Simulation of needle insertion into liver

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ABSTRACT

During current minimally invasive interventions for liver tumors, e.g. core biopsy and radiofrequency ablation, accurate placement of the needle tip into the target lesion is of utmost importance for successful diagnosis and therapy on patients with liver cancer, especially since detected targets are getting smaller with increased diagnostic performance. However, it is extremely difficult to precisely target the needle at expected region of the patient liver due to the liver deformation and displacement, as well as the deflection of the flexible needle during the insertion. An accurate model is thus necessary to generate the curved trajectory of the needle for training novice clinicians, or needle path planning. In this research, a three-dimensional finite element (FE) model is developed to simulate the dynamic analysis of needle insertion into the liver organ. The physical properties of a hog liver measured by experiments are input into the Abaqus software as the material properties to ensure the reality of the model. In order to avoid the severe distortion of meshes due to the large deformation and fracture, the liver is discretized by the Eulerian mesh, thus an arbitrary Lagrangian-Eulerian method is employed for the computation. The needle deflection is also calculated by the beam deflection formulae, which is used to compare with the FE results to validate the accuracy of FE model. By using this model, the deflection of the needle is predicted and analyzed before the insertion, thus it is useful for better path planning and more precise needle control.