Evaluation of lymph node metastasis in human by ultrasound super-resolution imaging

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Background, Motivation and Objective

The presence of metastasis in tumour-draining lymph nodes (LNs) is considered one of risk factors for local tumour recurrence and cancer-specific mortality and accurate detection of lymph node metastasis significantly impacts patient management. Contrast enhanced ultrasound (CEUS) has been used to evaluate nodal perfusion patterns and improves accuracy of diagnosis of metastatic cervical lymph nodes in patients with papillary thyroid carcinoma (Hong et al. 2017). However, as a consequence of limited spatial resolution the identification of cancer lesions, especially for small LNs, is problematic. Super-resolution ultrasound (SR-US) techniques are able to visualise vascular structures beyond the diffraction limit. In this work, we apply SR-US to clinical datasets with an aim to improve diagnostic confidence.

Statement of Contribution/Methods

US-SR was performed on CEUS datasets acquired from a range of benign and malignant LNs in cancer patients using clinical scanners with a transmit frequency of 6 MHz. In order to control the microbubble concentration, destruction pulses were performed at a high mechanical index (MI) of 0.75 to achieve bubble destruction. After the destruction pulses, images were acquired at an MI of 0.06 after the routine clinical CEUS examination. SR images were generated through off-line post-processing of the acquired image data. Two-stage motion correction (Harput et al. 2018) was applied on the B-mode images. Spatially isolated microbubble signals were extracted and localised from the CEUS images. SR velocity maps were generated by tracking individual microbubble trajectories.

Results, Discussion and Conclusion

Fig. 1A shows Colour Doppler image where only major vessels with fast blood flow (28 cm/s outside the LN) are visualised. This mode failed to detect any slow flow inside the LN. Fig. 1B and 1C show the maximum intensity projection over time (MIOT) compared to the SR image generated from the same acquisition with 471 frames. SR image contains small vessels which cannot be seen in MIOT. Fig. 1D shows a magnified region of interest from SR velocity map where the detected microbubble flow is below 4 mm/s. The visualisation of microvasculature in the LN by SR ultrasound offers opportunities to detect early metastatic changes and assist diagnosis by revealing morphological and functional changes in the microvasculature.

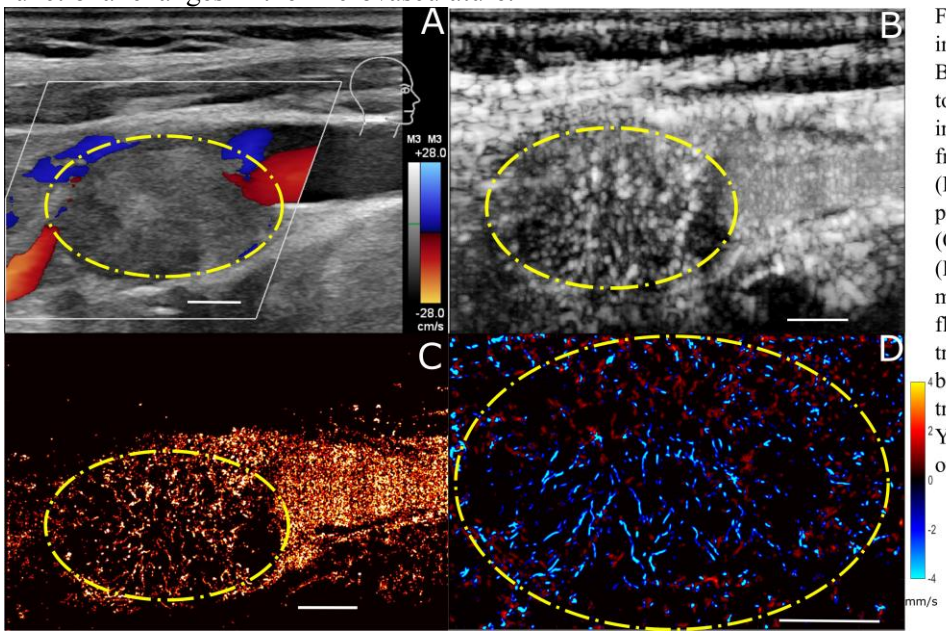

Figure 1 (A) Color Doppler image from clinical scanner, Blue indicates blood flowing towards transducer and red indicates blood flowing away from transducer; (B) Maximum intensity projection over time (MIOT); (C) SR-US image; (D) magnified SR velocity map. Blue indicates blood flowing away from transducer and red indicates blood flowing towards transducer. Yellow contour denotes the outline of LN Scale bar: 5 mm