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**Endoscopic ultrasound-guided portal pressure gradient measurement in managing portal hypertension**

Lesmana CRA. EUS-PPG in PH

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**Abstract**

Portal hypertension (PH) is still a challenging clinical condition due to its silent manifestations in the early stage and needs to be measured accurately for early detection. Hepatic vein pressure gradient measurement has been considered as the gold standard measurement for PH; however, it needs special skill, experience, and high expertise. Recently, there has been an innovative development in using endoscopic ultrasound (EUS) for the diagnosis and management of liver diseases, including portal pressure measurement, which is commonly known as EUS-guided portal pressure gradient (EUS-PPG) measurement. EUS-PPG measurement can be performed concomitantly with EUS evaluation for deep esophageal varices, EUS-guided liver biopsy, and EUS-guided cyanoacrylate injection. However, there are still major issues, such as different etiologies of liver disease, procedural training, expertise, availability, and cost-effectiveness in several situations with regard to the standard management.

**Key Words:** Portal hypertension; Hepatic vein; Endoscopic ultrasound; Portal pressure

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**Core Tip:** Portal hypertension (PH) is a challenging clinical condition due to its silent manifestations in the early stage. Hepatic vein pressure gradient measurement is still the gold standard for PH diagnosis; however, it is not recommended for a routine measurement in daily practice. Esophagogastroduodenoscopy is still the main procedure for variceal screening due to PH. Recently, there has been a development in using endoscopic ultrasound (EUS) for managing liver diseases. EUS-guided portal pressure gradient measurement seems to be a promising method in the future for early detection and management of PH.

**INTRODUCTION**

Portal hypertension (PH) is a challenging clinical condition due to its silent manifestations in the early stage and it needs to be measured accurately for early diagnosis. PH is defined when there is an increase of portal pressure above 5 mmHg. Clinically significant PH (CSPH) is defined when the portal pressure reaches 10 mmHg and above. CSPH is an important clinical condition because of its clinical consequences, such as the presence of esophageal and gastric varices, ascites, kidney dysfunction, as well as cardiopulmonary complications. These conditions are mostly observed in liver cirrhotic patients with liver disease progression, even though there are non-cirrhotic conditions with PH[1,2]. Hepatic vein pressure gradient (HVPG) measurement has been considered as the gold standard measurement for PH; however, it needs special skill, experience, and high expertise. This procedure also needs to be performed in a dedicated catheterization procedure room[3]. Esophagogastroduodenoscopy (EGD) is a standard procedure for early detection of PH complications, *i.e.*, the presence of varices[4,5]. A major drawback is that these two procedures might not be performed in the same session. Another issue in clinical practice is that not all cases might have accurate portal pressure measurement through this indirect measurement procedure due to the pathology of the portal vein (PV), which does not include the liver architecture disturbance[6,7]. Recently, there has been innovation for portal pressure measurement through endoscopic ultrasound (EUS). The liver images as well as the liver vascularity will be shown clearly for puncture location. However, it needs special skill and knowledge to perform the procedure[8]. In our center, this procedure is also only performed by endoscopists with more than ten years of clinical experience (Figures 1A and 1B).This review will discuss the role of EUS in portal pressure measurement and its impact in clinical practice.

***PH, portal pressure measurement, and issues in clinical practice***

PH has been divided into prehepatic, intrahepatic, and post-hepatic. This condition happens due to increased portal blood flow resistance, where it is mostly caused by intrahepatic vascular resistance in chronic liver disturbances. Imbalanced activation between vasoconstrictors and vasodilators due to liver architectural disturbance is the main key to the development of PH. In non-cirrhotic condition, or commonly known as non-cirrhotic PH (NCPH), PV fibrosis or thrombosis is the main issue[9,10].

