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EDITORIAL

Standardized HVPG measurement: call for action

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Considering the importance of hepatic venous pressure gradient (HVPG) in diagnosing and treating portal hypertension, the Baveno VII workshop explored the relevance and indications of HVPG measurement as a gold standard as well as updated and refined standard practices for HVPG measurement [1]. The emergence of HVPG results from clinicians' continuous pursuit of precise diagnosis and treatment of portal hypertension. In 1951, Meyers and Taylor firstly described the wedge pressure measured during hepatic venous cannulation to be comparable to portal venous pressure [2], given that the altered architecture of the cirrhotic liver dissipates little blood pressure in the sinusoids. In 1980, Groszmann first came up with the concept that the balloon occlusion pressure measured in the hepatic vein was equivalent to the portal vein pressure [3]. In addition, after taking the hepatic vein free pressure as a dependable internal reference point, the pressure difference obtained can reflect the resistance of the liver and help diagnose portal hypertension [3].

HVPG development in China

Over the past 40 years, as clinicians have learned about HVPG, the number of HVPG measurement performed has climbed as per the hepatologists' requests. Primarily with the Baveno VI consensus recognizing HVPG-guided stratified treatment as a critical component of clinical research on portal hypertension [4], the Chinese Portal Hypertension Alliance (CHESS) has conducted a series of multi-center clinical studies in China [5–7]. As a result, HVPG measurement has increased from 136 cases in 2015 to 4,398 cases in 2021 in 70 hospitals of 28 provinces across China (Fig. 1). With the emergence of non-invasive HVPG technology, HVPG measurements are regarded as the reference standard, and standardized HVPG measurements of a higher level are required [1, 8].

Approaches to HVPG measurement

The most commonly used path of HVPG measurement is to access from the internal jugular vein and go through the superior vena cava, right atrium, and inferior vena cava, and finally hepatic vein catheterization. This path is straight, short, and easy to maneuver. When the right internal jugular vein is inaccessible, the left internal jugular vein can be used as a backup. However, accessing the cranial veins involves covering the patient's face with sterile drapes, and this may increase patient anxiety. Recently, accessing the right antecubital vein has been proposed to improve patient satisfaction, which had been well verified by CHESS and Japanese collaborators.

HVPG measurement catheter

In general, the compliant balloon catheters perform better than other balloon catheters or conventional straight angiography catheters on pressure measurements. Therefore, the Fogarty catheter (Edwards Lifesciences, Irvine, USA) takes the role of measuring in this scenario where no dedicated balloon catheter has been developed for HVPG

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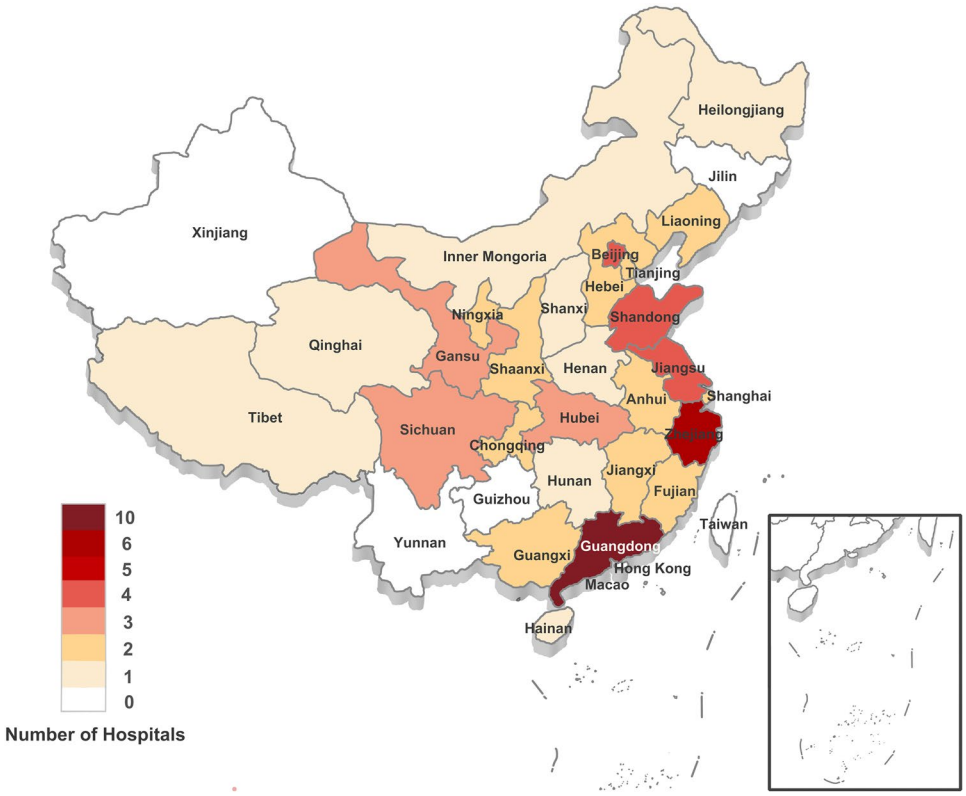

