Recent advances in hepatic imaging techniques have drawn particular attention to detection and characterization of liver lesions. Optimal imaging diagnosis of hepatic lesions surely depends on the understanding of currently available modalities and its tailored application in consideration of clinical information.

At present CT is the most frequently used modality for imaging the liver. The development of multi detector computed tomography (MDCT), which allows scanning the liver at multiple phases of contrast enhancement, may improve the diagnostic accuracy of hepatic lesions. Some of the recent advances in MDCT technology include three-dimensional (3D) imaging software and volumetric analysis. Dual energy technology attempts to reduce radiation dose by eliminating the non-enhanced phase of imaging. The advantages of MRI as a pre-operative imaging modality for liver masses are many fold. MRI with intravenous contrast can be used in patients with allergy to iodine based contrast. The emergence of liver specific MR contrast agents has added a new dimension by effectively discriminating between lesions of hepatocellular origin such as hepatocellular carcinoma (HCC) and focal nodular hyperplasia (FNH) from non-hepatocellular etiology such as metastases and cholangiocarcinoma.

CT of the liver

Non contrast CT imaging (NECT) alone is not routinely performed in clinical practice due to the low inherent attenuation difference between the normal liver parenchyma and lesions. Single phase imaging during the portal venous phase of enhancement is desirable, because ~ 75% of hepatic blood flow is supplied by the portal venous system, and hence better delineation of common hypovascular hepatic focal lesions, such as majority of metastases and cysts against enhanced hepatic background is possible.

A triple pass technique can be performed only on MDCT scanner (Fig. 1). The first imaging pass provides a true (or early) arterial phase and enhancement of hypervascular focal lesions. The second pass corresponds in timing to the initial opacification of the portal venous system and is called late arterial or 'parenchyma phase'. For both primary and metastatic hypervascular neoplasms such as HCC, islet cell tumor, carcinoid and sarcoma, approximately 30% additional lesions are detectable on the late arterial dominant phase than in the delayed hepatic venous phase of enhancement. In the third imaging pass also known as hepatic venous phase, the hepatic veins are enhanced and the enhancement of background hepatic parenchyma is maximized. Acquisition timing corresponds to what has been conventionally labeled as the ‘portal venous phase’. Tumors, like HCC which are hyperattenuating on the arterial phase and parenchyma phase may become isoattenuating or hypodense on the hepatic venous phase (1, 2).

The appropriate scan delay for helical CT depends upon the contrast medium injection protocol used. The timing of peak aortic and hepatic contrast enhancement depends primarily on the injection duration. Rapid or low-volume (shorter duration) injections produce earlier peak enhancement, whereas slow or high-vol-

Fig. 1. — Early arterial (A), venous phase (B), and delayed phase (C) images demonstrate a right lobe HCC (arrow on A). An additional lesion is seen as a hypodense lesion against an enhanced hepatic background, consistent with multifocal HCC in a non-cirrhotic liver (arrow on C).
The ability to lower- and higher energies, are independently reconstructed. The ability to
to scan delay for multiphase imaging. Two passes during the arterial
phases can also be evaluated.

Clinical utility
The shorter acquisition time of MDCT provides intense enhancement with
and improved separation between the phases of contrast enhancement. There is less
improved resolution, and improved lesion detection. Use of 2.5-mm-thick sections result-
small lesions and improved lesion detection. Use of 2.5-mm-thick sections result-
ction tim e, motion artifacts are com-
mation, yielding greater conspicuity of small lesions and improved lesion detec-
detection of microscopic in hepatic neoplasms.

Multiplanar reconstruction algorithm allows complete delineation of normal
artery and hepatic infarction can also be evaluated.

MDCT with dual energy capabilities have been introduced recently. The most
current dual-energy technique is based on dual detector capability. There are two
layers of detectors on the CT, the upper layer primarily absorbs the lower X-ray
energy spectrum, and the lower detector layer absorbs the remainder of the spec-
trum, mainly in the higher energy range. Data from each layer, corresponding to
lower- and higher energies, are inde-
developmentally reconstructed. The ability to
process virtual nonenhanced (VNE) images, by subtracting the iodine content of
contrast-enhanced CT images using image post-processing techniques, may
obviate the need for the nonenhanced imaging phase in multiphase studies. The
benefits include shorter scan time and reduced radiation. VNE images can be
useful in various clinical settings, such as CT urogram (7, 8).

MRI
MRI allows better detection and characterization of diffuse and focal hepatic
parenchymal lesions and the biliary system. Newer contrast agents have provided
a new dimension to imaging of the liver.

Technique
MRI of the liver consists of the following elements:
1) T1-weighted imaging
2) T2-weighted imaging
3) “Ghost” control techniques to reduce fat or respiratory motion artifact.
4) T1 and T2 weighted images and contrast imaging.
5) New techniques such as Diffusion weighted imaging (DWI), MR Elasto-

Table I. — MDCT Protocol for liver in our practice.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Indications</th>
<th>IV rate/vol</th>
<th>Delay (sec)</th>
<th>Area</th>
<th>Collimation (mm)</th>
<th>Feed (mm)</th>
<th>Reconstruction (thk./int.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic liver</td>
<td>Metastatic work up</td>
<td>C+</td>
<td>4/100</td>
<td>70</td>
<td>liver A/P</td>
<td>3.0</td>
<td>15</td>
</tr>
<tr>
<td>Hypervascular liver lesion</td>
<td>Hypervascular, metastasis, HCC, FHN, hemangioma</td>
<td>H2O</td>
<td>4/100</td>
<td>20</td>
<td>liver</td>
<td>3.0</td>
<td>15</td>
</tr>
</tbody>
</table>

C+: 2.1% dilution of barium sulfate, H2O: water, A/P: abdomen to pelvis, thk: Thickness, int.: interval.

1) Conventional spin-echo pulse sequence (CSE) is used in patients incapable of holding their respiration for breath-hold gradient-echo pulse sequences. Due to prolonged acquisition time, motion artifacts are common.
2) Gradient-echo pulse sequence (GRE) is more common and multi-section spoiled gradient-echo pulse sequences image the entire liver in one or two breath-holds with higher contrast and SNR.
3) Chemical shift imaging uses two T1-weighted gradient-echo pulse sequences with identical parameters except for TE, to produce in-phase and opposed-phase images, thereby aids in the diagnosis of steatosis and detection of microscopic in hepatic neoplasms.

T1-weighted imaging
1) Conventional T1 spin-echo sequences have been practically abandoned due to their long acquisition times (up to 20 minutes) resulting in cardiac flow and particularly respiratory artifacts.

T2-weighted imaging
1) Conventional T2 spin-echo sequences have been practically abandoned due to their long acquisition times (up to 20 minutes) resulting in cardiac flow and particularly respiratory artifacts.

Fig. 2. — Coronal reformatted image demonstrates thrombosis of the right and left branches of portal vein (white arrows) with multiple rim enhancing abscesses (black arrows).
to characterize hepatic masses. EPI allows diffusion images that can be used due to marked chemical shift artifacts. EPI requires enhanced gradients with high field strength, a higher soft tissue contrast resolution can be achieved (9).

2) Fast spin-echo (FSE)
   a. Rapid acquisition with relaxation enhancement (RARE) uses a single excitation pulse followed by a long train of spin-echoes with a different amplitude phase encoding gradient applied for each spin-echo.
   b. Hybrid RARE. Hybrid RARE uses multiple excitation pulses, with each excitation pulse followed by two or more 180° refocusing pulses.

