% (95%-confidence interval (CI): 44.7-49.7%) and 85.1% (95%-CI:81.2-89.0%), respectively. For irregular and non-spherical nodules, mean overestimation was higher; 161.7% (95%-CI:131.7%-191.8%) and 168.9% (95%-CI:155.2%-182.5%), respectively. Manual diameter measurement overestimated SA maximum diameter by  $\geq 10\%$  in 44% (44/100) and underestimated by  $\geq 10\%$  in 18% (18/100) of the nodules. Using a 10-mm criterion for referral, SA maximum diameter measurements of indeterminate nodules would have led to direct referral in 7.9% (177/2240). Manual measurements would have led to 31% (31/100) referrals.

**Conclusion:** The agreement between manual and SA diameter, as well as between volume extrapolated from SA diameter and SA volume is poor. Applying manual and SA diameter measurement in CT lung cancer screening leads to a substantial shift in nodule stratification compared to SA volume measurements.

## S5

### Robot-assisted navigation system for CT-guided percutaneous lung tumour procedures: our initial experience in Hong Kong

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Cancer Imaging 2014, 14(Suppl 1):S5

**Purpose:** To evaluate the new robot-assisted navigation system for CT-guided lung tumour procedures

**Materials and methods:** Imaging-guided lung procedures are usually challenging due to patient breathing. This is an ongoing prospective study with 50 patients targeted in a university-based hospital. This was an initial assessment of efficacy involving 10 patients with lung tumours who underwent CT-guided lung interventions utilizing the robot-assisted Navigation system (Maxio, Perfint Healthcare, USA). The targeted needle pathway was planned on Maxio Robotic system based on pre-procedural CT-scans. The primary endpoint was satisfactory instrument position for intended intervention. Lesion size and depth from skin were noted. Performance level was documented on a five-point scale (5-1: excellent-poor). Total radiation doses were recorded and compared against 20 patients with conventional CT-guidance and CT-fluoroscopy lung procedures (ratio 1:1).

**Results:** There were 7 male and 3 female patients in the robotic group. Average age was 72.1 years (range 67-78). 8 patients underwent lung biopsy while the rest had thermal ablation or fiducial marker insertion. Average lesion size was 2.8cm (range 1.9-4.1cm). Average lesion depth was 6.2cm (range 3.7-8.6cm). All interventions met the primary endpoint of satisfactory instrument positioning. Average performance levels were 4.5. Average radiation dose (Dose Linear Product) was 480.4 (range 196.5-959.8) whereas conventional CT-guidance was 645.4 (range 285.1-1043.5) and CT-fluoroscopy was 460.1 (range 214.2-1157.0).

**Conclusions:** Our initial experience demonstrated effectiveness of the robot-assisted navigation system for CT-guided lung tumour interventions with lower radiation dose compared with conventional CT-guided procedures. Radiation doses were similar to CT-fluoroscopy without radiation exposure to interventional radiologists. Targeting success rate for satisfactory intervention was 100%.

## S6

### CT texture analysis of pulmonary lesions in patients suspected for lung cancer

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**Objective:** In this preliminary report we evaluate the impact of CT texture analysis (CTTA) of pulmonary lesions when compared to final tumour stage in patients with suspected lung cancer on contrast enhanced CT.

**Methods:** Using texture analysis, we analysed 104 lesions in 104 patients suspected for lung cancer with a positive CT correlate. The analysis was performed using TexRAD (developed by TexRAD Ltd. UK). Histology was our reference standard. Malignancy was present in 92 lesions. CTTA comprised a filtration-histogram technique where filtration extracted and enhanced features of different sizes (fine, medium, coarse – scales) followed by histogram analysis using mean (M), entropy (E), uniformity (U), total number of voxels and kurtosis (K) within the entire volume of the suspected lesion. The operator performing the CTTA was blinded to the histological results.

