Contrast-Enhanced Subharmonic Hepatic Vein Signal as an Imaging Screening Test for Portal Hypertension

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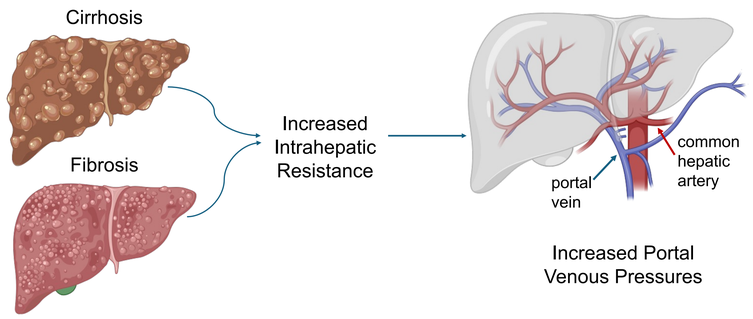
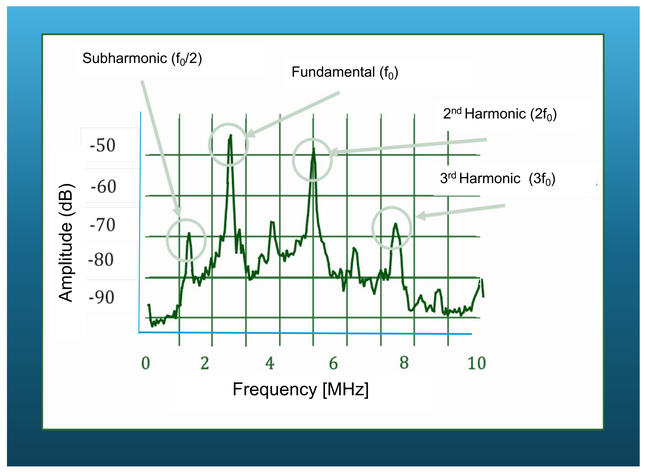
Background

- Portal hypertension (PTH) is the underlying cause of most complications associated with cirrhosis, which is currently optimally diagnosed by the hepatic venous pressure gradient (HVPG) which can also be used to evaluate disease progression.

Portal Hypertension (PTH) Pathophysiology



- Ultrasound contrast agents (UCA) are gas filled microbubbles measuring 1 to 10 μm (similar to the red blood cells), the gas is encapsulated with a protein, lipid or polymeric shell to increase stability.
- UCA can act as nonlinear oscillators producing significant energy components in the received echo signals and these nonlinear bubble echoes preferentially enhances and displays contrast signals rather than surrounding tissue echoes.
- Subharmonic imaging (SHI) is a contrast-specific ultrasound (US) imaging technique receiving at half the transmit frequency resulting in better tissue suppression



Objective

- The objective of the study was to determine if the presence of SHI signals inside the hepatic vein could be used as a qualitative screening sign of portal hypertension.

Acknowledgments

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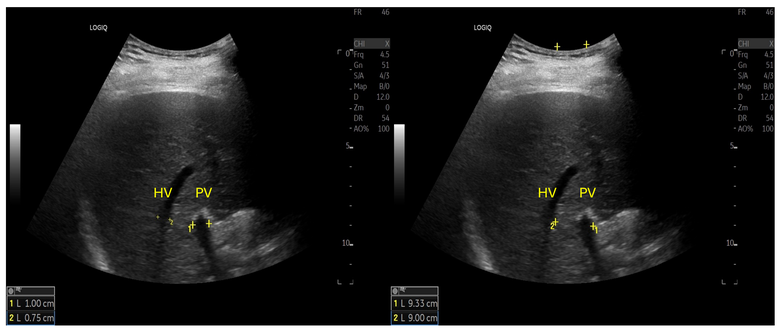
Sonazoid was supplied by GE HealthCare, Oslo, Norway.
Logiq9 and LogiqE10 scanners were provided by GE HealthCare, Waukesha, WI, USA.