Fast recovery fast-spin-echo (FRFSE) is a breath-hold pulse sequence that utilizes additional radiofrequency pulses after each echo-train to drive the recovery. Some breath-hold techniques such as FRFSE show lower lesion-liver contrast and low SNR, which may reduce the detection of solid liver masses requiring additional sequences.

c. Single short hybrid RARE (SSHR) sequences are termed: 1) half Fourier acquisition single-shot turbo spin-echo (HASTE); and 2) single-shot fast spin-echo (SSFSE).

SSHR allows sub second single-slice imaging, obviating motion artifact reduction measures. While producing high quality abdominal images, the limitations include reduced contrast between solid hepatic lesions and the surrounding parenchyma. However, increasing the sampling rate with enhanced gradient field strength, a higher soft tissue contrast resolution can be achieved (9).

3) Gradient echo pulses sequences have been replaced by SSFSE and FRFSE sequences.

4) Echo-planar Imaging (EPI)
   It uses ultra fast T2-weighting which requires enhanced gradients with high bandwidths and good fat suppression due to marked chemical shift artifacts. EPI allows diffusion images that can be used to characterize hepatic masses.

Contrast agents
1. Gadolinium based extracellular contrast (Magnevist, Optimark, Omniscan, ProHance).
2. Currently, in USA, there are two FDA-approved liver-specific MRI contrasts: gadoxetate (Eovist) and gadobenate dimeglumine (Multihance).

Extracellular agents (Gadolinium DTPA)
   After intravenous injection, gadolinium chelate rapidly distribute in the interstitial spaces of the body. In the liver, this happens both in the normal parenchyma and in tumors, but at different rates, resulting in tumor-liver contrast which lasts for a short period of time. Clinically, this implies the use of rapid image acquisition techniques (gradient echo sequences) and a bolus injection. Some patients, who receive GBCAs, appear to be at an increased risk for developing a serious systemic fibrosing disease, Nephrogenic Systemic Fibrosis (NSF). The patients at risk are those with severe renal (kidney) insufficiency (glomerular filtration rate < 30 ml/min/1.73 m²). NSF can progress with time and can even cause death. In November 2009, the World Health Organization issued a restriction on use of some GBCA, stating that High-risk gadolinium-containing contrast agents (Optimark, Omniscan, Magnevist) are contraindicated in patients with severe kidney problems, in patients who are scheduled for or have recently received a liver transplant, and in newborn babies up to four weeks of age.

Iron oxide based particles
Superparamagnetic iron oxides (USPIO) and Ultra small super paramagnetic iron oxide (USPIO) are nanoparticles composed of a magnetically active crystalline iron core (magnetic) surrounded by a dextran or starch coating. Because of its long residence in the vascular system, USPIO is considered a blood-pool agent. These reduce the T2 signals of absorbing tissue. Many of the agents, which were previously approved by the FDA including Ferumoxides (Feridex), Sinerem (Combidex), and Resovist (Clivast), have been taken off the US market.

Hepato-biliary agents
   There are two different types of hepatobiliary agents: gadolinium-based and manganese-based.

The gadolinium based agents are often called bimodal contrast agents since they demonstrate both hepatocyte and perfusion imaging properties. These include gadoxetate (Eovist or Primovist, also known as Gd-EOB-DTPA, Bayer) and gadobenate dimeglumine (MultiHance, Bracco, formerly known as Gd-BOPTA). Following a rapid bolus, dynamic T1W GRE sequences are performed similar to those performed with non specific Gadolinium based agents. The enhancement of the liver on T1-weighted images peaks at about 20 minutes for Eovist and lasts for at least 2 hours after injection of the contrast agent. Tumors of hepatocellular origin show enhancement whereas non hepatocellular tumors such as metastases appear hypo-intense on delayed images (10) (Fig. 3).

Magnefodipir trisodium (Tesla scan), withdrawn from US markets is predominantly a T1 shortening agent. The liver is enhanced onT1-weighted sequences from the end of the perfusion to 4 hours later. The free manganese released in the hepatocyte is excreted into the bile and the remnant ligand excreted through the kidneys.

**Diffusion Weighted Imaging (DWI)**

DWI can be easily added to the current MRI protocol. Some studies have shown higher sensitivity for hepatic lesion...
detection when compared to T2-weighted imaging. The liver lesions are detected using low b values (below 100 sec/mm²), providing black-blood images, with high inherent tissue contrast and robust image quality. Higher b values (≥ 500 sec/mm²) can assess lesion signal intensity qualitatively. Malignant lesions typically demonstrate impeded diffusion and appear bright against a dark hepatic background (11) (Fig. 4).

**MR elastography**

MR Elastography is a newer technique currently used for evaluating hepatic fibrosis in cirrhosis, based on the viscoelastic properties of the tissue. Determining the viscoelastic characteristics differentiate between dysplastic nodules and HCC may prove to be valuable in the future (12).

**MRI applications**

MRI is able to characterize with higher accuracy than CT the following:

1. Hemangioma: In addition to assessing morphology and enhancement pattern like CT, MRI also provides signal intensity characteristics (Fig. 5).
2. FNH: FNH is diagnosed with MRI based not only on the enhancement pattern (including delayed enhancement of the scar), but also on signal characteristics of the tumor and scar (bright in T2) (Fig. 6).
3. Fat containing tumors (hepatocellular adenoma, hepatocellular carcinoma): Using chemical shift imaging MR is able to prove fat in hepatocellular neoplasms with higher sensitivity than CT.
4. Cysts: Hepatic cysts are confidently diagnosed with MRI even if they are sub-centimeter in size, based upon its very high signal intensity and lack of enhancement.
5. Hemorrhage in tumors: The visualization of hemosiderin rings allows characterizing internal hemorrhage within neoplasms.

**PET/CT and MRI/PET**

Positron emission tomography (PET)/CT is a functional imaging modality that has proven useful as a diagnostic tool for staging a wide variety of cancers. Tumor cells demonstrate increased glucose uptake mediated by glucose transporters (GLUT) and accelerated glycolysis leading to tumor specific high intracellular accumulation of the glucose analog fluorodeoxyglucose (18F-FDG). While PET/CT has demonstrated immense benefit in staging extra hepatic disease in colorectal cancer staging, its role in initial staging and follow up of hepatic metastases is limited. Moreover, the sensitivity of PET in detecting metastases decreases considerably following neoadjuvant chemotherapy (13, 14).

**Fig. 4.** — DWI demonstrates HCC in the right lobe, which appears bright against dark hepatic background.

**Fig. 5.** — MRI of the liver with a (arterial -15 sec) and b delayed (2 min) phases depicts early peripheral nodular enhancement of two Hemangioma with delayed centripetal filling in.
PET/CT has limited role in imaging HCC or other primary liver tumors except lymphoma, but our recent experience has demonstrated that PET maybe helpful in detecting extra hepatic spread of HCC. MRI/PET, with superior imaging MRI characterization of liver lesions, may prove to be beneficial in future in assessing tumor recurrence or residual tumor in post-therapy patients.

Conclusion
Both CT and MRI with continuously evolving technologies are effective in imaging of the liver. MRI allows better characterization of liver lesions, but is expensive as a screening tool. The choice of imaging study should be determined by the clinical indication, with considerations of availability, technical and clinical expertise, cost, and patient tolerance.

References

Hepatocellular carcinoma: the multi-step process
C. Bartolozzi

The recent availability of different imaging modalities has improved the investigation of the processes taking place during the carcinogenic pathway towards dysplasia and full malignancy, represented by the alteration of lesion vascular supply (progressive capillarization of the sinusoids and increasing number of muscularized, unpaired arteries); and to the progressive histological changes (loss of biliary polarization of the hepatocytes and derangement of the microscopic secretory structure) (1).

