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3D auto-segmentation of biliary structure of living liver donors using magnetic resonance cholangiopancreatography

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Introduction: Bile duct division during donor hepatectomy is a challenging and crucial procedure. To address this, all potential donors undergo magnetic resonance cholangiopancreatography (MRCP) prior to surgery. In our center, the biliary structures obtained by MRCP are manually segmented and reconstructed into three-dimensional structures for better visualization during operation. The aim of the study is to leverage the accumulated annotated dataset to train a deep-learning model capable of automatically segmenting biliary structures from MRCP.

Methods: 250 living liver donors at Samsung Medical Center between Jan 2014 and Feb 2021 were included. Demographic data including age, sex, and body mass index (BMI), and 3D MRCP images using a gradient and spin echo (GRASE) technique were collected. 3D GRASE MRCP datasets were manually labeled for the common bile duct (CBD), intrahepatic duct (IHD), cystic duct, and gall bladder (GB) by two trained biomedical artists and the results were confirmed by a board-certified abdominal radiologist and several hepatic surgeons. The study utilized a 3D residual U-Net model, and training and test sets were allocated in a 9:1 ratio.

Results: The mean age was 34.4 ± 11.3 years old with 58% of males (145/250) and type I bile duct as the most common (183/250, 73.2%) anatomical type. There were no statistical differences in demographic and morphological characteristics between training and test sets. The results of the manual segmentation and automatic segmentation using the 3D residual U-Net model for each case are summarized in the figure, showing the 3D reconstructed structures. The mean DSC for the biliary structure with GB was 0.79±0.19, and without GB was 0.65±0.07.

Conclusion: The proposed deep-learning model demonstrated promising performance in automatically segmenting bile ducts from MRCP images. The application of this technique holds significant promise in enhancing the preoperative understanding of bile duct structures and augmenting surgical guidance during living-donor liver transplantation procedures.