Fig. 1 Hospital distribution of HVPG measurement in China. A total of 4,398 HVPG measurements were completed in 70 hospitals of 28 provinces across China in 2021

measurement. However, one pitfall of this catheter is that its straight tip is prone to obstruction when the measured hepatic vein is in a curved shape. In addition, when measuring free hepatic venous pressure (FHVP) or wedged hepatic venous pressure (WHVP), it is difficult for the catheter tip to stay 2–3 cm away from the inferior vena cava if the patient has a large breathing amplitude. As a result, the measured HVPG value will be less accurate. For this reason, the patented CHESS catheter (CN110270004) for 0.035-inch guidewire was designed with an additional side hole on the tip to prevent errors in pressure measurement caused by the obstructed end hole (Fig. 2).

Sedation and HVPG

In a previous study, hepatic vein cannulation from the femoral vein was performed without specifying the type of anesthesia, but the patient was able to tolerate the whole procedure [3]. The CHESS1904 study (ClinicalTrials.gov Identifier: NCT04121520) found that with local anesthesia at the puncture site, only very few patients experienced short-time discomfort when the pressure was measured by occluding the hepatic vein with a dilated balloon [9]. The symptoms were soon relieved after the balloon was deflated, and the procedure was tolerable overall. Although HVPG measurement is a minimally invasive procedure with a very low rate of adverse events, some patients may be anxious and require sedation. Midazolam, desflurane, propofol, and remifentanil are the most frequently used sedatives with safety proven. On the other hand, deep sedation can cause prominent respiratory oscillations in abdominal pressure throughout the respiratory cycle, and the HVPG values on expiration and inspiration are significantly different. In this case, it is inaccurate to measure HVPG or test responsiveness to non-selective beta-blockers [10]. However, whether the hemodynamic changes caused by moderate sedation will affect the accuracy of HVPG measurement has always been questioned. In *Ebrahimi* et al. study, using the moderate-level propofol to maintain adequate cardiorespiratory function in fact induced hypotension by lowering cardiac and stroke volume indices and peripheral vasodilation. WHVP was decreased by 2.05 mmHg on an average and was significantly different from the value in the awake condition [11]. Midazolam (0.03 mg/kg), desflurane (0.2–0.6 mg/kg), and propofol (1.5–2 mg/kg) were reported to make changes to HVPG values [12, 13]. No data have been published to reveal the relationship between remifentanil dosage and HVPG value. To summarize, the type of sedatives and timing of application during HVPG measurement deserve much attention.

