EUS-guided portal pressure measurement using a digital pressure wire with real-time remote display: a novel, minimally invasive technique for direct measurement in an animal model

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Background and Aims: Hepatic venous pressure gradient (HVPG) currently serves as a surrogate for portal pressure measurement but has many limitations. We developed a novel technique for rapid and direct portal pressure measurements using a digital pressure wire delivered through an EUS-guided 22-gauge FNA needle. Our aims were to evaluate (1) the short-term safety and technical feasibility, (2) procedural duration and subjective workload assessment, and (3) accuracy compared with a transjugular criterion standard approach.

Methods: The subjects were Yorkshire pigs, weighing 40 to 55 kg. The portal vein was identified by using a linear array echoendoscope and accessed with a commercially available 22-gauge FNA needle preloaded with a digital pressure wire. Access was confirmed by portal venography. Mean digital pressure measurements were recorded over 30 to 60 seconds, and the National Aeronautics and Space Administration Task Load Index was scored. The control measurements were conventional transjugular catheterization with a balloon occlusion catheter to obtain free and wedged hepatic pressures, with subsequent HVPG calculation.

Results: The total time required for EUS identification and needle access of the portal vein, venography, and digital pressure measurement was less than 5 minutes in 5 of 5 pigs. The National Aeronautics and Space Administration Task Load Index scores revealed a low subjective workload. Baseline portal pressure measurements via EUS ranged from 5 mm Hg to 10 mm Hg (mean, 6.4 mm Hg). HVPG measurements were consistently ±1 mm Hg of portal pressure.

Conclusions: This study is the first report of direct EUS-guided portal pressure measurements by using a digital pressure wire. This method is routinely performed in minutes and provides real-time pressure tracings via wireless transmission. This novel approach for direct portal pressure measurement has the potential to replace traditional indirect HVPG measurements.

Portal hypertension, defined as a pathological increase in portal venous pressure, is an important adverse event of liver disease. It is necessary for the development of most clinical adverse events including variceal hemorrhage, jaundice, ascites, and encephalopathy and should ideally be known in all patients.[1-4] However, direct measurement requires transcutaneous transhepatic portal vein puncture, which is technically difficult and carries a high rate of adverse events, and therefore is not routinely performed in clinical practice.[5-8]

Abbreviations: HVPG, hepatic venous pressure gradient; NASA, National Aeronautics and Space Administration; TLI, Task Load Index.

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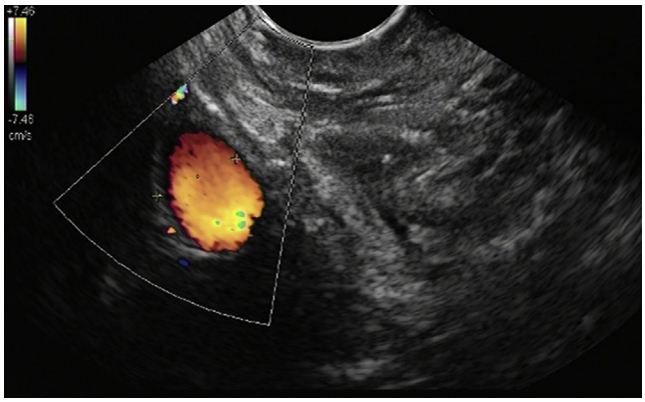

Figure 1. Location of portal vein confirmed by Doppler imaging.

Instead, indirect pressure measurements, whereby a balloon catheter is advanced through the jugular or femoral vein and into the hepatic vein, are performed. The hepatic venous pressure gradient (HVPG) is derived from subtracting the free hepatic vein pressure from the wedge hepatic vein pressure and serves as a surrogate for portal pressure. This procedure is invasive and performed only in specialized centers and may not always accurately reflect portal vein pressures.[9]

As such, a straightforward minimally invasive technique for direct portal pressure measurements may be useful. We developed a novel approach for rapid and direct portal pressure measurements by using a digital pressure wire delivered through an EUS-guided 22-gauge FNA needle. The aim of the current study was to evaluate (1) the short-term safety and technical feasibility, (2) procedural duration and subjective workload assessment, and (3) accuracy compared with the criterion standard approach.

METHODS

Preparation of animals

Five consecutive Yorkshire pigs weighing 40 to 55 kg were used in this study and housed at the Pine Acres Research Facility (Norton, Mass).

Direct portal access procedure

A linear array echoendoscope (Pentax EG-387OUTK; Hitachi Preirus System, Montvale, NJ, USA) was used to identify the portal vein. With a commercially available 22-gauge FNA needle (Beacon BNX system, Medtronic, Minneapolis, Minn) preloaded with a digital pressure wire (PressureWire Aeris; St. Jude Medical, St. Paul, Minn), the portal vein was punctured under Doppler imaging to ensure avoidance of other vasculature (Fig. 1). Of note, this wire has a pressure sensor 3 cm from the tip and therefore was extruded this distance after puncture. Furthermore, this wire features a transmitter with the potential to stream pressure data wirelessly to a remote vital signs display. Access was confirmed with portal venography under fluoroscopic and EUS guidance (Fig. 2). Digital pressure measurements were recorded continuously over 30 to 60 seconds. Procedure times and video logs were maintained for subsequent review.

Control measurements

Conventional transjugular catheterization was performed after cut-down to the right internal jugular vein. Per standard technique, needle aspiration confirmed venous entry. A 0.038-inch guidewire was inserted in the superior vena cava and an 8F introducer sheath (Boston Scientific, Marlborough, Mass) was placed over the wire. Access to the right atrium and inferior vena cava was performed carefully to prevent coiling of the wire. A balloon occlusion catheter (Berenstein 8.5 mm/11.5 mm, 80 cm, 6F; Boston Scientific) was placed over the wire and advanced into the right hepatic vein under fluoroscopic guidance. Free and wedged hepatic pressures were transduced and recorded continuously over 30 to 60 seconds with subsequent HVPG calculation.

Postprocedure

After euthanasia, necropsies were performed to evaluate for hemorrhage in both intraperitoneal and retroperitoneal spaces. Mean portal and HVPG pressure measurements (± standard deviation) were calculated from the EUS-guided and transjugular approaches, respectively.

After completion of each procedure, the endoscopist completed the National Aeronautics and Space Administration (NASA) Task Load Index (TLI) questionnaire,[10] a reliable and validated multidimensional scale designed to obtain workload estimates through assessment of 7 parameters: mental demand, physical demand, temporal demand, performance, effort, and frustration in relation to a task (NASA TLI v1.0, NASA Ames Research Center, Moffett Field, Calif). Each procedure was assigned a level of difficulty score based on a visual analog scale.

RESULTS

Puncture of the portal vein with a 22-gauge FNA needle was successfully performed in all pigs. The mean diameter of the portal vein was 1.04 cm. The pressure wire was continuously advanced through the FNA needle until the floppy tip extruded from the needle under sonographic visualization. However, in many cases, pressure readings occurred immediately after needle puncture before wire extrusion. Direct pressure measurements were successfully performed in 5 of 5 pigs (Fig. 1). The total time required for EUS identification and needle access of the portal vein, venography, and digital pressure measurement was routinely less than 5 minutes (range 2.3-4.7 minutes). Baseline portal pressure measurements via EUS ranged