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Reliability and Variability of Hepatic Venous Pressure Gradient as a Surrogate of Portal Pressure Gradient: Insights from a Computational Model-Based Study

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Abstract: Hepatic venous pressure gradient (HVPG) measurement has been increasingly accepted as a useful means for indirectly measuring portal venous pressure in patients with portal hypertension (PHT) caused by chronic liver diseases. Despite the existence of numerous studies addressing the clinical utility of HVPG measurement, it is as yet unclear how the accuracy of measured HVPG as a surrogate of portal pressure gradient (PPG) is influenced by the pathological status of the hepatic circulation that not only changes with the progression of liver disease but also differs considerably among patients. In addition, it remains unclear whether HVPGs measured in different hepatic veins (HVs) are exchangeable, and if not, what factors determine inter-HV HVPG differences? In this context, we developed a stochastic computational model of the hepatic circulation, and performed a series of model-based numerical experiments to quantitatively investigate the respective/combined effects of various hepatic vascular properties on the accuracy of HVPG measurement. Major findings were: 1) a variation in presinusoidal portal vascular resistance significantly altered the difference between HVPG and PPG, whereas, an enhancement in portosystemic collateral flow (caused by growth of portosystemic collateral vessels or shunt intervention) tended to improve the accuracy of HVPG measurement; and 2) misdiagnosis of clinically significant PHT with HVPG was more likely to occur in the presence of high splanchnic vascular resistance combined with low presinusoidal and postsinusoidal portal vascular resistances. Stochastic numerical simulations of HVPG measurement in multiple HVs revealed that HVPGs measured in the right and middle HVs were basically exchangeable, whereas HVPGs measured in the left HV were relatively lower. The difference in measured HVPG between the middle/left and right HVs correlated positively with the proportion of blood flow rate through the middle/left HV, implying that the lower reading of left-HV HVPG measurement is due primarily to the lower blood flow rate through the HV. These findings may contribute as useful theoretical references for guiding data interpretation or choosing a proper HV for implementing catheterization in the clinical application of HVPG measurement.

Keywords: Hepatic venous pressure gradient, portal hypertension, stochastic computational model, numerical simulation.

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