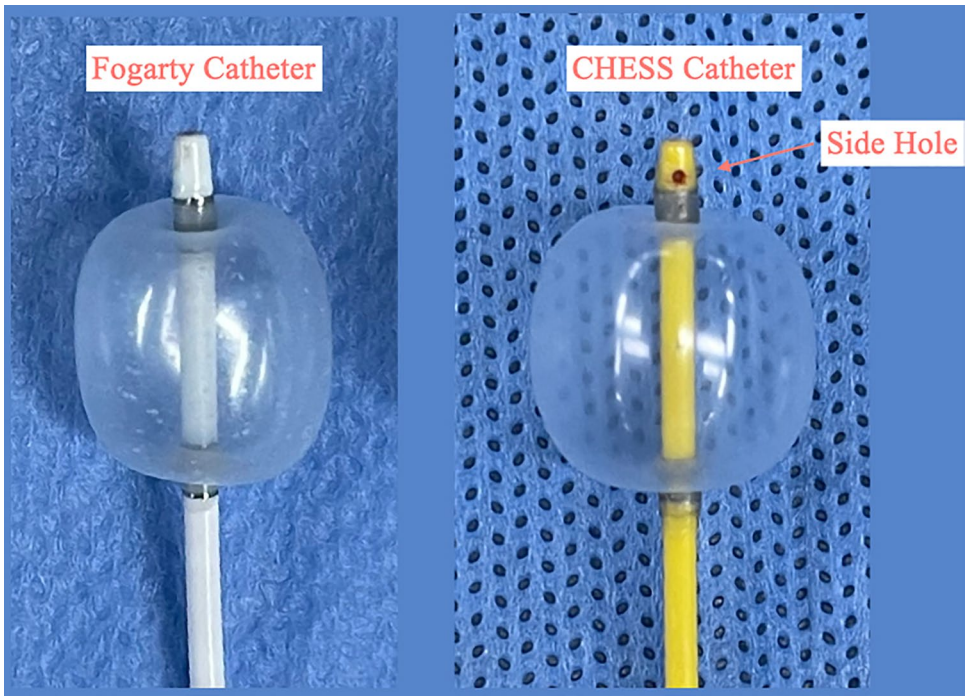

Fig. 2 HVPG measurement catheters. The straight tip and end hole of the Fogarty catheter makes it prone to be obstructed. Having an additional side hole on the tip of the patented CHESS catheter, the side hole can still take the role in manometry and angiography even the end hole is obstructed

HVPG measurement and errors

Portal hypertension, whose severity can be evaluated by HVPG, is known as one of the major factors of the progression of cirrhosis. When HVPG rises above 10 mmHg, clinically significant portal hypertension (CSPH) appears. When HVPG goes beyond the 12 mmHg threshold, serious decompensated events, such as bleeding, may occur [1]. HVPG-guided therapy produced a higher reduction in portal pressure, contributed to a lower risk of rebleeding and further decompensated cirrhosis, and resulted in improved survival. Meanwhile, the most accurate possible HVPG values became the key to successful treatment. Even a 1-mmHg error can lead to an entirely different recommended treatment. For example, transjugular intrahepatic portosystemic shunt (TIPS) is recommended for HVPG > 20 mmHg [4]; however, due to possible measurement error, whether TIPS can be performed for those with HVPG = 19 mmHg is debating and worth further investigation. In addition, both FHVP and WHVP values may fluctuate during the measurement, and the fluctuation is frequently above 1 mmHg. The readings on the screen can be hardly stabilized during the recording, and it is recommended to document the maximum and minimum values. Thus, the BAVENO VII recommends measuring HVPG in triplicate, and the WHVP recording should last at least 1 min for more accurate results [1]. Furthermore, balloon occlusion angiography of the hepatic veins can confirm the presence of the communicating hepatic vein branch, which could result in an underestimated WHVP that must be reported [1]. Nonetheless, prior to manometry, balloon occlusion angiography may influence the initial FHVP value.