**Results:** In 58 malignant lesions with histologically verified TNM tumour stage, a Spearman's rank correlation found significant positive correlations between Kurtosis and tumour stage at coarse filter scales. ( $\rho(58)=0.476$ ,  $p<0.0005$ ). We also found a significant positive correlation between total number of voxels and tumour stage on unfiltered data ( $\rho(58)=0.387$ ,  $p=0.003$ )

**Conclusion:** A significant correlation between texture figures and final tumour stage was found in patients with lung lesions suspected for lung cancer. Texture analysis may add complementary information to CE-CT.

## S7

### Whole-body diffusion-weighted MRI versus CT for detection, restaging and operability assessment of recurrent ovarian carcinoma

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**Aim:** To evaluate whole body diffusion-weighted MR imaging (WB-DWI MRI) for detection, staging and operability assessment in recurrent ovarian cancer compared with CT.

**Methods:** Fifty-one women suspected for recurrent ovarian cancer underwent 3-Tesla WB-DWI/MRI using 2 b-values ( $b=0-1000$  s/mm<sup>2</sup>), T2- and contrast T1-weighted sequences in addition to CT. WB-DWI/MRI and CT were compared for per-patient detection of recurrence, per-site detection of disease extent including peritoneal, serosal, retroperitoneal, periportal and distant metastases and for detecting disease extent according to institutional operability criteria. Imaging findings were correlated with surgical/pathological findings or imaging follow-up for at least 6 months.

**Results:** According to the reference standard, recurrence was confirmed in 48/51 patients. WB-DWI MRI showed 94% accuracy for detecting recurrence, versus 78% for CT. Per-site analysis showed significantly higher sensitivity of WB-DWI MRI over CT for assessing disease extent of the peritoneum, small bowel and colon mesentery and serosa ( $p<0.000001$ ,  $p<0.000001$  and  $p=0.00002$ , respectively), retroperitoneal suprarenal lymphadenopathies and periportal lesions (both  $p=0.031$ ). Following institutional operability criteria, WB-DWI/MRI showed better sensitivity for detection of disease extent compromising operability; mesenteric root infiltration ( $p=0.008$ ), carcinomatosis of small bowel ( $p=0.002$ ) and colon ( $p=0.016$ ), high volumetric peritoneal disease load ( $p=0.004$ ) and irresectable distant metastases ( $p=0.016$ ). WB-DWI MRI correctly predicted complete cytoreduction in 93% patients undergoing cytoreductive surgery versus 40% for CT.

**Conclusion:** WB-DWI MRI showed higher accuracy compared with CT for recurrence detection while improving the sensitivity for staging and operability assessment of disease extent. WB-DWI MRI may be most valuable to select patients for surgical resection.

## S8

### Three-dimensionally fused gadolinium-enhanced and diffusion-weighted images: value in determination of multi-centricity of breast carcinoma

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**Purpose:** 72 patients with biopsy-proven breast carcinoma were sent to MR imaging for preoperative assessment of multicentricity. Based on mastectomy/ lumpectomy specimens and further biopsies, 47 patients had single lesions, and 25 had multiple lesions with a total number of 116 proven malignant foci. The preoperative MR images were retrospectively reviewed and post-processed to obtain three-dimensional fused images of early gadolinium enhancement (encoded in red) and diffusion-weighted images (encoded in green) at  $b=1500$  s/mm<sup>2</sup>. To eliminate the T2 shine-through effect, lesions with  $ADC \geq 1 \times 10^{-3}$  mm<sup>2</sup>/s were eliminated. The post-processed images were reviewed by an experienced blinded radiologist, who noted all the lesions with a diameter  $\geq 5$  mm, classifying them into three groups: matched enhancement and diffusion restriction (matched E-DR), unmatched diffusion restriction (DR), and unmatched enhancement (E).

**Results:** 313 lesions with a diameter  $\geq 5$  mm were identified. 101 lesions showed matched E-DR. Taking matched E-DR as indicative of malignancy, sensitivity, specificity, positive predictive value, negative predictive value and accuracy for diagnosis of individual malignant foci were 84.5, 98.5, 97, 91, and 93.3 % respectively. Three false positive foci of matched E-DR were due to fibroadenomas. 18 false negative foci have been due to foci of DCIS less than 1 cm in diameter. Conclusion: Fused images of gadolinium enhancement and diffusion restriction offer a reasonably accurate assessment of multicentricity in patients with breast carcinoma.