HVPG measurement is the gold standard for PH assessment. This measurement technique is considered safer than direct measurement *via* transhepatic or transvenous catheterization because a more advanced approach to the inferior vena cava will be required for portal pressure gradient (PPG) measurement. HVPG has been considered as a safe procedure. However, there are several patient conditions which need special attention, such as cardiopulmonary disorders, hepatic encephalopathy, history of cardiac arrhythmias, and evidence of vena cava thrombosis. There are also some possible conditions which can happen during the procedure itself, such as allergic reaction to contrast agent, cardiac arrhythmia during catheter insertion *via* the transjugular route, and bleeding in patients with a very low platelet count or prolonged international normalized ratio[11,12]. On the other hand, this procedure is preferable in patients with significant ascites[3]. Based on HVPG measurement, the strategy of further management has been clearly defined with possible mortality rate. In the early stage, CSPH complications can be prevented with early medication. A randomized controlled trial of carvedilol *vs* endoscopic band ligation (EBL) by Tripathi *et al*[4] has showed that carvedilol has the same efficacy as EBL primary prophylaxis in terms of bleeding prevention. This study has also been supported by another more recent study by Shah *et al*[13] in a multicentre randomized controlled trial. A recent systematic review and meta-analysis by Dwinata *et al*[14] showed that carvedilol had similar efficacy to EBL for primary variceal bleeding prevention. Follow-up HVPG value can also be used to determine the response to the treatment and change to another strategy if needed. In the late stage of the disease or decompensated condition, more advanced complication prevention or advanced management can be decided based on HVPG value[2]. Moitinho *et al*[15] showed the usefulness of early portal pressure measurement in acute variceal bleeding scenario. This prospective study concluded that higher HVPG value is associated with a longer interval between each hospital admission and lower mortality rate. Another study conducted by Ripoll *et al*[16] on 213 liver cirrhosis (LC) patients within a 6-year period showed that HVPG value with a 10 mmHg cut-off can be a good predictor of liver decompensation. The hazard ratio for liver decompensation of HVPG is higher than those of albumin level and model for end-stage liver disease score.

There has been a development of non-invasive methods for PH assessment. A prospective study by Bureau *et al*[17] on the use of transient elastography for PH prediction showed that there was a good correlation between liver stiffness and HVPG (*P* < 0.001). However, based on further analysis, the sensitivity and specificity were becoming higher in line with the increase of the liver stiffness. The main issues were the high value of liver stiffness due to the severity of liver fibrosis condition and varied etiologies of liver diseases[17]. Another prospective study conducted by Palaniyappan *et al*[18] on patients with advanced liver disease using magnetic resonance imaging (MRI) parameters, where the patients also underwent liver stiffness measurement (LSM) before the MRI examination, showed that two MRI parameters, *i.e.*, liver T1 relaxation time and splenic artery velocity, were significantly associated with HVPG values (*r* = 0.90, *P* < 0.001). Even though the LSM was significantly correlated to HVPG (*r* = 0.791, *P* < 0.001), no significant correlation was found in the subgroup of patients with an HVPG value more than 10 mmHg[18]. Another innovation of non-invasive method for assessing PH in clinical practice has been showed in a study by Frankova *et al*[19], where liver stiffness measured by ultrasound-based shear-wave elastography has been correlated well with HVPG values in all LC patients as well as in a subgroup of patients. The liver stiffness values of 16 and 20 mmHg were considered as the best predictive values associated with HVPG. In daily practice, non-invasive methods are still debatable due to their different study results and early detection for PH. MRI examination is also a major issue at present as a routine follow-up examination due to its cost, availability, and patients’ comfort[20].

Metabolic condition, such as non-alcoholic fatty liver disease (NAFLD), now well-known as metabolic dysfunction associated fatty liver disease, might be a new challenge in the field of hepatology. It has been postulated that this condition might not have liver fibrosis progression and PH condition in the same line[21]. A prospective study published by Hirooka *et al*[22] revealed that there was a hemodynamic change in early course of the disease process in NAFLD patients, where patients were still in the early liver fibrosis condition based on the median hepatic arterioportal ratio together with splenic elasticity evaluation. Another database study conducted by Mendes *et al*[23] on 354 NAFLD patients showed that 6% of NAFLD patients without evidence of LC had PH complications. NCPH is another issue, where HVPG measurement may not be as good as it is. The complexity of the vascular system and liver pathology assessment for confirming diagnosis have been a challenging issue in clinical practice[24].