Imaging cirrhotic patients still remains a challenging issue, especially when a differential diagnosis between pre-neoplastic hepatocellular lesions, such as dysplastic nodules (DNs), and early neoplastic lesions, is requested. Actually, vascular supply to the lesion represents the key pathologic factors for differential diagnosis of nodules in cirrhosis, that can be evaluated by dynamic imaging studies; particularly, changes in lesions’ vascular supply, such as the development of new arterial vessels, suggest lesions’ diagnosis. If ultrasound (US) examination still represents the first diagnostic approach in the follow-up of cirrhosis, nowadays nodules characterization is demanded to contrast enhanced Multidetector...
Computed Tomography (CT) or Magnetic Resonance (MR) (2).

At dynamic studies performed with both techniques, typical HCC shows a clear-cut enhancement on the arterial phase and rapid wash-out on subsequent phases (Fig. 1), while preneoplastic nodules usually have no specific features, because of different intranodular vascular supply. In doubtful cases, MR study, performed with hepatobiliary contrast agents, can furnish an insight on the so called "grey area", in which significant histological changes are already present without an evident arterial supply of the nodule (Fig. 2) (3). Contrast behaviour of HCC after hepatobiliary agents is strictly related to tumor degree of differentiation: whereas moderately or poorly differentiated lesions fail to take up hepatobiliary agents, appearing as hypointense on T1-w, well-differentiated tumor may appear as hyperintense, as a result of the uptake and trapping of the agent within the lesion.

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**Fig. 1.** — On A, a clear cut enhancement of a small nodule within segment IV is appreciable, while on figure B, the nodule shows as hypodense. On the basis of these typical enhancement features, a diagnosis of HCC can be performed.

**Fig. 2.** — Man with HCV related cirrhosis. On segment VI, no nodules are clearly appreciable on the arterial phase (A), while on late dynamic and hepatobiliary phases (respectively B and C), a hypointense nodule is appreciable. A similar nodule is appreciable on segment III. Despite the lack of enhancement on arterial phase, the wash-out on the late phase and the hypointensity on hepatobiliary phase suggest premalignancy of nodules.

**Body MRI: fast, efficient, and comprehensive**

R.C. Semelka, B.S. Kim

The use of fast scanning techniques allows for consistent high image quality and good conspicuity of disease with a decrease of imaging times. Examination time is critical because longer MRI studies may result in worsening of imaging quality due to motion that tends to progress through the course of the study from patient exhaustion. The inability of noncooperative patients to hold their breath impairs the image quality substantially on abdominal MRI. Therefore, it is useful to separate protocols are required for noncooperative patients from a standard cooperative protocol.

**Cooperative protocol**

**T1-weighted sequences**

In-phase 2D spoiled gradient echo (SGE) has become a routine part of every liver MR imaging for investigating disease of the abdomen. This sequence is primarily used to know abnormally increased fluid content, presence of subacute blood or concentrated protein, and presence of fat. Out-of-phase SGE sequence is very helpful for the recognition of diseased tissue in which fat and water protons are present within the same voxel. This sequence plays a important role in detecting the presence of fat within liver and lipid within adrenal adenoma. The value of magnetic susceptibility effects to assess the presence of iron using in- and out-of-phase image is also important.

3D GRE is suitable for dynamic contrast-enhanced MR because of thin section acquisition with larger volume coverage, and excellent inherent fat suppression and sensitivity to enhanced tissues. The hepatic arterial dominant phase (HADP) is the single most important data set. Hypervascular liver tumors, especially hepatocellular carcinomas, focal nodular hyperplasia and metastases, are well...
recognized as intensely enhancing lesions on HADP. The pancreas demonstrates uniform capillary blush on HADP, which is thought to be marked high in signal intensity. In general, pancreatic cancer usually appears as a focal hypovascular mass. In the early hepatic venous phase (1-1.5 minute postcontrast), the hepatic parenchyma is maximally enhanced so that hypovascular lesions are more clearly identified as regions of absent or diminished enhancement. Interstitial phase (2-4 minute postcontrast) are helpful to recognize critical late enhancement features such as washout and delayed capsular enhancement with hepatocellular carcinoma, for example Turbo-fast low angle shot (FLASH), which operates as a single shot technique, can generate T1-weighted images that are resistant to motion from respiratory motion. This sequence can be used to obtain motion-free and moderate quality images with acquisition times as short as 1 second. The MP-RAGE in/out-of-phase images are able to demonstrate the presence of fat, which is necessary to evaluate the liver and adrenal masses in patients who cannot cooperate with 10-20 second breath holds. Water excitation (WE) MP-RAGE should be used to provide fat-suppressed contrast-enhanced T1-weighted images as excitation spoiling fat-suppression does not work with MP-RAGE due to the length of this preparatory scheme. WE-MPRAGE at 3T can achieve better image quality and fat-suppression than 1.5T.

Free-breathing T1 fat-suppressed 3D radial gradient echo sequences provide motion resistant data acquisition. In part this reflect that radial acquisition technique (projection reconstruction) has higher sampling density for central k-space. This technique results in excellent motion control images in noncooperative patients, especially children.

T2-weighted sequences

The SS-ETSE sequence is a breathing-independent technique which is useful both in standard and motion resistant protocols. An additional advantage of this sequence is resistance to susceptibility artifact. As a result, the bowel wall can be clearly demonstrated and susceptibility artifact from metallic devices is minimal. In these settings it is however important to not use fat suppression.

Conclusion

Separation of protocols for cooperation and cooperation-challenged patients is necessary. Fast studies render MRI more cost effective in a progressively more cost contained environment. The clinical MRI study should be performed in a fast, efficient, and comprehensive fashion, and focus on the benefit to the patient and emphasize clinically essential strategies.

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Diffusion imaging of the liver

F. Deckers

Magnetic resonance imaging of the liver has been advocated as a highly accurate technique for diagnosing liver lesions since several years. Driven by technological advances, diffusion-weighted (DW) sequences for the abdomen have become available on most commercial imagers in recent years. In highly cellular tissues (e.g., neoplasm) the narrowing of interstitial space and the high density of cell membranes restrict the free motion of water molecules. This phenomenon generates the contrast between tissues in DW imaging. Because it reflects underlying cellular density and integrity of cell membranes DW imaging of the liver opens up interesting opportunities for evaluating the effects of antitumor treatment. DW imaging can be easily implemented in clinical setting as an added sequence in existing protocols. All these factors have contributed to the fast adoption of DW imaging of the liver in the radiologic community.

Diffusion imaging provides both qualitative and quantitative assessment of lesions. ADC maps are automatically generated by most modern MR units and provide a quantitative insight in the degree of diffusion restriction. As most malignant lesions demonstrate impeded diffusion they will show up as areas of lower ADC values. Several described cutoffs for detection of malignant liver lesions (1). However there is important overlap in ADC value between benign and malignant lesions. Furthermore, ADC measurements in the liver suffer a lower reproducibility. As opposed to benign lesions, most malignant lesions will manifest a high signal intensity compared with the background liver on images with high b values. By visually comparing the contrast between the liver and the lesion at different b-values a qualitative interpretation of lesions can be performed. Using this qualitative visual approach excellent specificity and sensitivity are obtained (2). Not all lesions that display restricted diffusion are malignant however DW images should always be interpreted as part of a complete liver MR protocol, including conventional T1 and T2 images. For detecting liver lesions DW imaging generates very high sensitivity and specificity, particularly in detecting small metastasis (2, 3). In the investigation of liver metastasis DWI can be used as an alternative to gadolinium enhanced imaging in patients with impaired renal function or who have other contraindications for injection of gadolinium chelates.

