Focal abdominal lesions: added value of diffusion-weighted MRI

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Magnetic resonance imaging (MRI) has found many applications in abdominal oncology and is mainly used for lesion detection and characterization, determination of locoregional tumor extent and treatment monitoring. Similarly to computed tomography (CT), MRI mostly relies on morphological criteria for lesion differentiation. The use of morphological criteria, however, suffers from a number of limitations, such as failure to detect small tumoral depositions and a probable lower specificity for differentiation of tumoral and inflammatory lesions. Although differences in T2 or T1-signal intensity (SI) are helpful for lesion differentiation, like in the liver and pancreas, definite tissue differentiation based on these sequences alone is often not possible, as there is not straightforward correlation between SI on these sequences and lesion cellularity. Therefore, a contrast agent is usually required to improve lesion conspicuity and characterization. However, the increase in sensitivity is sometimes gained at the cost of specificity, as for example in patients with hepatic cirrhosis, the differentiation of arterial enhancing benign and malignant lesions can be difficult. For nodal staging, gadolinium-based contrast-agents have only minor impact. Eighteen-Fluoro-deoxy-glucose Positron Emission Tomography (FDG-PET) provides additional information to morphological imaging and shows benefit for tumor detection and staging in selected indications, such as lung cancer, colorectal cancer and lymphoma. However, the low spatial resolution and the difficulties in differentiating tumoral and inflammatory tissue may lessen the accuracy of this technique.

Diffusion-weighted MRI (DWI) offers a different approach to lesion characterization by probing the tissue microstructure based on differences in water mobility, which can be quantified by the apparent diffusion coefficient (ADC). The ADC shows an inverse correlation with the tissue microstructural density and allows to differentiate hypercellular tissue (malignancy) from hypocellular tissue (benign lesions, necrosis).

This particular way of contrast generation and lesion differentiation by DWI holds a number of potential advantages for detection of focal abdominal lesions. As DWI does not require contrast-injection, the technique is not dependent of vascularisation patterns which may sometimes be aspecific in their appearance. Also, the technique does not depend on size-related or gross morphologic criteria for lesion differentiation, which offers a potential advantage for evaluation of lymph nodes or for the detection of small tumoral deposits at primary sites like the pancreas or –if sufficiently suppressed SI of the bowel- the intestinal or colonic wall.

Furthermore, the high contrast-to-noise ratio (CNR) of DWI, due to the efficient suppression of background (normal) tissue and blood vessels facilitates the detection of small tumoral lesions, which may otherwise remain undetected on conventional sequences. Contrary, potential disadvantages include the non-standardized image interpretation and image artefacting. As both problems are increasingly dealt with, abdominal DWI shows additional value for detection and characterization of focal abdominal lesions.

DWI may be of additional value in three major areas of abdominal MRI. First, abdominal DWI may be of value in the detection and characterization of primary tumours in the abdomen and pelvic cavity. Due to the ability to minimize the influence of perfusion and thus the sensitivity of DWI to cellular changes, the technique may show additional value to conventional imaging sequences in the
Additionally, the detection of small HCC in the cirrhotic liver, where contrast-enhanced MRI may have problems in the differentiation of small arterial enhancing benign and malignant lesions.

In the extrahepatic abdomen, the technique may show value in the detection and differentiation of solid pancreatic lesions and masses. The high CNR of the technique can help to locate small neuro-endocrine neoplasms in correlation to conventional imaging sequences and potentially offer an improved microstructural/anatomical correlate to nuclear imaging techniques. Additionally, DWI may have use in the differentiation of pancreatic cancer from pancreatic inflammatory or pseudo-tumors in cases of chronic pancreatitis.

The improved lesion conspicuity of DWI also appears to be useful for lesions in the gastro-intestinal tract and can improve the detection of tumors involving he colon, rectum, stomach and oesophagus compared to conventional MRI. As the technique is gradually progressing to a full-body imaging technique this may be of interest for detection of second primary tumors in patient at risk.

Furthermore, the technique may help in the evaluation of suspected endometrial cancer, which is sometimes difficult to distinguish from benign endometrial changes related to anti-oestrogenic medication.

Next to primary tumor detection, DWI may have an important role in tumor staging as the detection of locoregional or distant metastatic spread will largely influence treatment planning.

DWI can improve the detection and differentiation of hepatic metastases and can be used as an additional imaging technique for differentiation of lesions with conflicting results on anatomical and metabolic imaging modalities.

Additionally, DWI may be advantageous in the detection of small hepatic lesions due to its high contrast-to-noise ratio complemented with the signal-suppression of normal tissue structures and intravascular flow on a high b-value image. As such, it can help to detect small lesions initially missed on T2w images or SPIO enhanced T2*-weighted images where the hyperintense signal of adjacent vessels can obscure these lesions.

Next to detection of hepatic metastases, studies have reported on the added value of DWI for the detection of nodal and peritoneal dissemination. Although high b-value imaging improves the detection of metastatic adenopathies, ADC-calculation remains necessary, potentially leading to a more difficult image interpretation. Nevertheless, the high CNR enables DWI to be used as a potential rapid screening tool in tumors with high risk for intra-abdominal metastatic spread like pancreatic cancer or gynecological malignancy.

A third important area in focal lesion detection where DWI can show additional value to conventional imaging is that of the post-radiotherapeutic and post-surgical pelvic cavity. As DWI probes the tissue based on its microstructural properties and is not influences by the underlying anatomy or metabolism (eg inflammation), the technique can be used for differentiation of post-treatment pelvic scar tissue and tumoral recurrence or the detection of pelvic tumour recurrence in case of increasing tumour markers.

The aim of the presentation is to give an overview of the potential applications of DWI in abdominal imaging from the viewpoint of the practical clinical setting.