Utility of Intra-procedural Gadoxetate Disodium Administration during MRI-Guided Laser Ablation of Hepatic Metastases: Experience with 47 Treated Lesions

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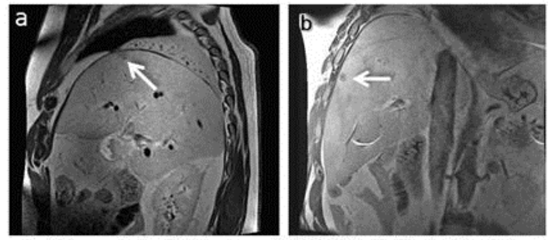

Fig 1: Intraprocedural sagittal (a) and coronal (b) TSE T1WIs after IV gadoxetate disodium injection to confirm metastatic burden prior to laser ablation demonstrate 2 unexpected additional subcentimeter lesions.

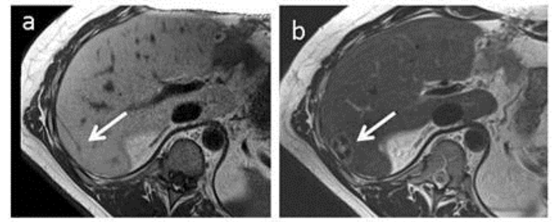

Fig 2: Intraprocedural axial gadoxetate disodium enhanced TSE T1WI (a) precise placement of laser fiber within a 7mm metastatic colon cancer lesion. Axial intraprocedural TSE T2WI (b) demonstrates the ablation zone.

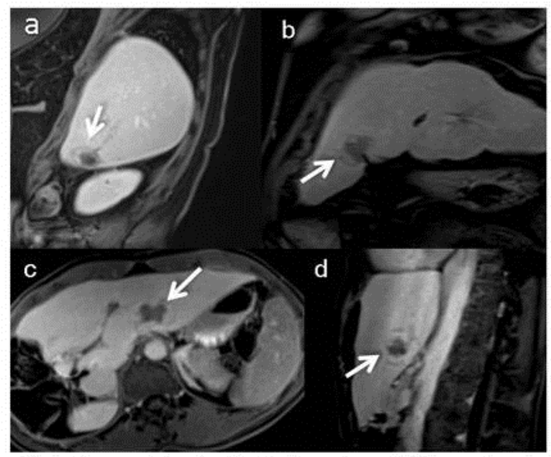

Fig 3: Intraprocedural gadoxetate disodium enhanced VIBE scans from 3 different patients obtained immediately following the ablation after additional administration of MultiHance demonstrate the exact delineation of original tumor margins (central dark areas) relative to the margins of the ablation zones (outer thin rims). All lesions are metastases from colorectal primaries. c and d are from the same patient. b-d demonstrate the value of the technique in tailoring the ablation zone to cover infiltrative/lobulated lesions.

Introduction & Purpose: Management of patients with occult metastatic liver disease is challenging and requires appropriate quantification of hepatic tumor burden, proper multidisciplinary treatment planning, and access to reliable minimally invasive modes of Locoregional tumor control. The current standard of care available for these patients falls short in two aspects of this process: a) providing consistent pre-operative detection of subtle disease, a fact that rendered direct intra-operative ultrasound of the exposed liver a standard practice prior to metastatectomy; and b) allowing unequivocal identification of subcentimeter metastases for precise targeting when percutaneous ablation is the treatment option of choice. This currently leads to hepatic resections and/or open ablations that maybe avoidable particularly in poor surgical candidates. The aim of this study is to assess the value of a modified technique for MRI-guided laser ablation of liver metastases utilizing intra-procedural IV gadoxetate disodium (Eovist®) administration and controlled breath suspension under general anesthesia for a) detecting subtle metastases not seen on pre-procedure scans; b) facilitating precise targeting of subcentimeter lesions; and c) enhancing the safety of ablation near central bile ducts.