Indications for HVPG measurement

HVPG is the gold standard for diagnosing CSPH in patients with viral and alcoholic cirrhosis [1]. However, the insufficiently accurate HVPG value frequently underestimates the severity of portal hypertension, especially for those having an additional pre-sinusoidal component [1]. HVPG values in patients with decompensated cirrhosis occasionally do not reflect the actual degree of cirrhosis, particularly when significant esophagogastric varicose veins, large umbilical veins, and splenorenal shunts were present to diminish portal pressure and lower HVPG value. Additional clinical trials are necessary to verify whether the portal pressure following complete embolization of these collateral arteries can more accurately represent the degree of cirrhosis. Therefore, additional parameters should be taken into account for more effective HVPG-guided therapy.

Defects of HVPG measurement

Despite being a minimally invasive procedure, HVPG measurement is still invasive. The procedural expense is also a major factor for patients' decision on the measurement in certain countries. Furthermore, intrahepatic and communicating veins are more frequent in patients with

decompensated cirrhosis, which can lower the accuracy of HVPG measurement.

Conclusion

The accuracy of HVPG values can be influenced by various factors, and non-standard technique diminished the clinical utility of HVPG. More advanced non-invasive HVPG technology is believed to facilitate the expansion of clinical application of HVPG measurement.

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Declarations

Conflict of interest Lei Li, Shanghao Liu, Hao Wu, Xiaolong Qi have no conflict of interest.

References

1. de Franchis R, Bosch J, Garcia-Tsao G, et al. Baveno VII–renewing consensus in portal hypertension. J Hepatol. 2021;76(4):959–974
2. Myers JD, Taylor WJ. An estimation of portal venous pressure by occlusive catheterization of a hepatic venule. J Clin Invest. 1951;30:662–663
3. Groszmann RJ, Atterbury CE. Clinical applications of the measurement of portal venous pressure. J Clin Gastroenterol. 1980;2:379–386
4. de Franchis R, Baveno VIF. Expanding consensus in portal hypertension: report of the Baveno VI consensus workshop: stratifying risk and individualizing care for portal hypertension. J Hepatol. 2015;63:743–752
5. Liu Y, Ning Z, Ormeci N, et al. Deep convolutional neural network-aided detection of portal hypertension in patients with cirrhosis. Clin Gastroenterol Hepatol. 2020;18(13):2998–3007
6. Shao R, Li Z, Wang J, et al. Hepatic venous pressure gradient-guided laparoscopic splenectomy and pericardial devascularisation versus endoscopic therapy for secondary prophylaxis for variceal rebleeding in portal hypertension (CHESS1803): study protocol of a multicenter randomised controlled trial in China. BMJ Open. 2020;10: e030960
7. Liu Y, Tang T, Ormeci N, et al. Noncontrast-enhanced MRI-based noninvasive score for portal hypertension (CHESS1802): an international multicenter study. J Clin Transl Hepatol. 2021;9:818–827
8. Qi X, An W, Liu F, et al. Virtual hepatic venous pressure gradient with CT angiography (CHESS 1601): a prospective multicenter study for the noninvasive diagnosis of portal hypertension. Radiology. 2019;290:370–377
9. Sun J, Zhao H, Zhang H, et al. Tolerance and acceptance of hepatic venous pressure gradient measurement in cirrhosis (CHESS1904): An international multicenter study. Port Hypertens Cirrhos. 2022. https://doi.org/10.1002/poh2.4
10. Reverter E, Blasi A, Abraldes JG, et al. Impact of deep sedation on the accuracy of hepatic and portal venous pressure measurements in patients with cirrhosis. Liver Int. 2014;34:16–25
11. Ebrahimi F, Semela D, Heim M. Impact of propofol sedation on the diagnostic accuracy of hepatic venous pressure gradient measurements in patients with cirrhosis. Hepatol Int. 2021;26:1–7
12. Steinlauf AF, Garcia-Tsao G, Zakko MF, et al. Low-dose midazolam sedation: an option for patients undergoing serial hepatic venous pressure measurements. Hepatology. 1999;29:1070–1073
13. Mandell MS, Durham J, Kumpe D, et al. The effects of desflurane and propofol on portosystemic pressure in patients with portal hypertension. Anesth Analg. 2003;97:1573–1577