Three-Dimensional Blood Vessel Structure on Whole-Block Image: Benign vs Malignant

Takashi Ohnishi[1)], Alexei Teplov[1)], Hirotsugu Sakamoto[1), 2)], Emine Cesmecioglu[1)], Noboru Kawata[1), 3)], Kareem Ibrahim[1)], Peter Ntiamoah[1)], Canan Firat[1)], Meera Hameed[1)], Jinru Shia[1)], Yukako Yagi[1)]

1) Departments of Pathology, Memorial Sloan Kettering Cancer Center, New York 10065, USA
2) Division of Gastroenterology, Jichi Medical University, Tochigi 329-0498, Japan
3) Division of Endoscopy, Shizuoka Cancer Center, Shizuoka 411-8777, Japan

Background

We have developed a deep-learning based blood vessel segmentation method for whole-block images (WBIs) acquired by micro-computed tomography (micro-CT). It allows us to analyze the three-dimensional (3D) characteristics of blood vessel in a noninvasive manner. In this study, we applied the proposed method to WBIs of colorectal tissue and tried to visually compare the 3D structure of the blood vessels between benign and malignant cases as a feasibility study.

Methods

70 Formalin-Fixed Paraffin-Embedded colorectal tissues were scanned with a custom-build micro-CT scanner (Nikon Metrology NV, Leuven, Belgium). We implemented the blood vessel segmentation method using deep learning with Pytorch API (Facebook, Menlo Park, CA). A VNet was used as a basic network structure and the convolution block was modified to a residual-inception module. The implementation environment was as follows: Intel Core i7-5960X with 8 cores, 128GB RAM and GeForce RTX 2080 Ti with 4352 cores and 11GB VRAM (Nvidia, Santa Clara, CA). To compare the 3D structure of blood vessels, we selected 5 WBIs from benign and malignant cases respectively.

Results

Figure 1 shows examples of the WBI with segmented blood vessels. The shape of segmented blood vessels was smooth, and we confirmed our method could clearly segment and visualize thin blood vessels as well as thick ones. We can see the blood vessels were more densely distributed in the malignant case than the benign case. Similar to Figure1, we could observe many blood vessels in other malignant cases.

Conclusions

We applied the blood vessel segmentation method to whole-block images (WBIs) acquired by micro-computed tomography. Our method could segment blood vessels from WBIs and the three-dimensional structure and distribution of blood vessels could be visually compared between benign and malignant. The results showed the density of blood vessel in malignant cases tends to be increased. In the future, we will develop additional automatic analysis methods to quantitatively measure and compare the density or number of the blood vessels.