### S9

#### Whole-body diffusion-weighted imaging for staging lymphoma: are apparent diffusion coefficient derived histogram parameters useful for lesion characterisation?

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**Aim:** To evaluate apparent diffusion coefficient (ADC) derived histogram parameters for lesion characterization in whole-body diffusion-weighted imaging (WB-DWI) of lymphoma.

**Methods:** Fifteen patients with histopathology proven lymphoma (11 Non-Hodgkin; 4 Hodgkin lymphomas) underwent WB-DWI using 2 b-values (0-1000 s/mm<sup>2</sup>). On coronal reformatted b1000 WB-DWI images, regions of interest (ROI) were drawn semi-automatically on lymph nodes in all nodal stations (n=267) and in axial and appendicular bone regions (n=53). For each ROI, a histogram was constructed from which volume,  $mean_{(ADC)}$ ,  $median_{(ADC)}$ ,  $skewness_{(ADC)}$ , and  $kurtosis_{(ADC)}$  were calculated. Mann-Whitney-U tests were performed to detect significant differences between malignant and benign ROIs per tissue type. Receiver-operating-characteristic curves (ROC) were constructed from which an optimal threshold was determined as well as sensitivity, specificity and accuracy. PET/CT plus bone marrow biopsy (BMB) served as reference standard.

**Results:** All parameters were significantly different between malignant and benign lymph nodes ( $p < 0.001$ ) with  $skewness_{(ADC)}$  being the most accurate. A positive skewness exceeding 0.3041 mm<sup>2</sup>/s allowed for detection of malignant lymph nodes with 88% accuracy, 88% sensitivity and 87% specificity compared to 63% accuracy, 61% sensitivity and 64% specificity for  $mean_{(ADC)}$ . Only  $kurtosis_{(ADC)}$  ( $p < 0.001$ ) and  $skewness_{(ADC)}$  ( $p = 0.003$ ) were significantly different between malignant bone marrow infiltration and normal bone marrow.  $kurtosis_{(ADC)}$  showed highest accuracy and a threshold exceeding 5.26 allowed for detection of malignant bone marrow infiltration with 89% accuracy, 86% sensitivity and 90% specificity.

**Conclusions:** ADC histogram analysis is feasible for lesion characterization in WB-DWI of lymphoma. Lymph nodes were most accurately characterized using  $skewness_{(ADC)}$  and bone tissue using  $kurtosis_{(ADC)}$ .

### S10

#### Staging the clinically negative neck in T1-T2 oral cancers: USgFNAC and sentinel node biopsy

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**Background:** A meta-analysis by deBontd declared ultrasound guided fine needle aspiration cytology (USgFNAC) as the method with the highest diagnostic odds ratio for detecting metastatic nodes in head and neck squamous carcinoma (HNSCC). Sentinel node biopsy (SNB) is another emerging method for evaluating neck nodes in HNSCC with reported high sensitivity and negative predictive value (NPV).

**Objective:** The aim of this study was to compare USgFNAC with SNB for the preoperative evaluation of the clinically negative neck in T1 & T2 oral cavity squamous cell carcinoma (OCSCC).

**Methodology:** This is a prospective observational study in 51 patients with T1-T2 N0 OCSCC. Pre-operative ultrasonography (US) of the neck was performed in all patients. USgFNAC was performed in patients where US was reported as indeterminate or positive. SNB was performed in all patients and was followed by elective neck dissection (END). The sensitivity, specificity, positive predictive value (PPV) and NPV of SNB, USgFNAC and US were calculated considering END and histopathology (HP) as the gold standard.

**Results:** The incidence of occult metastasis on HP was 26.4%. The sensitivity, specificity, PPV and NPV were 71.4%, 100%, 100% and 90.2% for SNB; 50%, 82%, 50% and 82% for US; and 14.3%, 100%, 100% and 76.5% for USgFNAC respectively.

