Contrast enhanced magnetic resonance angiography versus Intra-arterial Digital subtraction angiography in transplantation medicine
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Summary

The main purpose of this study was to investigate whether contrast enhanced magnetic resonance angiography (ce-MRA) can replace intra-arterial digital subtraction angiography (i.a.DSA) in liver transplantation candidates, patients after pancreas-kidney transplantation and living renal donors. For this purpose we used a trade-off model consisting of diagnostic strength, costs aspects and the patient's acceptance of the new technique ce-MRA compared to the older technique i.a.DSA to decide on replacement of i.a.DSA or not. Besides this multi-perspective approach an attempt has been made to optimize the ce-MRA scan protocol for optimal diagnostic strength, efficiency and time saving purposes.

Chapter 1 provides a general introduction to the technique ce-MRA and i.a.DSA and its advantages and disadvantages. General remarks about transplantation, in particular liver, kidney and pancreas transplantation, and some remarks about the trade-off character give the reader some background information. At the end of the introduction chapter the following questions are presented:

1. Can ce-MRA-MRI in the orthotopic liver transplantation candidate replace i.a.DSA?
2. Can ce-MRA-MRI in the potential living (un)related renal donor replace i.a.DSA?
3. Can ce-MRA-MRI in the patient with suspected vascular or non-understood problems after pancreas and/or kidney transplantation replace i.a.DSA?
4. What are the financial consequences of replacement of i.a.DSA by ce-MRA-MRI?
5. What is the opinion of the patient about the examinations ce-MRA-MRI and i.a.DSA? Which procedure is preferred by the patient?
6. Is the proposed ce-MRA scan timing scheme suitable for an optimal signal intensity in the arterial, portal venous and systemic venous system in the abdomen? Does a difference exist between patients with cirrhosis (liver transplantation candidates) and healthy individuals with respect to the point in time when the maximum signal intensity occurs?

In Chapter 2 we studied the diagnostic value of ce-MRA compared to i.a.DSA in 50 patients with chronic liver disease in the work up for an orthotopic liver transplantation. No significant differences were found in the diagnostic value for that part of the arterial system that is considered important for the transplant surgeon. The small vessel detail was less in ce-MRA, but this was not considered a drawback in this patient group. With respect to the portal venous, the porto-systemic collaterals and the systemic venous system ce-MRA was superior to i.a.DSA. Although better than i.a.DSA also ce-MRA-MRI showed disappointing results in the detection of hepatocellular carcinoma. We concluded that ce-MRA-MRI has a superior diagnostic strength compared to i.a.DSA in the radiological work-up for liver transplantation. Therefore ce-MRA-MRI should replace i.a.DSA in these patients.

In Chapter 3 we reported the results of ce-MRA in 26 living (un)related living renal donors. Ce-MRA showed good and comparable results to i.a.DSA in the detection of supernumerary renal arteries. Ce-MRA depicted the renal veins much better. This may be an advantage if the nephrectomy is performed by laparoscopy. Ce-MRA gave better parenchymal detail. However, the urinary collecting system was better depicted on i.a.DSA. In this patient group we considered the less spatial resolution an insurmountable problem to accept ce-MRA as a replacement for i.a.DSA because ce-MRA was unable to detect fibromuscular dysplasia.

In Chapter 4 we investigated the diagnostic value of ce-MRA-MRI in 29 patients with suspected vascular or non-understood problems after pancreas and/or kidney transplantation compared to i.a.DSA. The
depiction of the venous drainage from the grafts was much better on ce-MRA-MRI. Ce-MRA-MRI and i.a.DSA were of equal value in the assessment of the perfusion in the renal grafts. In the pancreatic grafts, however, the perfusion was more easily seen on ce-MRA-MRI.

The three-dimensional character of ce-MRA made the evaluation of tortuous graft arteries possible from any desired angle. This was an advantage over i.a.DSA. Disadvantages were artifacts of vascular clips that suggested stenoses in the graft arteries. A careful evaluation of the source images should alert the radiologist on the occurrence of these artifacts. The urinary collecting system was better depicted on ce-MRA-MRI compared to i.a.DSA. Because the gadolinium contrast agents as used in ce-MRA-MRI have a much higher safety profile compared to the iodine contrast agents in i.a.DSA, ce-MRA-MRI is preferred over i.a.DSA to evaluate the patients with suspected vascular or non-understood problems after pancreas and/or kidney transplantation as the first screening modality.