When applied to molecular-targeted therapies anatomic measurements can be misleading in the evaluation of response in oncologic patients. In these treatments response is often not reflected in a change in diameter. DW MR of the liver could be an interesting parameter for the follow up of these patients (4).

Lower ADC values have been observed in cirrhotic liver compared with normal hepatic tissue. However, an important overlap exists between measured ADC values in different stages of fibrosis (5).

Reflecting tissue cellularity, DW MR of the liver holds promise as a biomarker in oncologic imaging. Furthermore it has proved to be an excellent tool to improve the diagnosis of liver lesions. Therefore this attractive technique has become a part of routine liver imaging protocols.

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Fig. 1.— Periprocedural evaluation with CEUS a hour after laser ablation assesses the presence of neoplastic persistence within the target nodule (A). The evaluation after a second procedure of laser ablation, performed within two hours shows a complete ablation of the residual tumor (B). Complete response has been confirmed at CT examination after 1 month (C).

Fig. 2.— CT examination before treatment did assess the presence of a small HCC within segment III (A). CT evaluation 1 month after microwave ablation did show a complete ablation area, larger that target lesion (B), suggesting complete response to treatment.

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Hepatic tumor response after interventional treatment
C. Bartolozzi

Non-surgical imaging-guided interventional therapies are actually largely applied for the treatment of hepatocellular carcinoma (HCC). Imaging techniques play a key role in all the subsequent steps of ablation treatments, from pre-treatment assessment, passing through the evaluation of technical success, up to the assessment of tumor response to therapy (1).

Complete or partial response, as well as progression of disease after interventional treatments have been re-defined depending on the percentage of enhancing areas appreciable within the treated lesions at the evaluation control (2).

Regarding percutaneous ablation therapies, Contrast-enhanced US (CEUS) is routinely performed during peri-procedural evaluations, allowing both to target areas of residual viable tumor, as well as to monitor first tissue changes depending on the applied ablation modality (Fig. 1).

Anyway, dynamic multidetector CT and MR imaging are still considered as the reference techniques to assess technical effectiveness of treatments (3).

On both dynamic imaging studies, residual viable HCC is reliably depicted as it stands out in the arterial phase images against the unenhanced areas of coagu-
lotion necrosis, while in cases of complete response, no tumoral enhancement should be appreciable (Fig. 2).

Moreover, MRI performed with hepato-specific agents can furnish more information about post-ablation tissue components, revealing useful in doubtful cases, in differentiating periablation hyperemia or artero-venous shunts/thrombosis, from tumoral persistence or recurrence (3).

MDCT and MR must be moreover considered as the reference methods for the evaluation of chemo and radio embolization treatments, usually performed in large, otherwise untreatable HCCs, as well as in patients on waiting list for transplantation as a down-staging approach.

MDCT can furnish an accurate evaluation of the homogenous distribution of Lipiodol as well as the progressive shrinkage of successfully treated lesions, dynamic MRI study has revealed very accurate in the assessment of residual enhancing viable tumor, thanks to the avoidance of iodinate oil artefacts that largely affect MDCT images (4).

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CT/MRI imaging of benign liver tumors
B. Op de Beeck

Today, most benign liver lesions are incidentally diagnosed using ultrasound (US), MDCT, and MRI. Most commonly, a liver tumor will be detected on US because this is the first line imaging examination for the liver. For characterization MDCT and/or MRI will be performed with a higher accuracy for MRI. Detection and characterization of liver lesions with MDCT is based on differences in density (attenuation), mainly during the different phases of dynamic imaging following a rapid bolus infusion of contrast material. Late arterial phase (35-40 sec) is the best for hypervascular tumors (FNH, HCA, small hemangiomas) and portal venous (parenchymal) phase (70 sec) for hypovascular lesions should be obtained in almost all abdominal CT scans. Equilibrium (delayed) phase (2-10 min) can sometimes be of help for characterizing hemangiomas. Detection and characterization with MRI is mainly based on intensity differences on T1- and T2-weighted imaging, DWI and ADC values, vascular enhanced imaging with extracellular gadolinium agents, and eventually reticulo-endothelial enhanced with SPIO or hepatocyte enhanced with Gd-BOPTA or Gd-EOB-DTPA. The use of US or CT-guided biopsy for characterizing benign liver lesions is in the last decade dramatically decreased due to the better non-invasive characterization of these lesions, especially with state-of-the-art MR imaging.

In the group of benign hepatic masses we can distinguish primary benign liver lesions, secondary benign liver lesions, and hepatic pseudolesions. The primary benign hepatic neoplasms are of hepatocellular origin (hepatocellular hyperplasia, most commonly FNH, and hepatocellular adenoma), cholangiocellular origin (hepatic cysts), or mesenchymal origin (most commonly hemangioma). The secondary benign liver lesions are mostly abscesses, and in the group of hepatic pseudolesions we are most commonly dealing with focal steatosis, a focal spared area in a fatty liver or vascular disorders. Typical imaging findings of these benign hepatic masses will be discussed during the presentation.

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Imaging of focal splenic lesions
EM. Vanhoenacker, A. Snoeck

The learning objectives of this presentation are to discuss the 10 most frequent encountered focal splenic lesions in Europe and to discuss the imaging characteristics of these lesions.

The spleen is regarded as the forgotten and silent organ in the abdomen. Compared to the extensive literature on liver and pancreatic imaging, little has been written on imaging of splenic lesions. However, splenic lesions may be encountered on imaging (ultrasound and computed tomography) done for other reasons. Characterization of splenic incidentalomas may be challenging for the radiologist.

Haemangioma
A haemangioma is the most common benign splenic lesion. It is usually solitary, but multiple lesions may occur. The CT appearance is variable. Solid and cystic portions may be seen and the degree and pattern of enhancement may differ on CT and MRI. Rarely, central or curvilinear peripheral calcifications may be seen on CT.

Calcifications
The most frequent causes of splenic calcifications are healed postinfectious granulomas (tuberculosis or histoplasmosis) and phleboliths. Peripheral rim-like calcifications may be seen in cysts. Rare causes of calcifications include old infarcts, splenic hematoma, collagen-vascular diseases, amyloidosis, silicosis, Gamma-Gandy bodies,...

Cystic lesions
Two types of splenic cysts are distinguished along with the presence or absence of an epithelial lining, i.e. true cysts (20% of cases, true epithelial lining) and false cysts (80% of cases, with an absence of an epithelial lining usually due to a posttraumatic etiology or old infarcts). The imaging appearance of both types is very similar. The clue to the correct diagnosis is the cystic content on US, CT and MRI. The signal intensity on T1-WI images may – however – be relatively high due to protein content. CT may show subtle wall calcifications (Fig. 1).
the spleen. Usually, there is concomitant
and non-Hodgkin disease may involve
multiple splenic malignancy. Both Hodgkin
and non-Hodgkin disease may involve
the spleen. Usually, there is concomitant
widespread disease and associated
adenopathy. Imaging features include
splenomegaly, solitary or multiple focal
lesions of variable size and splenic infarc-
tions.

Splenic infection
Splenic infection is relatively rare in
Western countries, but may be seen in
immuno compromised patients, after
chemotherapy and transplantation.

Ganma-Gandy bodies
Ganma-Gandy bodies consist of
organized foci of hemorrhage and contain
a mixture of hemosiderin, fibrous tissue
and calcium. It is associated with
long-standing portal hypertension. CT is
insensitive for early detection and MRI is
the preferred technique. The lesions are
of low signal on both pulse sequences
and may show blooming on gradient
echo imaging.