Materials and Methods

- This is an ongoing sub-study of patients that were enrolled in one of two IRB and FDA approved multi-center portal hypertension studies.
- Patients undergoing a hepatic vein catheterization to acquire HVPG measurements also underwent a SHI contrast-enhanced US (CEUS) examination of their portal and hepatic veins using a modified LOGIQ 9 or E10 scanner (GE HealthCare, Waukesha, WI, USA) with a 4C or a C1-6 curvi-linear probe, respectively.
- SHI is a new CEUS imaging technique where the receive frequency is half of the fundamental (in this implementation 1.25 and 2.5 MHz, respectively) resulting in better tissue suppression. The scanner was also equipped with a calibration algorithm to allow for SHI optimization of acoustic pressures on an individual subject basis.
- Images were acquired during the infusion of the ultrasound contrast agent Sonazoid (GE HealthCare, Oslo, Norway) at a rate of 0.18 ml/kg/hour and analyzed for the presence or absence of SHI signals in the hepatic vein, based on the assumption that in portal hypertensive patients SHI signals would be seen in the hepatic vein, due to the presence of shunting.
- Assessment of clips for presence/absence of signal was done by a single experienced operator blinded to the HVPG measurement results. SHI results were compared to findings from HVPG measurements (i.e., the clinical reference standard).

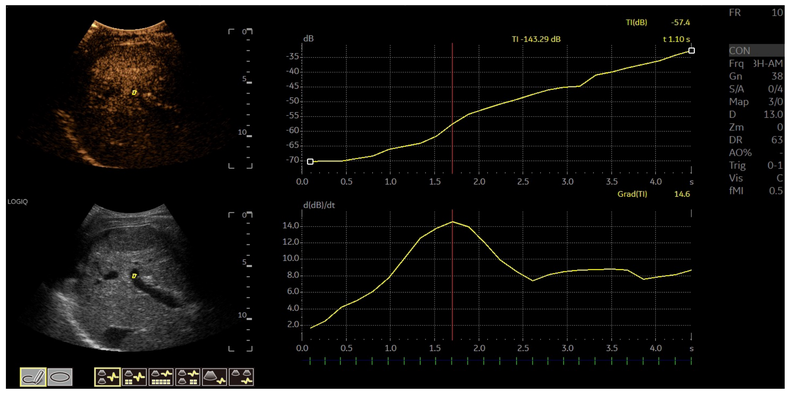
Example of the contrast set-up.



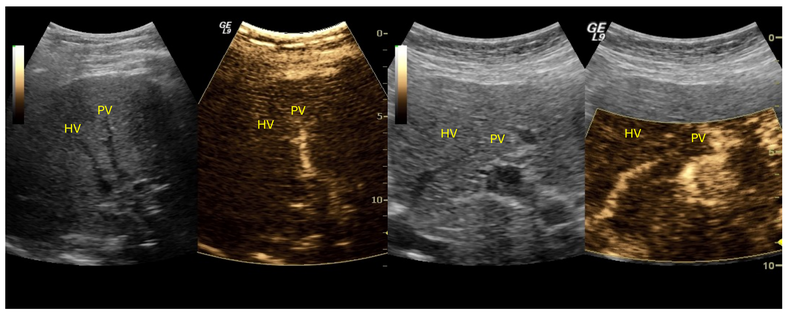
The ultrasound window selected for the study had portal vein (PV) and hepatic vein (HV) at similar depths.

Results

- Currently, 167 patients had their data analyzed, 87 had increased HVPG values corresponding to subclinical and clinical portal hypertension (6-9 mmHg and >10 mmHg, respectively), while 80 patients had normal HVPG values (≤ 5mmHg).
- Qualitative assessments of the digital clips acquired showed that in all of the 87 cases with increased HVPG values a SHI signal was seen in the hepatic vein.
- Among the 80 cases with normal HVPG values, 68 cases had no SHI signal in the hepatic vein.
- The overall accuracy for the diagnosis of any degree of portal hypertension based on the presence of SHI signals in the hepatic veins was 93% (155/167) with a sensitivity of 100% (87/87) and specificity of 85% (68/80).



The optimization curve is acquired after the run of the optimization algorithm, where an ROI is drawn inside the portal vein and the optimization curve from the ROI determines the optimal acoustic power.



Case examples. The image on the left shows dual B-mode/SHI imaging. There is no SHI signal inside the hepatic vein indicating normal pressure values; HVPG value for this case was 2 mmHg. HV: hepatic vein, PV: portal vein. The image on the right shows dual B-mode/SHI imaging. There is SHI signal inside the hepatic vein indicating portal hypertension; HVPG value for this case was 13 mmHg. HV: hepatic vein, PV: portal vein.

Conclusion

- The presence of optimized SHI signals inside the hepatic vein can be used as a qualitative screening test for portal hypertension.
- SHI of the hepatic vein is a noninvasive and safe method that could be used as a new initial, qualitative sign of portal hypertension minimizing the need for invasive procedures.

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