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Leading Innovation

Volume CT-Perfusion Imaging

Evaluating early response after transarterial chemoembolization (TACE) of hepatocellular carcinoma (HCC)

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Hepatocellular carcinoma (HCC) is one of the most frequent malignant tumors worldwide and with 80–90 % the most common primary malignancy of the liver. While surgical therapy provides the only possible curative approach, only 10 to 15 % of the patients are eligible. Transarterial chemoembolization (TACE) is widely recognized as an interventional therapeutic option in patients who are not able to undergo surgical resection. The therapeutic rationale of TACE is based on the findings that normal liver tissue receives 75–83 % of its blood supply from the portal vein while HCC tumor tissue receives 90–100 % of its blood supply from the hepatic artery since the tumor is highly vascular and forms neovasculature through angiogenesis. TACE enables specific targeting of tumor lesions with chemotherapeutic agents and reduces arterial tumor blood supply while sparing normal liver tissue. The goal is to induce tumor necrosis and to inhibit tumor growth while preserving functional liver tissue.

Multiphase contrast-enhanced computed tomography plays a crucial role in determining therapeutic response after TACE since it shows deposits of embolic material such as lipiodol, tumor necrosis and residual or recurrent vital tumor tissue. The assessment of therapeutic response with contrast-enhanced CT facilitates further therapeutic decisions, including retreatment with TACE. However, this technique is limited since it may fail to show vital tumor tissue due to visually not detectable contrast media enhancement or the presence of embolic deposits which compromise the detection of tissue contrast media enhancement. Therapy response may better be assessed by a method which is able to dynamically display tumor vascularization rather than tissue enhancement at a given delay after contrast media application.

CT perfusion imaging (CTPI) represents a functional method which is able to depict tumor vascularization taking into account the dual blood supply of the liver via the portal vein and hepatic artery thus allowing discrimination between tumor and normal liver tissue. Due to its functional approach CTPI might be a more sensitive tool to assess therapeutic response after TACE compared to multiphase contrast-enhanced CT. The continuous increase in the number of detector rows since the introduction of multi-detector row CT led to an increase of detector width which is up to 16 cm with the 320 detector row CT scanner Aquilion ONE by Toshiba Medical Systems.

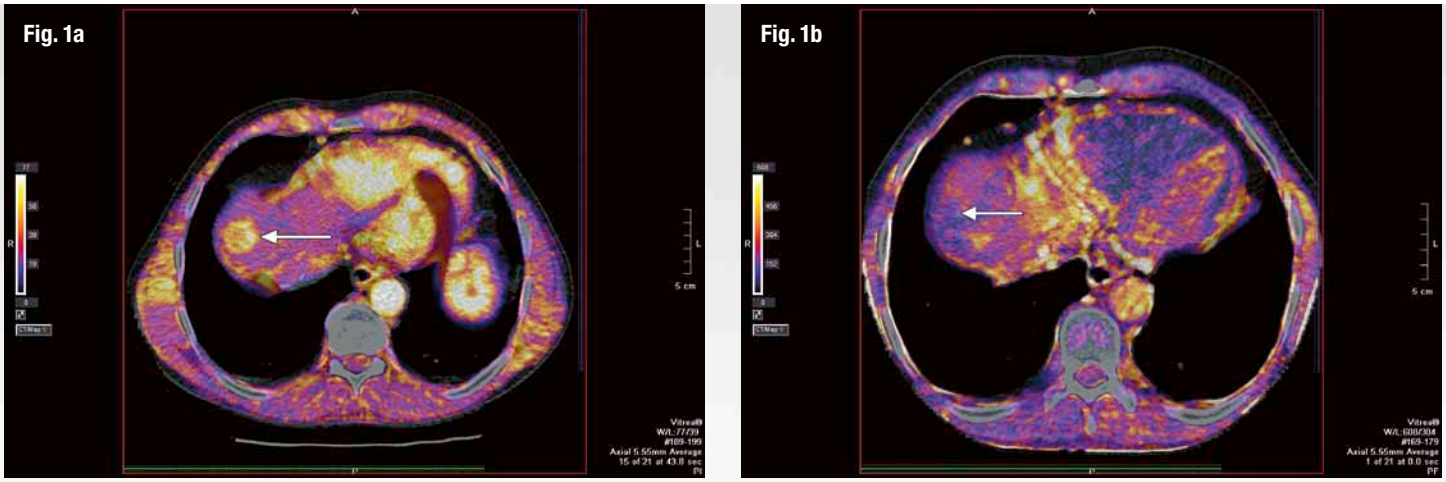


Fig. 1: PI color mapping of a small HCC in the right liver lobe before (a) and after TACE (b). PI color mapping before TACE in a shows a high PI of the lesion (arrow) demonstrating that the overall perfusion of the lesion is mainly due to arterial perfusion. PI color mapping after TACE in b shows a significant decrease of the PI of the lesion without evidence of residual tumor (arrow).

