Syllabus

„Dynamic MR Cholangiography“

Presenter

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Highlights

Dynamic MR cholangiography (T1-MRC) exploits the unique properties of some Gadolinium-based agents that show hepatocellular uptake and biliary secretion.

In the presence of funtioning hepatocytic transport, biliary excretion allows for T1-weighted cholangiography with information derived from the intrinsic bile-specificity.

T1w-MRC should be understood as an added value examination in comprehensive liver protocols not meant to replace T2w-MRCP

Talk Title

Dynamic MR cholangiography

Target audience

MD students / radiologists, physicists / PhD-students with interest in body MR imaging

Outcomes

It is the purpose of this talk to introduce the participants in the so-called „dynamic“ or functional MR imaging of the biliary system achievable with Gd-based contrast agents that exhibit a hepatocytic uptake and excretion.

It is the goal to provide a comprehensive understanding of available Gd-based „hepatobiliary“ contrast agents and their specific characteristics. Imaging strategies and protocol optimization options will be proposed and potential pitfalls discussed. Typical cases will be used to compare T1w MRC to T2w MRCP and endoscopic retrograde cholangiopancreaticography (ERCP) and put into anatomical and clinical context.

Text

The biliary system has two major roles: On the one hand, secretion of bile acids helps emulsifying fat in the small intestine by forming micelles. This, in turn, supports the uptake of vital vitamins E, D K, and A. On the other hand, bilirubin, a by-product of red blood cell degradation, is secreted via the bile. Bile also helps neutralizing stomach acids and playes a role in controlling intestinal bacteria. Hepatocytes actively secrete bile into biliary canaliculi which merge to form larger pathways, finally forming intrahepatic bile ducts that merge into the common hepatic duct (CHD). The CHD is located outside the liver. It is joined by the cystic duct from the gallbladder and runs towards the head of the pancreas where it usually opens into the duodenum via the major duodenal papilla or Ampulla of Vater.

The biliary system can be affected by various diseases that include tumor, trauma, and infection, some of which alter the appearance ductal luminograms and can thus be detected by imaging methods. Also, pre- and postoperative assessment in conditions such as cholangiocellular carcinoma or liver segment resection due to tumor needs to be performed and becomes especially important during the evaluation for living donor liver transplantation.
Common clinical dagnostic approaches include routine percutaneous ultrasound, endcoscopic ultrasound, endoscopic retrograde cholangio[pancreatico]graphy (ERC[P]), and MR-cholepancreaticography (MRCP). None of the non-invasive tools offers dynamic information specific to the biliary system. With the introduciton of so-called „hepatobiliary“ Gadolinium-based contrast agents, T1w-MRC became available. To differentiate the MR apporaches, „T2w-MRCP“ will be refering to 3-dimensional fast T2w sequence approaches, whereas „T1w-

MRC“ will be used when speaking of contrast-enhanced T1-weighted MR cholangiography.

In T1w-MRC, a unique feature of some of the Gd-based contrast agents is used: Next to renal excretion, gadoxetate disodium (Eovist / Primovist ®, Bayer HealthCare), gadobenate dimeglumine (MultiHance ®, Bracco Diagnostics) as well as gadofosveset trisodium (Ablavar ®, Lantheus) exhibit a additional excretion pathway via the liver (1). In the case of gadoxetic acid, this pathway is described via an active take up in hepatocytes by a canalicular multispecific organic anion transporter 8 (OATP 8). Similar transport pathways are assumed to exist for gadobenate dimeglumine as well. Excretion of gadoxetic acid into the bile has been described as being achieved through the multidrug resistant protein 3 (MRP 3) (2).
Exhibiting an additional excretion pathway via the liver implies that these so-called „hepatobiliar“ contrast agents also show a contrast agent behaviour similar to that of other extracellular Gd-based contrast agents during the dynamic phase. MR-cholangiography based on the application of biliary contrast agents, however, allows depicting the biliary system with information related to the presence of contrast agent. Thereby, biliary leakage or biliomas can principally be unambiguously identified (3); apart from anecdotal reports broad scientific data are, however, lacking.

To exploit the the hepatobiliary imaging features of hepatobiliary contrast agents, a contrast-agent-specific timing needs to be considered during protocol setup and patient management. For gadoxetic acid, the so-called „hepatobiliary phase“ can be imaged starting at approximately 20-60 minutes after injection while the patient is still on the table. For gadobenate dimeglumine, however, 45-120 minutes after injection is appropriate for the „delayed“ hepatobiliary scan. Thus far, no data are available on the hepatoblliliary features of gadofosveset trisodium.
Since the hepatobiliary phase of both gadoxetic acid and gadobenate dimeglumine lasts over several minutes to hours, imaging approaches can be altered to optimize image quality and/pr patient comfort. Usually, fast T1w volume-interpolated gradient echo sequences with fat saturation are used

during a breath-hold to capture the dynamic phase during injection and contrast agent distribution through the body and liver without image quality deterioration due to breathing motion (VIBE, THRIVE, LAVA, TIGRE). However, the duration of the heaptobiliary phase with near constant enhancement values in both biliary system and liver allows, e.g., for free-breahing navigator-gated imaging approaches in high detail (4). To optimize signal-to-noise- and/or contrast-to-noise-ratios for imaging with hepatobiliary contrast agents, flip angle modifications can be helpful (5,6). During protocol optimization, some typical liver imaging sequences (DWI, T2w) can usually be moved to the interval between dynamic phase and delayed hepatobiliary phase imaging. However, 3D T2w MRCP should not be performed during maximum hepatobiliary enhancment because of T2w-shortening effects of gadoxetic acid that can be detrimental to T2w-MRCP image quality (7).

For gadoxetate disodium and gadobenate dimeglumine, data evaluating MRC imaging characteristics are available. It has to be noted, however, that the aforementioned contrast agents are not specifically FDA-approved for MRC. Gadoxetate disodium has received FDA-approval for „imaging of the liver to detect and characterize lesions in adults with known or suspected focal liver disease“, gadobenate dimeglumine has received approval for CNS-imaging and MRA, gadofosveset for MRA in aorto-iliac occlusive or peripheral vascular disease. Data include overall T1w-MRC imaging performance in comparison to T2w-MRCP or ERCP serving as the reference standard. Also, the clinical importance in situations such as liver transplant evaluation or diseases such as primary sclerosing chlonagitis (PSC) are availabe (8-11).

There is, however, sparsity with respect to data concerning the reliability of T1w-MRC in the presence of potential pitfalls related to liver physiology or biliary system affection: In cases of decreased hepatocytic function, no excretion and hence biliary contrast can be expected (12). Next to potential limitations concerning the secretion of bile, problems concerning ist transport such as CHD obstruction (e.g., by gallstones, tumor) should be considered although report the added value of gadoxetic acid as well (13). Thus far, there is only a very limited

body of literature concerning the conditions that influence T1-MRC under those or similar circumstances.

In summary, hepatobiliary contrast agents have enriched MR diagnostic imaging by making T1w-MRC available that provides biliary information that is based on functioning hepatocytes and biliary transport, thus „dynamic“ information is availbale. T1w-MRC is a field that is still under active research which is needed to further investigate ist strengths and weaknesses. So far, T1w-MRC should be understood to provide added value to biliary imaging in the MR imaging of the liver and not to replace T2w MRCP.

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