Miscellaneous
Rare benign and malignant tumor and
tumorlike conditions may involve the
spleen (hamartoma, litteral cell angiom,
Gaucher’s disease,…).

Conclusion
Most focal splenic lesions are inciden-
tally found on imaging and are benign.
CT is the primary imaging modality for
detection of these lesions. MRI may be of
additional value in lesion characteriza-
tion. Although imaging will not always
provide a specific diagnosis, the combi-
nation of the clinical history, laboratory
data and imaging is usually sufficient
for characterization. In most clinical
scenario’s, a wait-and-see policy is
preferred.

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Update in abdominal ultrasound
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Ultrasound remains a current imaging
procedure still required in many abdomi-
nal conditions. The advantages of sonog-
raphy are a low cost technique, its
repeatability, its bedside availability and
the lack of radiation and side effects (1).
The reason of the “sound” success story
is based on permanent technical
improvements and access to portable
machines at a low cost.

Improvements and innovations are
constant in the sphere of B mode sonog-
raphy, Color Doppler technique, Contrast
ultrasound, elastography and volumetric
approach, giving more confidence for the
ultrasound practitioner.

- the B mode improvements are based
on efforts of the companies to
increase the number of piezoelectric
and develop specific process to reduce artifacts.
- Contrast ultrasound is permanently
optimized. New indications are under
evaluation, particularly in the field of evaluation of response to therapy (2).

- Volumetric ultrasound has moved from the obstetrical to the abdominal area, with applications for liver, kidney, bladder and bowel imaging. Volumetric ultrasound has been optimized with the development of matrix probes. Volume imaging is also incorporated in the interventional radiology room, allowing better guidance for difficult biopsies based on the "GPS" philosophy (3).

- Elastography of the liver, initiated with the "Fibroscan" is integrated into our common probe, accelerating the access to liver stiffness evaluation and also new applications, including characterization of focal liver lesions.

High quality portable devices are available, with high quality B Mode imaging, color Doppler and contrast ultrasound imaging in an easier way, particularly in the critical care and emergency medicine area, with a side effect: ultrasound can not be restricted to radiologists and the battle of "who has to perform ultrasound ?" is still alive (4, 5). These improvements (volumetric ultrasound and portable device) are an opportunity for a new approach for teaching medicine and radiology at the University: ultrasound is used to give a better anatomical understanding of the human body (6).

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US of the acute abdomen
J.B. Puylaert

CT has several advantages over US in the diagnosis of the acute abdomen: CT is extremely rapid, the true costs of CT are fairly low and probably lower than a time-consuming US examination, CT images are not disturbed by gas and bone, while obesity is even an advantage; producing the CT images is not operator-dependent and CT can be reviewed at a later point in time and even from a distance by means of teleradiology. Finally, CT images are easier understood and accepted by clinicians than US images are.

However, there are also specific advantages of US over CT: US has an image definition in the close range which is much higher. US is more interactive: patient's history as well as painful area or palpable mass can be correlated with the US findings. US shows peristalsis, pulsations and blood flow. US shows the effects of respiration, Valsalva manoeuvre, gravity and compression with the probe, allowing to assess whether organs as bowel and gallbladder are soft or rigid. US allows easy puncture of intraperitoneal fluid and drainage of pus. US in acute abdomen is performed with graded compression. Compression is necessary to displace or compress bowel, eliminating the disturbing influence of bowel gas and to approach the pathological structure closely. This allows using a high frequency transducer with a better image quality. The compression should be graded to avoid unnecessary pain and to avoid pushing organs out of the US plane.

US examination should be symptom-directed and requires communication with the patient. In patients with an acute abdomen the entire abdomen should be examined, i.e. from the axilla to the groin. The final US report should be integrated with the clinical findings, laboratory data, CT-scan and possible other radiological examinations.

The US images of appendicitis, diverticulitis, intussusception, acute biliary, urological and gynecological conditions, infectious ileocolitis, perforated peptic ulcer, small bowel obstruction, ruptured aneurysm, pancreatitis, Crohn's disease, epiploic appendagitis, omental infarction and perforating malignancy will be demonstrated using illustrative case histories, with emphasis on the specific advantages of US over CT.

Cystic tumors of the pancreas: imaging and management
K.J. Mortele

Cystic tumors of the pancreas are a diverse group of lesions which vary from benign to pre-malignant to frankly malignant entities. There has been a 20-fold increase in detection of cystic pancreatic lesions over the last 15 years most notably by cross-sectional modalities such as computed tomography (CT) and magnetic resonance imaging (MRI). The true prevalence of pancreatic cystic lesions is unknown but has been previously reported to be around 2.4-16.0%, and they appear to be increasingly detected with increasing age. One study reported a prevalence of incidental pancreatic cystic lesions on MRI to be in the order of 13.5% and showed that the prevalence and cyst size also increased with age. These findings have been corroborated at autopsy with the prevalence of cystic lesions approaching 25%.

Given the fact that the prevalence of pancreatic cystic lesions is increasing...
due to increased detection by cross-sectional imaging, and the fact that most cystic pancreatic lesions are neoplastic in nature. Accurate diagnosis via clinical information, radiological images, +/- endoscopic ultrasound (EUS) with cyst fluid analysis plays an important role. The majority of these lesions, especially when large, have characteristic imaging features at radiology, and accurate differentiation between them is important to help guide future treatment and management. Nevertheless, smaller lesions may appear indeterminate and the management pathways of these may be confusing and variable. The aim of this lecture is to review the histopathologic features and common imaging findings for a vast array of cystic pancreatic neoplasms. These include the relatively common cystic tumors of the pancreas: serous microcystic adenoma, mucinous cystic tumor (MCT), intraductal papillary mucinous neoplasm (IPMN), and solid pseudopapillary tumor (SPT). Uncommon cystic tumors of the pancreas include cystic endocrine tumors, cystic metastases, cystic teratomas, and lymphangiomas. This lecture also aims to provide comprehensive algorithms on how to manage the individual lesions with recommendations on when to reimaging patients (Table I).

Reference


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Imaging of abdominal and retroperitoneal soft tissue tumours: a practical approach

F.M. Vanhoenacker, A. Snoeckx, B. Op de Beeck

The learning objectives of this presentation are to describe the imaging features of abdominal and retroperitoneal soft tissue tumours with emphasis on MRI and to define a practical approach for differential diagnosis. Abdominal and retroperitoneal soft tissue tumours are rare. Since clinical implications and therapeutic strategy vary depending the cause, imaging plays an important role.

Imaging findings

When approaching abdominal or retroperitoneal soft tissue tumours, the initial step in the evaluation is defining the precise localization of the lesion. The next step is to differentiate between cystic and non-cystic masses. Cystic lesions can be classified as neoplastic or nonneoplastic. Neoplastic lesions include cystic lymphangioma (Fig. 1), mucinous cystadenoma, cystic teratoma, cystic mesothelioma, Mullerian cyst, epidermoid cyst, tailgut cyst, bronchogenic cyst, etc. Nonneoplastic lesions include pancreatic pseudocyst, lymphocele, urinoma and hematoma. Non-cystic masses can be classified according to their origin. Lesions of vascular origin are hemangiopericytoma and retroperitoneal lesions associated with angiomatosis. Lesions of neurogenic origin are associated with NF-1 and include neurofibroma, schwannoma, malignant peripheral nerve sheath tumor and dural ectasia. Tumours of fibrous origin are desmoids and inflammatory pseudotumor. Liposarcoma (Fig. 2) and GIST are the most common malignant retroperitoneal tumours. Abscesses, iliopsoas bursitis, ischemic fasciitis, endometriosis and cisterna chyli are pseudotumoural lesions that may mimic a retroperitoneal or abdomi-

Fig. 1. — Retroperitoneal lymphangioma. Diffuse infiltrating serpiginous lesion at the left flank and abdominal wall on fat-suppressed (FS) T2-Weighted image (WI).

