Flow vector analysis of portal venous flow using Time-SLIP (time-spatial labeling inversion pulse) with an optical flow method

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INTRODUCTION

Time-SLIP (time-spatial labeling inversion pulse) technique is an arterial spin labeling, in which the movement of labeled blood by selective and non-selective IR pulses within vessels is observed as a flow-out effect after a certain inversion time. However, it is not easy to estimate the velocity and the direction of blood flow from the visual inspection of images alone. Optical flow presents the distribution of apparent velocity movement of bright patterns in an image and provides the velocity vector in a flow field. The optical flow is approximated from sequential time-ordered images. The purpose of this study is to evaluate the feasibility of flow vector analysis using optical flow to assess portal venous hemodynamics enhancement using Time-SLIP.

METHODS AND MATERIALS

All MR examinations were performed using a 1.5-T clinical imager (EXCELART Vantage^{TM} XGV PPP powered by Atlas, Toshiba, Tokyo). An Atlas SPEEDER body and an Atlas SPEEDER spine coil were used. The flow-out effect was obtained using Time-SLIP acquisition parameters as follows: TR=5-6000msec, TEeff =80 msec, ETS= 5 msec, matrix=256 x 256, section thickness of 4 mm, and field of view of 40 x 40 cm. Both non-selective and selective IR pulses were used to observe the signal flow-out from the vessel of interest.

Maximum intensity projection (MIP) images of eight sequential TI phases were transferred to an offline computer in bitmap format, which were analyzed by the optical flow method using custom software provided at Open CV library by Intel Corporation [1], which is based on the methods developed by Lucas BD and Kanade T [2]. The optical flow processing time was several second on a standard desktop PC (Inspiron 530, Dell Inc.) with 2.66-GHx core 2 duo (Intel).

Three healthy volunteers (3 men, mean age, 26.9 years; age range, 24-33years) were enrolled. Informed consent was obtained from each volunteer before the study. Time-resolved MR portography was obtained using Time-SLIP with TI of 600 to 1300 msec in 100 msec intervals. The IR tag pulse was separately placed on the spleen and abdominal area where the portal vein is supplied from the superior mesenteric vein (SMV), to investigate the splenic venous flow and the SMV flow separately.

RESULTS

Figure1 shows that flow vector movement from the splenic vein and SMV to the main portal vein, then finally to the right and left portal veins. After applying the selective IR tag pulse on the SMV area, the flow vector appeared at the main portal vein at 700 msec, and the right and left portal veins at 900 msec. After applying the selective IR tag pulse on the spleen, the flow vector appeared at the splenic vein at 700 msec, the main portal vein at 1000 msec, and the right and left portal veins at 1200msec. Flow vectors within the main portal vein tended to be greater than within the splenic vein.

DISCUSSTION

It is important to assess the volume or direction of portal venous flow in the management of liver diseases. During the progression of liver cirrhosis, the hepatopetal portal flow will change to the hepatofugal flow, thus various collateral vessels may develop. The ability to recognize the hemodynamics of the portal system is significantly important in the determination of the therapeutic approach for portal hypertension, such as balloon occluded retrograde transvenous obliteration (B-RTO) or transjugular intrahepatic portosystemic shunt (TIPS). The observation of the portal venous hemodynamics was possible using the Time-SLIP technique and flow vector analysis of optical flow provided direction and velocity information of the portal venous flow. To accurately analyze the results, high SNR source Time-SLIP images, with optimization of the threshold, filtering and the extraction of image noise were required.

References

1) http://opencv.willowgarage.com/wiki/

2) Lucas BD, Kanade T. An iterative image registration technique with an application to stereo vision. In: *Proceedings of the Seventh International Joint Conference on Artificial Intelligence.* San Francisco, CA. Morgan Kaufman: 1981:674–679

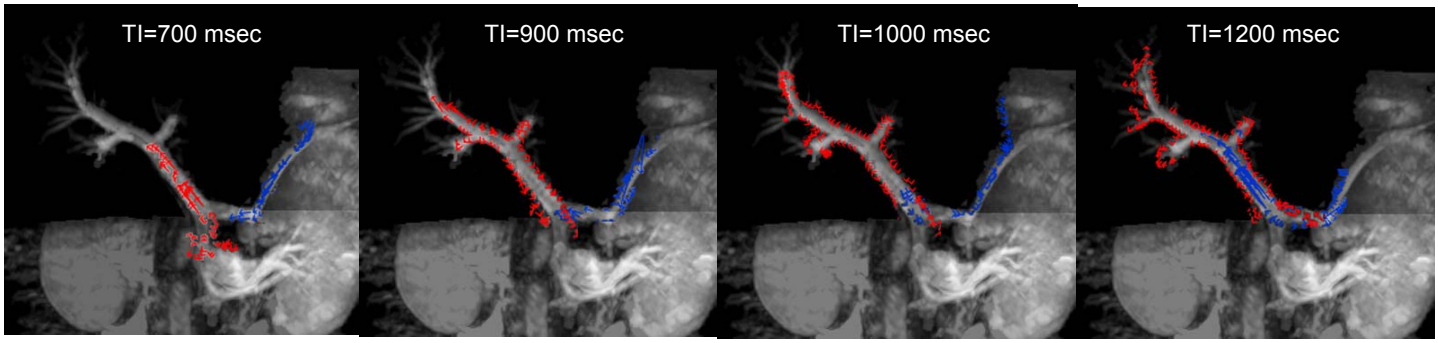

Figure1 Flow vectors calculated by optical flow superimposed on Time-SLIP portography. Blue vectors represent the splenic venous flow, and red vectors represent SMV flow