Patients & Methods: 25 patients (15M, 10F, age=29-84y) with 47 liver metastases (22 colorectal, 2 gastric, 3 melanoma, 17 pancreatic neuroendocrine, 1 pancreatic adenocarcinoma, 2 parotid merkel cell carcinoma) are included in this analysis. Patients were referred for MRI guided intervention because of the subtle nature of metastases, challenging location, and/or the desire to assess for further disease not seen on pre-procedure diagnostic MRI scans. Procedures were performed within an interventional MRI suite equipped with 1.5T wide bore scanner. Interventions were performed under general anesthesia within the scanner bore while viewing real-time image updates on an in-room monitor. Initially, IV (0.025 mmol/kg) was administered and whole liver imaging was performed using VIBE (TR/TE 4.19/2.1), TSE T1(TE/TE=436/4.4) and TSE T2 (TE/TE=3000/84) in 3 planes during suspended breathing. Once the metastatic burden has been confirmed/updated, an interactive visualization on a tri-orthogonal plane FLASH sequence (TE/TE=1220/1.92) was used to guide a laser fiber with 15mm diffusing tip encased in 5.5 F cooling catheter (Visualase, TX) into the target lesion(s). A test dose of diode laser energy (980nm,30sec,4.5W) was applied to verify the location of ablation nidus on real-time temperature and cumulative damage estimate mapping(TE/TE=24/10). Subsequently, ablative energy dose was delivered with treatment endpoint based on on-line thermal monitoring of growing ablation. Fiber repositioning for additional ablation was conducted as needed. Final ablations were evaluated on a repeat set of pre-ablation scans with VIBE and TSE T1 scans repeated after a final dose of MultiHance (0.1 mmol/kg).

Results: Target tumor sizes were 0.7-4.0 cm. Locations included all liver segments but the caudate lobe. Complete ablation was achieved in 1 session for each lesion. Applied laser energy was 1080-40716J per lesion. Intra-procedural imaging with the hepatocyte-specific contrast agent under controlled suspended breathing allowed accurate mapping of metastatic tumor burden within the liver prior to proceeding with the planned ablations. This approach resulted in the detection of 17 additional subcentimeter metastases that were not accounted for on pre-procedure diagnostic MRIs in 5 patients (Fig. 1). The high tumor-to-liver contrast achieved allowed precise targeting of all subcentimeter lesions (Fig. 2) and accurate placement of the laser applicator within the desired part of the lesion when multiple placements were needed in larger metastases. The high contrast provided by gadoxetate disodium was also essential for unequivocal intraprocedural delineation of the margins of infiltrative/lobulated lesions, allowing for tailoring of the ablation zone to achieve adequate safety margins (Fig. 3). The biliary excretion of gadoxetate disodium resulted in exquisite mapping of the central biliary system, facilitating uncomplicated ablation of a lesion abutting the cystic duct (Fig. 4). The addition of MultiHance at the conclusion of ablation resulted in exact demarcation of the targeted tumor outline within the margins of the ablation zone (Figs 3 &4). No contrast toxicity or other early or delayed complications were encountered on follow-up durations of up to 54.6 weeks.

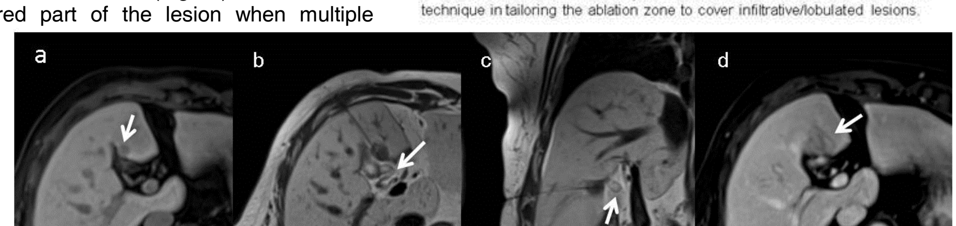

Fig 4: Intraprocedural gadoxetate disodium enhanced VIBE scan (a) demonstrates a neuroendocrine metastatic lesion abutting the liver capsule and bulging onto the GB neck and cystic duct. (b) and (c) are TSE T1WIs demonstrating the laser fiber accurately placed within target and the biliary system clearly opacified. (d) is an immediate post ablation VIBE following additional MultiHance injection and shows the relationship of target tumor (inner dark lesion) to the created ablation zone (outer thin rim).

Discussion & Conclusion: This investigation reports a comprehensive approach for minimally invasive MR-based locoregional control of hepatic metastases, with particular value in cases of occult liver lesions. The application of hepatocyte-specific contrast during high resolution MR imaging under GA controlled suspended breathing prior to focal ablation is analogous to using intra-operative ultrasound for definitive mapping of metastatic burden prior to hepatic metastatectomy. The on-board liver agent along with the interactive 3-plane MR guidance technique allow for a) precise targeting of subtle lesions that are typically considered unapproachable for percutaneous treatment; b) proper tailoring of ablations and inclusion of adequate safety margins around infiltrative lesions; c) increased safety while treating lesions in the vicinity of central bile ducts; and d) immediate accurate delineation of the targeted tumor margins relative to the outline of the created laser ablation zone.