Fig. 2. — Retroperitoneal liposarcoma. Huge retroperitoneal mass containing fatty and nonlipomatous components on a FS T2-WI.
overlapping characteristics, some imaging findings may suggest a specific diagnosis. Whereas CT is the initial imaging technique for detection, MRI can better characterize the tumour and define its extension.

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CT colonography: current status and pitfalls

Ph. LeFevre

Current status

Since its introduction as a revolutionary imaging technique for detecting tumoral lesions in the colon, CT colonography (CTC) has gained major interest from both the radiological and gastrointestinal community. After a rather long introductory period with variability of results, CTC is now more and more established as a useful and reliable technique to inspect the colon for colorectal cancer and its adenomatous precursors. Sustained efforts of the CTC community (ESGAR CTC faculty) resulted in the elaboration of a state-of-the-art technique focussing on the important aspects of patient preparation, colonic distension image acquisition and interpretation. The results of recently performed multicentre trials have proven these efforts to be worthwhile.

State-of-the-art CTC technique is based on 4 important pillars: colonic preparation with fecal tagging, adequate colonic distension using an automated CO2 injector, acquisition with a multi-slice scanner (using (ultra-) low dose in asymptomatic patients), interpretation with standardized software programs by an experienced CTC radiologist. Using this technique very good results of polyp detection have been obtained in several large trials with CTC obtaining a sensitivity of >80% for adenomas and/or advanced neoplasia 6-9 mm (some studies obtaining >90%) and >90% for adenomas ≥ 1 cm. CTC is now an accepted indication after complete optical colonoscopy, in case of contra-indications and patient refusal of optical colonoscopy. While the use of CTC for population-based screening is a matter of debate because of an issue of cost-effectiveness, CTC is a good option for individual screening. CTC is a very good indication in the frail and elderly patients. CTC can be considered in patients with symptoms suggestive of colorectal cancer and patients with vague abdominal symptoms. CTC can be used for preoperative mapping of diverticular disease and colorectal cancer and in the postoperative patient for colorectal cancer surveillance. CTC is also a good option in patients with endometriosis. CTC is very well accepted by the patient and currently techniques are developed to decrease the intensity the preparation in order to improve patient compliance. Furthermore CTC is a very safe examination with very few and mostly self-limiting complications. Radiation dose is very low with the development of better scanners and new acquisition and postprocessing methods.

Pitfalls in imaging

Pitfalls in imaging are related to the technical aspects of CTC, the anatomical aspect of the colon and two- and three-dimensional imaging.

Technique-related pitfalls are related to the preparation, colonic distension and CTC acquisition. Most problems are solved by preparing the patient with fecal tagging and obtaining optimal colonic distension. Some minor problems may be caused by noise added to the low dose technique and motion artefacts. Anatomy-related pitfalls are more difficult to handle. Some pitfalls occur in any colonic segment: segmental mobility, the artificial bowel wall, the flexural pseudotumour and extrinsic impressions. Some pitfalls are related to the colonic segments. As a closed structure the rectum is difficult to examine. The anal margin needs our particular attention because of possible internal hemorrhoids, hypertrophied anal papillae and true polyps. Furthermore the rectal catheter obscures this part of the rectum. The valves of Houston or rectal valves are 3 prominent folds that add more difficulties when inspecting the rectum. In the sigmoid most problems are caused by diverticular disease: diverticular facaliths, polypoid mucosal prolapse and wall thickening with the issue of chronic diverticulitis vs cancer. The descending colon does not cause a lot of problems. Having a round aspect in the sigmoid, the colonic lumen becomes somewhat more triangular in the descending colon with a typical aspect in case of spasm. In the transverse and ascending colon the lumen becomes...
Another pitfall is provided by the phenomenon of “spontaneously resolving appendicitis”. These patients are admitted with suspected appendicitis, but after a variable period of time (12-36 hours) they experience rather sudden relief of pain and concomitant symptoms. If examined at that point US is still able to confirm an inflamed appendix which is however not anymore tender on pressure. Repeat US scans show gradual decrease of the appendix diameter over the following days. Conservative management in a large series showed a 40% recurrence rate, usually within one year.

If appendicitis has been present for several days, and the erythrocyte sedimentation rate (ESR) is markedly elevated, while the patient’s condition is relatively stable, ultrasound will usually denote large hyperechoic fatty masses surrounding the appendix as well as secondary wall thickening of ileum and cecum. These hyperechoic masses, often interspersed with linear hypoluculent linear configurations, represent inflamed mesenterial fat and omentum, migrating towards the appendix in an attempt to wall-off the (imminent) perforation. These patients get the clinical diagnosis of “appendiceal mass”, which is commonly treated conservatively, because appendectomy is expected to be technically difficult or even impossible due to the large inflammatory mass. When these patients are followed up with US one observes a gradual decrease in size of the inflammatory perappendiceal mass. In case there is doubt whether to operate immediately or to remain conservative, the clinical impression and especially the duration of symptoms and the absence of peritonitis, has generally more weight than the US image. The diagnosis of appendiceal phlegmon can only be made in dialogue between radiologist and clinician, and never on the US or CT image alone. If there is a circumscribed fluid collection, this indicates the presence of an appendiceal abscess.

Appendiceal abscess

The treatment of choice for an appendiceal abscess is percutaneous drainage. However, it is important to realize that many appendiceal abscesses disappear spontaneously. The smaller ones are resorbed, the larger ones evacuate itself into neighbouring bowel. If an abscess causes pain or recurrent fever, or if the patient recovers too slowly, percutaneous drainage is indicated.

Preceding the drainage procedure, CT scan is mandatory to confirm the abscess, to delineate its extent and to establish a safe access route for the puncture. In general it is best to puncture from lateral, but all directions are possible, provided that vital structures as vessels and bowel are avoided. Puncture and insertion of the initial guidewire are best performed under direct US-guidance, subsequent dilatation and insertion of the final drainage catheter are performed using fluoroscopy.

In children, and in adults with frank peritonitis, surgical intervention is indicated.

Diverticulitis

Over all, the diagnosis of diverticulitis is more reliably made by CT than by US. However, since US is often used as a first modality in acute abdomen, it is important to be aware of the US signs of diverticulitis. Besides, in not too obese patients, US may be superior to CT. US is most useful in early, uncomplicated diverticulitis. Daily, repeated US examinations in patients with diverticulitis has taught us that diverticulitis, in the majority of cases, runs a predictable and benign course.

Initially, there is local wall thickening of the colon with preservation of the US layer structure. Within the inflamed diverticulum a fecolith is present and the diverticulum is surrounded by hyperechoic, non-compressible tissue, which represents the inflamed mesenterium and omentum “sealing-off” the imminent perforation. US follow-up shows evacuation of the fecolith to the colonic lumen, with or without the transient development of a small paracolic abscess, sometimes with disintegration of the fecolith. This process of spontaneous evacuation of pus and fecolith via local weakening of the colonic wall at the level of the original diverticular neck towards the colonic lumen, takes place within one or two days, rarely more.

The residual inflammatory changes remain present for several days after the evacuation, and it is not uncommon to find an empty diverticulum at first presentation. If, in such cases, patients are specifically asked about their symptoms, they invariably declare that “the worst pain is over”...

Whenever diverticulitis takes a complicated course, CT is superior to US, especially in the detection of free air, fecal peritonitis and deeply located abscesses, and in general in obese patients.