In chapter 5 the radiological costs aspects of ce-MRA and i.a.DSA in 102 individuals (50 liver transplantation candidates, 26 potential renal donors and 26 patient after pancreas and/or kidney transplantation) were compared. All these individuals had ce-MRA-MRI and i.a.DSA within a three days interval. In all three patient groups ce-MRA was less expensive than i.a.DSA (up to 20%). To achieve these relatively low costs in ce-MRA it is necessary that technicians perform the ce-MRA without the radiologist involved in the scan procedure itself. Moreover, efficient use of the MR equipment is a prerequisite for the lower costs in ce-MRA. The conclusion was that it is justified to replace i.a.DSA by ce-MRA in order to cut the spendings in health care.

In chapter 6 the acceptance of ce-MRA by 104 patients was compared to the acceptance of i.a.DSA. The liver transplantation candidate, the living renal donor and the patient after pancreas and/or kidney transplantation, they all preferred ce-MRA over i.a.DSA. The main reason for this preference was the non-invasive character of ce-MRA. Therefore the patients experienced less pain and did not have an obligatory bedrest after the examination. In contrast, after i.a.DSA patients had bedrest during four hours for safety reasons after an invasive procedure. The majority of the patients considered the bedrest as a pretty big nuisance.

In general the patients experienced less mental and physical strain during ce-MRA. Only a small group with definitely a claustrophobic predisposition experienced much fear and felt uncomfortable in the tight MR scanner. This small group will therefore refuse MR in the future. It could be concluded that ce-MRA was better accepted than i.a.DSA by most patients. Therefore there are from the patient’s point of view good reasons to replace i.a.DSA by ce-MRA.

In chapter 7 a scantiming scheme to depict the abdominal arterial, portal and systemic veins with the highest signal intensity is proposed and evaluated. The arteries showed the highest signal intensity on the first scan, the portal vein and the renal vein on the scan after 30 seconds. The scan that starts after 60 seconds is optimal for the depiction of the supra-renal inferior vena cava, the 90 second scan is optimal for the infra-renal inferior vena cava. No differences were found between 40 patients with cirrhosis and 20 healthy subjects. Therefore this scantiming scheme can be used in all patients, irrespective of possible underlying liver cirrhosis.

Chapter 8 discusses the results of the previous chapters and summarizes the different advantages and disadvantages of the ce-MRA technique that was used in this study.
Conclusions

The answers to the questions raised in the introduction are as follows:

1. Ce-MRA-MRI in the orthotopic liver transplantation candidate can replace i.a.DSA because it has a superior diagnostic strength.

2. Ce-MRA-MRI in the potential living (un)related renal donor cannot replace i.a.DSA because the spatial resolution is too low to detect fibromuscular dysplasia. However, if the nephrectomy is performed with a laparoscopic technique, ce-MRA gives additional information about the venous system that is necessary for a safe procedure. With that respect ce-MRA and i.a.DSA are complementary.

3. The diagnostic value of ce-MRA-MRI in the patient after pancreas and/or kidney transplantation is enough to replace i.a.DSA as the primary diagnostic procedure to demonstrate or exclude a vascular cause of the impaired function. However, one has to be aware of artifacts (especially surgical clip artifacts) that may simulate stenoses. If in doubt, additional i.a.DSA should be performed.

4. The radiological part of the work-up in liver transplantation candidates, renal donors and patients after pancreas and kidney transplantation costs significantly less if ce-MRA-MRI is performed instead of i.a.DSA. Besides the high diagnostic value this is an argument to replace i.a.DSA in the liver transplantation candidate and the patient after pancreas and kidney transplantation.

5. Liver transplantation candidates, renal donors and patients after pancreas and kidney transplantation, they all prefer ce-MRA over i.a.DSA. This is another argument to replace i.a.DSA in the liver transplantation candidate and the patient after pancreas and kidney transplantation. The only exception is the patient with severe claustrophobia and patients with contra-indications for MR like some ferromagnetic devices, they will continue to have i.a.DSA.

6. The proposed ce-MRA scan timing scheme is suitable for the depiction of the arterial, the portal and the systemic venous system in the abdomen with a maximum signal intensity. No difference exists between patients with cirrhosis and healthy individuals. Therefore the proposed scan timing scheme is suitable for subjects with and without cirrhosis.