EGD is still the main procedure in daily practice to diagnose PH condition based on the presence of esophageal or gastric varices[25,26]. However, luminal evaluation does not always show a significant parameter for the presence of PH as well as in further management for PH[27].

***EUS-PPG measurement in PH***

Recently, there has been an innovative development in using EUS for diagnosis and management of liver diseases. It has been proposed as “endo-hepatology”, where endoscopic technique innovation can be used in the field of hepatology. It is started from EUS-guided liver biopsy, followed by the use of EUS for abdominal fluid paracentesis, portal circulation, and EUS-guided intravascular injection for gastroesophageal varices[28,29].

The initial animal study by Lai *et al*[30] on feasibility of EUS-guided PV catheterization showed a good correlation between PV pressure (PVP) obtained through EUS procedure and *via* the transhepatic route (*r* = 0.91). Giday *et al*[31] conducted EUS-guided direct PVP measurement in pigs, and this study showed that there has been consistency in the pressure results, and no evidence of complications was recorded. Another pioneered animal study which used a novel device (compact manometer) was published by Huang *et al*[32], where the authors were able to show a good correlation between EUS approach and transjugular approach for right hepatic vein, PV, and aorta pressure measurements (*r* = 0.985). An innovative animal study on EUS-PPG measurement using a digital pressure wire showed that this method was safe, and there were no complications such as thrombus or bleeding[33]. A human pilot study was subsequently published by Huang *et al*[34], where 28 patients underwent EUS-PPG without any complications. The technical success rate was 100% and the PPG had a good correlation with varices (*P* = 0.002), low platelet count (*P* = 0.036), and gastropathy (*P* = 0.007). A recent study was conducted by Zhang *et al*[35] on the role of EUS-PPG measurement in patients with acute or subacute PH. In this study, the technical success was achieved in 91.7% of the cases, where EUS-PPG measurement had a higher success rate than HVPG measurement. A good correlation was showed through the manometry result between EUS-PPG value and HVPG value (*r* = 0.852). No adverse events were observed during examination. Recently, a retrospective study conducted by Choi *et al*[36] was looking at the correlation between portal pressure and clinical manifestations of PH. In that study, the PPG value was significantly higher in patients with LC (9.46 *vs* 3.61 mmHg; *P* < 0.0001), presence of gastroesophageal varices (13.88 *vs* 4.34 mmHg; *P* < 0.0001), and low platelet count (9.25 *vs* 4.71 mmHg; *P* = 0.0022). Seventy-one of 83 subjects underwent liver biopsy through EUS. No adverse events or complications were observed during and after the procedures. Lesmana[37] has recently published a technique innovation where EUS-PPG was conducted by using a standard manometer set in 13 patients diagnosed with PH. In this case series, two LC patients with Child-Pugh C liver function were included. One patient was diagnosed with NCPH. There were no adverse events or complications occurring during and after the procedure. Another more recent case report using a standard pressure monitor was published just to show the procedural steps and safety[38]. A systematic review and meta-analysis on EUS-PPG to diagnose cirrhosis showed that successful portal pressure measurement was achieved in 91.61% of the cases, with no post-procedural complications, such as bleeding, perforation, and infection (95% confidence interval: 0-2.85). However, based on pooled analysis, abdominal pain developed in 6.15% of cases, emergency department visit in 3.11%, and sore throat in 2.82%[39]. A very recent publication from Lei *et al*[40] on EUS-PPG in 52 LC patients showed that this method was successfully performed in 98% of the cases. The authors showed an innovative puncture location, *i.e.,* transduodenal route, where it can be an alternative location if conventional puncture location was difficult. This study also showed that none of the patients experienced any adverse event (Table 1).