Finally, US, if necessary followed by CT, has an important role in the diagnosis of alternative conditions: ureterolithiasis, pyelonephritis, perforated peptic ulcer, appendicitis, Crohn disease, epiploic appendagitis, gynecological conditions, colonic malignancy, pancreatitis, etc. Right sided colonic diverticulitis in many respects differs from its left sided cousin. Diverticula of the right colon are usually congenital, solitary, true diverticula containing all bowel wall layers. The fecoliths within these diverticula are larger and the diverticular neck is wider. There is no hypertrophy of the muscularis of the right colonic wall. My observations with US and CT in 110 patients with right colonic diverticulitis, clearly show that it invariably has a favorable course and never leads to free perforation or large abscesses. Although relatively rare (left: right = 15:1), it is crucial to make a correct diagnosis, since the clinical symptoms of acute RLQ pain may lead to an unnecessary appendectomy or even right hemicolectomy.


Inflammation and obstruction of the urinary tract

J.R. Fielding

What is the appropriate test for the evaluation of painless hematuria in the patient with high risk for TCC?

High risk patients include those over the age of 60 with a smoking history. These patients routinely undergo cystoscopy to exclude a primary bladder tumor. Assessment of the upper tracts is performed to exclude a synchronous tumor or in the case of a negative cystoscopy, a primary site of disease. There are many methods to perform CTU, however, all involve a non-contrast enhanced image of the abdomen to exclude stones and identify renal cortical masses. A second phase through the abdomen on pelvis following injection of 100 cc of contrast material (350 mg I/ml) is performed at 75 seconds. Finally, a third pass performed at 5 to 10 minutes following injection is used to assess the intrarenal collecting systems and ureters. Coronal reformatted images of the kidneys, ureters and bladder are obtained to evaluate for hydronephrosis, hydronephrosis, and bladder wall abnormalities. The use of urography, a split bolus of contrast agent and compression bands all increase opacification of the ureters.

What is the appropriate use of MR urography?

MR urography can be a valuable substitute for patients who require evaluation of the kidneys and upper tracts but cannot receive IV contrast agents. Although it lacks the spatial resolution of CT, there is increased contrast resolution theoretically allowing for more accurate identification of soft tissue masses. In those patients who have undergone therapy for TCC, it may replace CTU for follow-up examinations. Despite the perceived complexity of MR urography, it can be performed in a simple fashion. The two most crucial components are the use of hydration (250 ml IV) and diuresis (furosemide 10 mg IV). Once these steps are completed, the acquisition of a thick slab fat saturated T2 weighted coronal image with a large field of view should yield high quality results. Parameters used for MRCP are satisfactory.

Reference


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Abdominal emergencies represent one of the largest parts of the workload in a Paediatric Radiology Department. Emergencies encompass a very wide spectrum of diseases and entities some life threatening while other more benign. The role of imaging is of utmost importance as in many patients, the origin of the acute symptoms is not obvious. Furthermore some specific entities such as non accidental trauma and child abuse have to be considered and will be suspected through imaging findings only.

When considering abdominal emergencies, ultrasound (US) plays a central role in sorting between the differential diagnoses and therefore, a clinico-radiological triage has to be applied based on age, symptoms, medical history, and sonographic findings.

**Imaging techniques**

As mentioned, among imaging techniques, ultrasound (US) occupies a central role. The technique is not irradiating, easy to perform (yet operator - dependent) and relatively low cost. The US examination has to be optimized and fitted to the size and age of the patient. Whatever the purpose of the examination, the entire abdomen should be checked. In many cases, color Doppler will provide additional information.

In selected cases, a plain film of the abdomen will help to demonstrate calcifications or confirm intestinal subobstruction. In some others, a CT-scan would provide additional information useful for the proper management of the patient. Whenever performed, the CT technique should be optimized to deliver the lowest possible irradiation. MR Imaging is rarely performed as an emergency procedure, unless an abdominopelvic mass is detected. Finally, fluoroscopy has limited indications in emergency abdominal imaging.

**Acute abdominal conditions (trauma excluded)**

One way of defining the best optimal work up of an acute abdominal condition is to base the approach on the patient's age:

- The principal entities to consider among the first 6 months of age are congenital anomalies, those related to prematurity and hypertrophic pyloric stenosis. Congenital anomalies are frequently detected during obstetrical US examination; yet, some do escape antenatal diagnosis and will be detected after birth only, secondary to symptoms of intestinal obstruction. Prematurely born babies are at risk for developing digestive complications such as necrotizing enterocolitis. At an early stage, US may demonstrate bowel wall thickening and a small amount of free fluid.

Thereafter, free air may dissect the bowel wall and reach the portal vein system. It will be demonstrated as hyperechoic dots within the liver parenchyma. In case of an unfavourable evolution, a pneumoperitoneum may develop due to intestinal perforation.

In a 6-week-old vomiting babyboy, a hypertrophic pyloric stenosis is the most probable diagnosis. US is confirmatory as it demonstrates the thickened pyloric muscle. The stomach is distended since food remains trapped for an abnormal long duration.

- between 6 months and 2 years, the main diagnoses are intussusceptions, midgut volvulus and inguinal hernia. In classical cases, intussusception has a typical clinical and sonographic appearances. At US, a mass with target pattern is visualized (above 3 cm diameter). Many small ganglions are usually included within the intussusception. Most All are primary. Some (usually those before the age of 6 months or after 2 years) are secondary to leading lesions (e.g. intestinal duplications, Meckel's diverticulum, lipoma, lymphoma) that can be visualized as persisting masses after the therapeutic reduction.

A midgut volvulus is an acute condition that complicates intestinal malrotation and induces intestinal obstruction. In obvious cases of intestinal malrotation, the mesenteric vein lies to the right of the mesenteric artery; the condition can be complicated by a midgut volvulus where the bowel loops and the mesenteric vessels determine the so-called and characteristic Whirpool sign. Midgut volvulus is a surgical emergency.

An Inguinal hernia corresponds to bowel loops entrapped within the patent inguinal canal. Peristalsis within the herniated loops can be observed. Secondary obstruction may develop. Note worthy, in baby girls, an ovary can be entrapped within the hernia. This condition should be operated rapidly.

- Between 2 and 12 years, the spectrum of diseases occurring within this age group is wide and assessing the correct diagnosis is sometimes a real challenge. Still, by frequency, two conditions overlap all others. By far, constipation is the commonest cause for acute and chronic abdominal pain in children. This diagnosis can only be obtained through a careful interrogation of the child (if possible) and of his/her parents. If necessary, a plain film of the abdomen may confirm the condition.

The second most common condition for acute abdominal pain is acute appendicitis which is actually the most common diagnosis suspected by the ER physician. A US diagnosis of acute appendicitis (AA) is based on the demonstration by US of a thickened, swollen, non depressible appendix (above 6 mm diameter). The inflamed appendix is painful under gentle US compression. On color Doppler, the peri-appendicular mesenteric fat appears hypervascularized. An echogenic appendicolith can be visualized. As the disease progresses, perforation may occur and peritonitis develop with abscess formation. The latter may be difficult to delineate and complementary imaging is necessary. Those cases include unusual clinical presentation (i.e. infants), clinico-imaging discrepancy and complicated cases (multiple abscesses).

False negative diagnoses of acute appendicitis result from localized inflammation or abnormally located (retrocaecal or retrohepatic) appendix. False positive cases include other causes of appendicular infiltrations or thickening (e.g. carcinoid tumor, cystic fibrosis, Crohn's disease, ...).

