Why not MRI? Localization and characterization of parathyroid adenomas in primary hyper parathyroidism

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Purpose: Localization of parathyroid adenoma prior to surgery is crucial for cure of primary hyper parathyroidism. Standard modalities to localize them are Sestamibi with SPECT and ultrasound. Depending on a case, CT may be added. In primary hyper parathyroidism, there may be a single adenoma or multiple adenomas of parathyroid. Combination of imaging modalities seems to improve sensitivity to localize adenomas [1]. However, there are several problems with each of standard modalities. Some parathyroid adenomas have negative Sestamibi/SPECT result, and their low-resolution images do not provide good anatomical information. CT on the other hand provides excellent anatomical information and dynamic contrast enhancement study will show a characteristic hyper perfusion with early washout pattern in adenomas, which can be helpful to distinguish adenomas from near-by lymph nodes [1]. However, ionizing radiation of CT is concerning. Ultrasound is a sensitive and inexpensive way, no involvement of ionizing radiation, but it is heavily technique dependent and sometimes adenomas are missed. In addition, ultrasound cannot evaluate intrathoracic lesions. MRI is free of ionizing radiation, provides good tissue contrast and valuable anatomical information as well as perfusion information with gadolinium injection. Especially in cases with Sestamibi and ultrasound negative results (or in a case with Sestamibi positive result, but ultrasound cannot locate adenomas), MRI will be greatly helpful to localize parathyroid adenomas, distinguishing adenomas from lymph nodes, and searching for intra-thoracic adenomas. To solve multiple problems with currently used imaging modalities for localizing parathyroid adenomas, we propose an MRI protocol including dynamic contrast enhanced MRI (DCE-MRI) that is reasonably applicable to clinical setting. **Outline of Content:** MRI study included T2-weighted axial TSE images with fat-suppression, pre and post contrast T1-weighed axial TSE images with fat-suppression, post contrast axial T1-weighted volumetric interpolated breath-hold examination (VIBE) images, and 2D turbo FLASH DCE-MRI. The DCE-MRI study was designed for shallow free breathing, also the patients were asked not to swallow during the scan. A 3T-superconducting magnet (Siemens Trio, TIM system, Erlangen, Germany) with a neck coil was used. MRI parameters were as follows: T2-weighted TSE (TR/TE=1200/100msec, FOV=200mm, 320x320, 2 excitation, BW=260kHz, FA=140, ETL=14, 4mm slice thickness/0mm inter slice gap, scan time=4min, fat-saturation); T1-weighted TSE (TR/TE=750/9.8msec, FOV=200mm, 256x256, 2 excitation, BW=250kHz, FA=120, ETL=3, 4mm slice thickness/0mm inter slice gap, scan time=3min, fat-saturation); VIBE (TR/TE=15/2.3msec, FOV=200mm, 320x320, 1 excitation, BW=200kHz, FA=12, ETL=1, 3mm slice thickness/0mm inter slice gap, scan time=1.7min); turbo FLASH (TR/TE=500/1.6msec, FOV=250mm, 192x180, 1 excitation, BW=362kHz, FA=10, ETL=1, 5mm slice thickness, oblique sagittal orientation, Temporal resolution=2sec, 124 frames, scan time=4min, Gd-DTPA iv. 0.1 mmol/kg). Diffeomorphic Demons image registration and Chi-square optimization of reliable pixels in ROIs were performed on DCE-MRI to better calculate parameters [2]. Time-intensity curve was created in case 1. We performed MRI study in primary hyper parathyroidism cases in order to see the protocol feasibility. 3D models of neck including thyroid gland and the adenomas were created for surgical planning. The entire MRI protocol was reasonably done within a clinical MRI examination slot time (15-20min for scanning, 30min from set-up to end of exam). Anatomical images (T1-weighted images with and without contrast, T2-weighted images) demonstrated excellent tissue contrast and neck anatomy with 3 different plane orientations, which helped localization of parathyroid adenomas. Of all sequences, T2-weighred fat-suppressed images were the easiest to localize the adenomas as they were highlighted with hyper signal intensity in dark signal-suppressed fat tissue. T1-weighted contrast images with fat-suppression demonstrated the adenomas well. 3D VIBE images were used to create a 3D model for surgical planning, which was helpful for the surgeon to know exact location to look for the adenomas. In both cases, Sestamibi study was weakly positive and ultrasound study could not localize the adenomas, while MRI studies readily located the adenomas. DCE-MRI showed image shifts in a cranio-caudal direction due to free-breezing and swallowing motion. Since a thyroid lobe and parathyroid adenomas moved in the cranio-caudal direction, oblique sagittal plane through the adenoma was adequate so that the adenoma was always captured in the DCE-MRI image plane. Image shift due to breathing was corrected readily by Diffeomorphic Demons image registration, however, several frames that were affected by swallowing motion could not be well registered. The representative time-intensity curve of parathyroid adenoma is shown in Fig. 1. Anatomic T1 and T2-weighted images are shown in Fig. 2. MRI was performed in Sestamibi indeterminate and/or ultrasound negative cases under current pre-operative protocol. MRI could locate the adenomas in those cases and removals were successful confirmed by immediate decrease of serum calcium level and histology. Sestamibi with SPECT, ultrasound, and CT images of parathyroid adenomas will be demonstrated in the presentation, as well as 3D surgical planning models. **Summary:** MRI of parathyroid adenomas can be performed within a reasonable time and can provide valuable information about location and tissue characteristics of the adenomas. MRI solves numerous problems of currently used standard imaging modalities; 1. Detailed anatomic images with excellent tissue contrast are obtained, 2. No ionizing radiation exposure to patients, 3. Perfusion evaluation equivalent with CT perfusion study can be done without exposing patients to large amount of ionizing radiation, 4. It does not depend on technique/technician to evaluate the images or detection of adenomas, 5. Intra-thoracic parathyroid adenomas can be searched in a same MRI session (with a body array coil). Further more, it may have potential to distinguish co-existing thyroid tumors, malignant tumors, and nearby lymph nodes by calculating perfusion indices and pharmacokinetics from DCE-MRI. Surgical planning including a 3D model of the adenoma and surrounding neck anatomy is an additional advantage. Free breathing during DCE-MRI is easier for patients and there were no problems to create time-intensity curve with application of the image registration. However, image shift from swallowing motion was difficult to correct and asking patients to avoid swallowing during the scan is important. Mean transit time (MTT), time-to-peak (TTP), initial slope (IS), and maximum enhancement (E_{max}) can be calculated from time-intensity curves. k_{ep} can be calculated based on the two-compartment model [2, 3]. Such perfusion analysis will be helpful for differential diagnosis between parathyroid adenomas and other nodules, e.g. lymph nodes, nodular thyroid, malignant tumor, etc. One disadvantage of MRI study is its cost; it is more expensive compared with CT or ultrasound. However, because of so many advantages of performing MRI may put Sestamibi and CT lower in order of pre-surgical evaluation. We proposed an MRI protocol with DCE-MRI for localization and characterization of parathyroid adenomas in primary hyper parathyroidism. We will present Sestamibi SPECT, ultrasound, and CT images of the adenomas in comparison with MRI.

