Machine/Deep Learning with Compounding Contrast-Enhanced Ultrasound Image and Quantitative Parameters for Muscle Injury Classification

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Background, Motivation and Objective

Muscle injury is the most common trauma, in which the location and severity are crucial to be detected and classified for providing patients with appropriate treatments. With the capabilities of noninvasive imaging and blood flow detection, ultrasound modality is frequently applied to diagnose lesions in soft tissues. Yet, most of ultrasound diagnosis is still subjective to operator's experience. In the present study, efforts were made aiming to further improve the detection and classification of muscle injury with ultrasound compound imaging that fused quantitative ultrasound (QUS) parameters with perfusion information. Animal experiments incorporated with classification by machine/deep learning approaches were arranged.

Statement of Contribution/Methods

Experiments were performed from a total of 12 Sprague Dawley rats (male, 400-450g), where the contusion injury in response to a certain impact was made on the gastrocnemius (GM) muscle of the leg. Each measurement was carried out using a 7.5 MHz ultrasound system that covered the contusion healing process for four weeks. The GM injury level (GIL) was designated to classify contusion healing associated with the normal (0), destruction (1), and repair and remodeling (2) phases. The slice sections serving as ground truth were made corresponding to different healing phases. QUS parameters, including *IB* and Nakagami parameter, and perfusion, calculated from contrast agents time-intensity and time-Nakagami parameter curves, of contusion tissue were estimated. Three typical machine learning approaches, including naive Bayes (NB), support vector machine (SVM), and artificial neural network (ANN) were employed to classify the GIL utilizing the QUS and perfusion parameters. Subsequently, GoogleNet was adopted for training to extract the feature maps of those acquired images for automatically classifying the GIL with deep convolutional neural network (DCNN).

Results/Discussion

Results demonstrated that Nakagami parameters tended to decrease from 0.32 ±0.03 to 0.29 ±0.02 with the GIL from 0 to 2, and those of *IB*s tended to increase with the increase of GIL. The compounding images of B-mode with Nakgami window-modulation-contrast-ratio (WMCR) and activation map associated with different phases of 55s are capable of localizing the area of muscle injury. B-mode/Nakagami WMCR compound image is able to better discern the hematoma areas, granulation and mature regenerated muscle, and vessels wall. The classification with NB, SVM, ANN, and GoogleNet resulted in accuracy of 50.12 ± 18.40%, 64.52 ± 9.14%, 85.24 ± 12.04%, and 100%, respectively. These demonstrated that QUS and perfusion parameters with machine learning approach are of potential to sensitively detect and classify the muscle injury.