Once acute appendicitis has been excluded, the list of diagnoses widens. For instance, the digestive tract can be involved infectious or inflammatory processes that lead to its thickening and hypervascularization. It can also be involved in auto-immune diseases (e.g Henoch-Schönlein Syndrome, Hemolytic and uremic syndrome...).

Meckel's diverticulum is surely a potential diagnosis and it may be complicated by torsion, abscess formation and rupture.

Biliary lithiasis may occur under various favouring conditions (Sickle cell disease, infections, post-surgery, ...) and detected thanks to typical ultrasound features.

Abdominal tumors may develop at any age and involve any organ. Neuroblastoma, Wilms' tumor and lymphoma cause the most frequent tumors in children. Other classical tumors include cystic lymphangioma and teratoma. Both can be retro- or intraperitoneal. Cystic lymphangioma appears as large multiseptated fluid filled masses where as teratoma are usually more complex tumors including solid components and calcifications. In girls, the most common tumors in development in the ovary, Teratoma (or dermoid cyst) are the most classical histologic type encountered.

Other entities that may lead to acute abdominal pain include acute pneumonia, acute pylonephritis, testicular torsion, poas abscesses or skeletal diseases.

Above 12 years, the list of diseases to be considered resembles the ones occurring in adults as for instance gastritis, gastro-duodenal ulcers or bowel inflammatory diseases and their complications may occur. In adolescent girls, gynecological malformations may become obvious due to hematocolpos.

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**MRI in fistulizing perianal disease**

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Perianal fistulas are an uncommon but major cause of morbidity, occurring in 1/10000 predominantly male persons.
Normal anatomy

The anatomy of the anal region is well demonstrated on MR images (Fig. 1): the involuntarily internal sphincter, the intersphincteric space, and the voluntary external sphincter.

Etiology and classification

Perianal fistulas usually arise from infected anal glands, penetrating into the intersphincteric plane, spreading infection down to the skin.

In patients with Crohn disease perianal fistulas arise from inflamed or infected anal glands and/or penetration of fissures or ulcers in the rectum or anal canal.

Using the external sphincter as a reference point, Parks divided perianal fistulas in 5 types: intersphincteric, trans-sphincteric, suprasphincteric, extraspincteric, and superficial (1).

Diagnosis

Standard assessment of perianal fistulas combines examination under anesthesia and imaging with endoscopic ultrasound and/or pelvic MRI.

MRI protocol

Coronal and axial MR images demonstrate fistula tracks in relation to the sphincter complex, ischiorectal fossa, and levator plate.

Sagittal and oblique planes are helpful in anovaginal or presacral disease.

Contrast enhanced and fat suppressed sequences are used to improve contrast and can distinguish inflamed tissue from normal perineal tissues.

Accuracy and application of MR imaging

For surgical treatment (preoperative assessment)

Pelvic MRI may change surgical management in 10%-15% of cases (2).

For medical treatment (measurement of fistula disease activity)

Fistula inflammation and disease activity correspond well with the presence of T2 hyperintensity in fistula. Van Assche et al. have constructed a new MRI based score, taking into account both anatomical and inflammation criteria (3). This score correlates with clinical disease activity and with response to biological therapy.

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Imaging and interventional treatment of benign uterine tumors

Th.J. Kroencke, B. Hamm

Uterine artery embolization (UAE) is a nonsurgical intervention for treating symptomatic uterine leiomyomas and represents an alternative to surgical removal (hysterectomy, myomectomy, hysteroscopic resection). The indication for uterine artery embolization crucially relies on the preinterventional assessment of symptomology and burden of disease. Especially the location, size, and number of leiomyomas are important to determine treatment options of patients. As a rule, both single and multiple fibroids can be treated by UAE. The number and location of the individual tumors (subserosal, intramural, transmural, submucosal) does not affect the approach, technique or outcome of UAE.

MR Imaging of cervical and endometrial cancer

B. Hamm

MR imaging is the method of first choice for staging uterine malignancies. The main criterion for staging endometrial cancer is the depth of myometrial invasion. The diagnostic accuracy can be improved by performing a dynamic contrast-enhanced study in addition to T2-weighted imaging. Recently, it has been shown that DWI gives similar diagnostic information concerning myometrial invasion as dynamic contrast-enhanced imaging. The backbone of staging cervical cancer is T2-weighted imaging with a high spatial resolution performed in sagittal and transverse slice orientation. Invasion of the parametrium can thus be assessed with a high degree of accuracy. Especially in staging cervical cancer, MR imaging can replace numerous other diagnostic tests and thus improve pretherapeutic staging while at the same time reducing costs. In addition, MR imaging is used in planning radiotherapy and following up patients having undergone irradiation. MR imaging is a problem-solving method in patients with post-treatment complications such as assessment of fistulas and detection of recurrent cancer.

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MRI of the prostate

J. Fütterer

Prostate cancer is a major health issue in aging men. No treatment is required in less aggressive prostate cancer but there is consensus that radical treatment is needed in aggressive prostate cancer.

Radical treatment has to start while the tumor is still confined to the gland and has...
not spread beyond. Potential side effects of radical treatment, such as impotence and incontinence, have a substantial impact on quality of life. This is of special importance because more than 25% of patients eligible for radical treatment are in the age range of 40 to 65 years.

Conventional anatomical T2-weighted MRI is the mainstay in prostate cancer imaging. On T2-weighted images, normal prostate tissue displays an intermediate to high signal intensity while the transition zone has lower signal intensity than the peripheral zone. Currently several MR imaging techniques are being explored. These include: 1H-MR spectroscopic imaging, dynamic contrast-enhanced MR imaging, and diffusion weighted imaging. Multiple studies have explored optimal parameter settings for the diagnostic MR protocol, which allows accurate tumor localization. Although reported accuracies of the different separate and combined MP-MRI techniques vary for diverse clinical prostate cancer indications, MP-MRI has shown promising results and may be of additional value in prostate cancer localization and local staging. To increase MR imaging accuracy for the different clinical prostate cancer indications, one or more functional MR imaging techniques should be combined with T2-weighted MR imaging in a MP-MRI of the prostate. The optimal strength of MP-MRI is yielded by combining the information of the various techniques.

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**Transrectal ultrasound-guided biopsy is recommended as the gold standard to confirm the diagnosis of prostate cancer. This systematic approach is characterized by low sensitivity and high specificity. A large number of patients with elevated and/or rising PSA levels have negative results on initial transrectal ultrasound-guided biopsy. Therefore, repeated biopsies have to be performed to confirm the diagnosis of prostate cancer. Missed prostate cancer at the first transrectal ultrasound-guided biopsy is described in about 25% of the patients.**

Magnetic resonance imaging has established itself as a useful diagnostic modality for accurate localization of prostate cancer. It is a complementary reliable imaging technique after negative transrectal ultrasound-guided biopsy.

**MR-guided biopsy of the prostate is a promising technique which combines MR imaging and the possibility of a guided biopsy. Initial experience shows promising results using transgluteal, rectal and perineal approaches (Fig. 1).**

Manual MR-guided biopsy of the prostate gland with a transgluteal approach in a high-field MR system is feasible, safe and an advantage for prostate cancer detection.

1. Institute for Diagnostic and Interventional Radiology, Johann Wolfgang Goethe University Hospital, Frankfurt University, Frankfurt, Germany.

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**MR guided biopsies of the prostate, an update**

Th. Vogl

Prostate cancer is the most frequently diagnosed malignancy in the western hemisphere in men aged 50 years and older. Early detection programs for prostate cancer with prostate-specific antigen level testing and an annual digital rectal examination should be performed in men over the age of 50. In this context the incidence of prostate carcinoma increased after the introduction of PSA testing.

**Fig. 1.** — MR-guided prostate biopsy - transgluteal approach