Coverage of up to 16 cm allows volume CT perfusion imaging (VCTPI) of nearly the entire liver and thus functional imaging of singular or multiple HCCs after TACE.

Technique

VCTPI was performed in patients who underwent TACE of a known HCC one day before and 5 to 7 days after the procedure. Dynamic volume CT acquisitions were performed after administration of 30–60 mL of iodinated contrast media (Iomeron 400 mg/mL, Bracco) at a flow rate pg 5–8 mL/s followed by saline chaser. Arterial blood flow (AF; mL/min/100 mL), portal venous blood (PF; mL/min/100 mL) as well as perfusion index (PI; AF/(AF+PF); %) were calculated using the dual input maximum slope method of the body perfusion software.

Acquisition data	
Tube voltage	100 kV
Tube current	100 mA
Gantry rotation time	0.5 s
Detector width	10 cm

The acquisition was performed without table movement or shuttle mode ensuring uniform temporal resolution.

Initial results

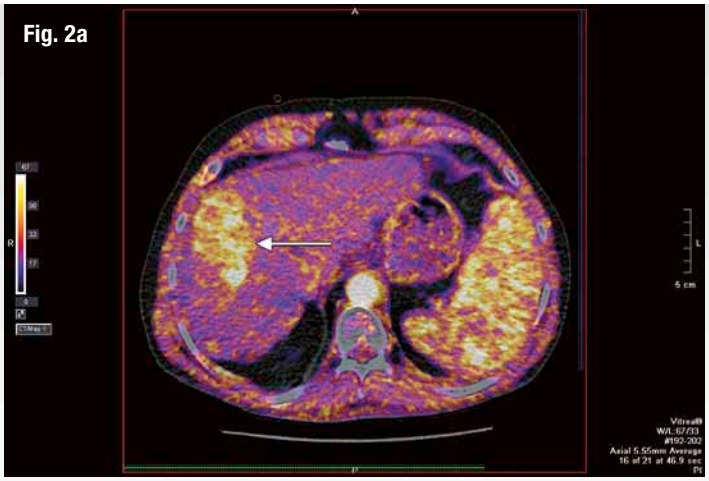
Figure 1 shows perfusion index (PI) color mapping of a small HCC in the right liver lobe before (a) and after TACE (b). PI color mapping before TACE shows a high PI demonstrating that the overall perfusion of the lesion is mainly due to arterial perfusion. PI color mapping after TACE shows a significant decrease of the PI of the lesion without evidence of residual tumor.

Figure 2 shows PI color mapping of a large HCC in the right liver lobe before (a) and after TACE (b). Although there is an obvious decrease in PI after TACE, areas of high PI are still clearly detectable consistent with residual tumor.

The overall DLP of 21 volumes (10 cm detector width) was 504 mGy*cm which is equivalent to an effective dose of 7.5 mSv.

Conclusion

VCTPI allows functional imaging of nearly the entire liver and thus evaluation of early success of TACE of HCC. Perfusion images with uniform temporal resolution were acquired with an effective dose of 7.5 mSv. Uniform temporal resolution can only be achieved by using non-shuttle acquisition, i.e. without table movement.



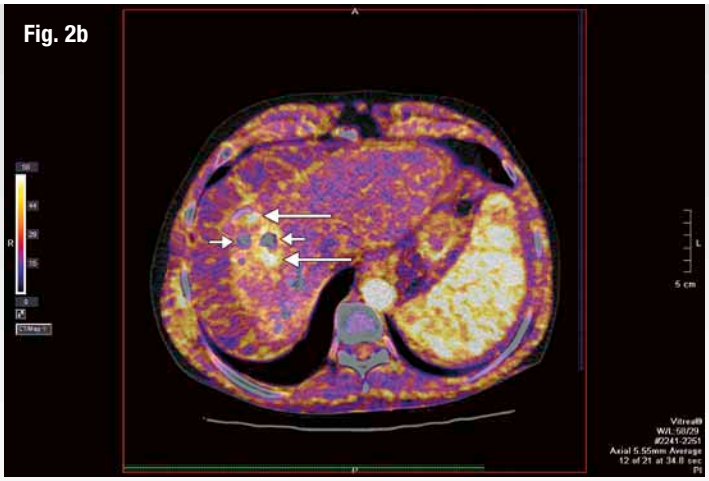


Fig. 2: PI color mapping of a large HCC in the right liver lobe before (a) and after TACE (b). PI color mapping before TACE in a shows a high PI of the lesion (arrow) demonstrating that the overall perfusion of the lesion is mainly due to arterial perfusion. PI color mapping after TACE in b shows a significant decrease of the PI of the lesion; however, areas of high PI are still clearly detectable consistent with residual tumor (arrows). Note lack of color mapping due to embolization material in b (arrowheads).

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