References: [1] Lubitz CC, et al. Surgery. 2010;148(6):1129-37. [2] Tokuda J, et al. J Magn Reson Imaging 2011;33(4):968-73. [3] Tofts PS. J Magn Reson Imaging 1997;7:91-101.

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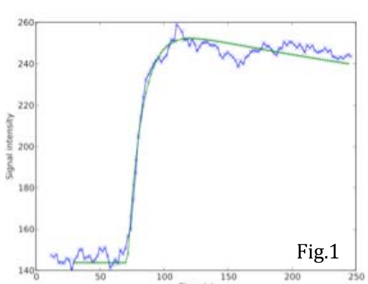

Fig.1

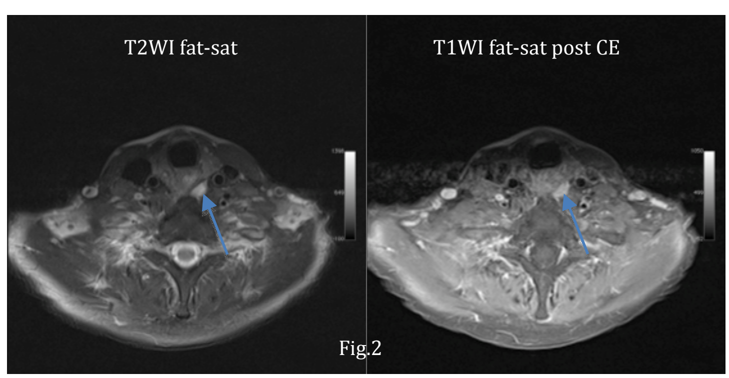

Fig.2