***Future directions***

EUS-PPG measurement is a better method in portal pressure measurement and diagnosing all PH conditions, not limited to chronic liver disease patients only. However, there are several issues that still need to be discussed before it becomes a clinical recommendation in daily practice. First, EUS-PPG measurement can be performed concomitantly with EUS evaluation for the presence of deep esophageal varices or gastroesophageal varices. The clinical impact of EUS evaluation in the presence of deep esophageal varices in naïve patients as well as in patients with recurrent esophageal varices has been reported in several studies[41-43]. However, whether EUS evaluation is needed in the first setting in all patients with LC for deep varices evaluation is still debatable because there is no strong clinical evidence yet regarding its impact as the first-line examination, and there is a different course of liver disease progression based on each etiology. Second, EUS-PPG measurement can be performed together with EUS-guided liver biopsy; however, EUS-guided liver biopsy is not considered as a routine procedure yet in clinical practice due to the unavailability of standard training, limited experience and availability, and high cost when compared to percutaneous liver biopsy[44,45]. Last but not least, EUS-PPG measurement can be performed and then followed by EUS-guided cyanoacrylate injection for large or deep gastroesophageal varices as well as isolated gastric varices[37,46]. However, the need of EUS approach in acute variceal bleeding and the impact of interventional radiology procedures, such as transjugular intrahepatic porto-systemic shunt or balloon-occluded retrograde transvenous obliteration, are still becoming a long way discussion for managing PH complications[30,47].

**CONCLUSION**

EUS-PPG is a promising method in future clinical practice for managing PH condition and complications. However, it needs further studies and re-evaluation before it can be recommended as a routine clinical procedure.

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**Figure Legends**



**Figure 1 Endoscopic ultrasound procedure.** A: Endoscopic ultrasound evaluation in a liver cirrhosis patient with portal hypertension; B: Endoscopic ultrasound-guided portal pressure gradient measurement. Non-surgical Integrated Procedural Room, Hepatobiliary Endoscopy Unit, Dr. Cipto Mangunkusumo National General Hospital, Jakarta, Indonesia.

**Table 1 Endoscopic ultrasound portal pressure gradient study for portal hypertension assessment**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ref.** | **Type of study** | **Study design** | **Results** | **Technical success rate** | **Adverse events** |
| Lai *et al*[30], 2004 | Animal | Experimental | EUS-PVP correlated well with transhepatic catheterization (*r* = 0.91) | 100% | None |
| Giday *et al*[31], 2008 | Animal | Experimental | Consistent results of portal pressure measurements for 1 h | 100% | None |
| Huang *et al*[32], 2016 | Animal | Experimental | Excellent correlation between EUS and IR methods in all pressure range (*r* = 0.985-0.99) | 100% | None |
| Schulman *et al*[33], 2017 | Animal | Experimental | EUS-PPG results did not differ from transhepatic portal venule measurement | 100% | None |
| Huang *et al*[34], 2017 | Human (*n* = 28) | Pilot | EUS-PPG had an excellent correlation with clinical parameters of portal hypertension (*P* < 0.05) | 100% | None |
| Zhang *et al*[35], 2021 | Human (*n* = 12) | Cohort prospective | Good correlation between EUS-PPG and HVPG (*r* = 0.923) | 91.7% | None |
| Choi *et al*[36], 2022 | Human (*n* = 83) | Retrospective | EUS-PPG correlates well with clinical markers of portal hypertension (*P* < 0.05) | 100% | None |
| Lesmana[37], 2022 | Human (*n* = 13) | Case series | EUS-PPG showed consistent pattern of portal pressure | 100% | None |
| Reddy *et al*[39], 2022 | Human (*n* = 128) | Systematic review and meta-analysis | Good correlation between clinical portal hypertension and portal pressure gradients | 91.61% | None |
| Lei *et al*[40], 2023 | Human (*n* = 52) | Case series | EUS-PPG results are significantly higher in patients with a history of gastro-esophageal bleeding (*P* < 0.05) | 98% | None |

EUS-PPG:Endoscopic ultrasound portal pressure gradient; HVPG: Hepatic vein pressure gradient; PVP: Portal vein pressure; IR: Interventional radiology.



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