**Conclusions and relevance:** The meta-analysis by deBontd with reported highest accuracy for USgFNAC included both clinically positive and negative necks. This study evaluated USgFNAC and SNB in the clinically negative neck in T1-T2 oral cancers and found SNB clearly superior to USgFNAC.

### S11

#### Multiparametrical diffusion weighted imaging for the detection of anaplastic transformation of low-grade gliomas

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**Aim:** The precise detection of anaplastic transformation in low-grade gliomas using magnetic resonance imaging (MRI) is impeded by postoperative changes in brain tissue. We tested the diagnostic value of diffusion tensor-derived axial diffusivity (AD), mean diffusivity (MD) (=apparent diffusion coefficient) and radial diffusivity (RD) maps in comparison to T1w and T2w sequences.

**Methods:** The study was approved by the local ethics committee. Forty-seven patients with histopathologically proven low-grade glioma II° were included, 28 were stable and 19 patients had post-surgical anaplastic transformation. All patients underwent pre-operative MRI, surgery and subsequent post-operative MRI follow-ups at 1.5T including T1w, T2w sequences and a DTI-protocol. The scalar indices AD, MD and RD were calculated voxel-by-voxel for all patients from the tensor eigenvalues and the minimum value within a gross tumour segmentation was extracted using MITK-Diffusion, respectively.

**Results:** Hypointense clusters were seen in every patient with anaplastic transformation in the DTI maps with best contrast-to-noise in AD. In 65% of patients with anaplastic transformation, these clusters were noticed at the same time when compared to contrast enhancement. In 35% of patients, hypointense changes were visible in AD maps in examinations prior to the initial contrast enhancement. ADmin showed best combined sensitivity/specificity (94.4%/89.7%, AUC 0.96) to indicate transformation.

**Conclusion:** AD maps provide additional essential information for anaplastic transformation of low-grade gliomas after resection and indicate the progress at the same time or earlier when compared to T1w-CE. We conclude that it is advisable to use a DTI-protocol instead of standard diffusion-weighted imaging for neuro-oncological exams.

**S12**

**Diagnostic accuracy of Staging of Wilms' Tumour in the era of multislice CT**

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**Aim:** To assess the diagnostic accuracy of CT in local staging of Wilms' Tumour.

**Method:** Audit of radiology reports (16 slice CT), surgical notes and histopathological reports in 24 cases of unilateral non-metastatic Wilms' tumour (2012 to 2014).

**Results:** 24 patients were eligible. 12 boys, 12 girls, age range of 1-10 years (mean 3.9). 6 patients underwent upfront surgery (Group A) while 18 patients received 4 weeks of chemotherapy (Group B). The post chemotherapy scans were compared to gold standard in latter group. Renal vein involvement: Present in 8 patients (all group B), CT had 100 % sensitivity, 90 % specificity, NPV 100%.

Renal sinus involvement: Present in 14 patients (4 group A, 10 group B). Sensitivity and specificity of CT was 25%, 100% for group A and 90%, 50% for group B.

Renal pelvis involvement: Present in 8 patients (1 group A, 7 group B). Sensitivity and specificity of CT was 71.4%, 81.8 % for group B and specificity of 100% for group A.

Renal Capsular involvement (but not necessarily the margin) was present in 6 patients (2 group A, 4 group B). Sensitivity and specificity of CT was 50%, 100% for group A and 42.8%, 75% for group B.

Overall, CT stage matched histopathological stage in 4/6 patients in group A and in 12/18 patients in group B (66.6% in both groups).

**Conclusion:** CT staging has higher specificity in upfront surgery, probably because the smaller tumour size. The sensitivity of CT staging with regards to renal vein, sinus and pelvic involvement is better than renal capsular involvement, where CT tends to over-stage disease in larger tumours.

**Cite abstracts in this supplement using the relevant abstract number, e.g.:** Kembhavi *et al.*: Diagnostic accuracy of Staging of Wilms' Tumour in the era of multislice CT. *Cancer Imaging* 2014, **14(Suppl 1)**:S12