



Liver, Pancreas and Biliary Tract

Assessment of the agreement between wedge hepatic vein pressure and portal vein pressure in cirrhotic patients

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Abstract

Background. Measuring wedged hepatic venous pressure and hepatic venous pressure gradient as indices of portal pressure is being increasingly used in assessing the prognosis and response to pharmacological treatment for portal hypertension in cirrhotic patients.

Aim. To re-evaluate the agreement and correlation between wedged hepatic pressures and directly measured portal pressures.

Methods. Medline search for studies comparing direct portal with wedged hepatic pressure measurement and assessment of correlation and agreement of the pooled data.

Results. Eleven suitable studies included 320 patients. Coefficient of determination (r^2) was 0.87 in all patients, 0.87 in 102 patients with alcoholic liver disease, 0.83 in 88 patients with non-alcoholic liver disease and 0.75 in 53 patients with hepatitis C-related liver disease. Coefficient of determination was 0.85 in the 194 patients in whom a wedge catheter and 0.90 in the 113 patients in whom a balloon catheter was used. Agreement according to the method of Bland and Altman was also found to be good, with only 4–8% of the measurements outside 2 standard deviations.

Conclusions. Wedged hepatic pressure measurement correlates well with direct portal pressure measurement and the agreement is sufficiently good to use this as a surrogate measurement.

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Keywords: Portal hypertension; Portal pressure measurement

1. Introduction

The measurement of the portal pressure gradient (PPG) provides prognostic information in the management of patients with cirrhosis [1,2] and we believe it should be more widely used, given that it has independent prognostic significance over and above scores of the severity of liver disease [1]. For many years, measuring hepatic venous pressures, both the free pressure (FHVP) and the wedged pressure (WHVP), either with a wedge catheter or a balloon catheter [3], has been

the standard approach for estimating portal venous pressure (PVP) [1,4–6].

Several studies have compared WHVP with portal pressure in cirrhotic patients but with relatively small cohorts and using different techniques for assessing portal pressure (Table 1). Some of them found good correlation between the two measurements, especially in patients with alcoholic cirrhosis [6–12] and hepatitis B virus (HBV) cirrhosis [13]; other studies reported less good correlations between the two techniques, especially in patients with non-alcoholic cirrhosis [7,9,14–16]. In hepatitis C virus (HCV) cirrhotic patients in particular, the data is conflicting [8,14].

Recently, the precision in measuring WHVP per se has been questioned [17]. In this study, 61% of the hepatic ve-

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Table 1
Studies comparing portal and wedge pressures included in the systematical evaluation

Author	Year	Patients (n)	Aetiology	ALD (%)	Cirrhosis (%)	Method of WHVP	Method of PVP
Reynolds et al. [16]	1955	19	ALD	100	100	Wedge	Direct portal vein catheterisation
Joly et al. [22]	1968	19	n/a	n/a	100	Wedge	Umbilical vein catheterisation
Reynolds et al. [11]	1970	22	ALD, non-ALD	73	<73	Wedge	Umbilical vein catheterisation
Viallet et al. [6]	1970	43	ALD, non-ALD	93	100	Wedge	Umbilical vein catheterisation
Boyer et al. [7]	1977	78	ALD, non-ALD	58	n/a	Wedge	Percutaneous transhepatic puncture
Okuda et al. [15]	1977	13	n/a	n/a	100	n/a	Percutaneous transhepatic puncture
Valla et al. [12]	1984	7	ALD	100	100	Wedge	Percutaneous transhepatic puncture
Rector [10]	1985	6	ALD	100	100	Wedge	Percutaneous transhepatic puncture
Lin et al. [13]	1989	21	HBV	0	100	Balloon	Percutaneous transhepatic puncture
Deplano et al. [14]	1999	21	HCV	0	100	Balloon	Percutaneous transhepatic puncture
Perello et al. [8]	1999	71	ALD, HCV	55	89	Balloon	Percutaneous transhepatic and transjugular puncture

ALD: alcoholic liver disease; non-ALD: causes other than alcoholic liver disease; HBV: hepatitis B virus-related liver disease; HCV: hepatitis C virus-related liver disease; n/a: not available.

nous pressure gradient (HVPG) measurements in two separate hepatic veins differed by as much as 4–34 mmHg. If confirmed, this finding would raise serious doubts about the validity of WHVP measurement as a reliable way of estimating PVP.

Thus, our aim was to evaluate the agreement between HVPG and PPG by systematically reassessing all the published data comparing these two measurement techniques. In particular, as the use of correlation for comparing two measurement techniques has been criticised as inappropriate (since it only describes a linear correlation between variables, but not necessarily an agreement), we decided to also apply an alternative approach which has been advocated for this purpose [18].

2. Materials and methods

We conducted a full Medline search in all languages for studies comparing WHVP with portal pressure, using the keywords ‘cirrhosis’, ‘wedge hepatic venous pressure’, ‘WHVP’, ‘hepatic venous pressure gradient’, ‘HVPG’, ‘portal pressure’ both alone and in combination between each other. We also searched the bibliographies of all relevant papers. In this way, we identified 17 studies, which had individual patient measurements, comparing WHVP with PVP [6–16,19–24]. We could only include 11 of these in our study; in five of them the measurements were reported as individual numerical values [6,12,15,16,22], in the remaining six we were able to extract the values from the graphs [7,8,10,11,13,14]. We excluded six studies from our evaluation, because in two it was not possible to determine which measurements had been taken in patients with liver disease [23,24], in one because only pressure changes after vasoactive drug therapy were reported [21], in one because it was not possible to extract the data from the graph [9], in one because the two different measurements were taken at a long interval of time from each other [20] and lastly in one because it only considered patients with spontaneous portosystemic

encephalopathy who were very likely to have a significant portosystemic shunt [19].

We pooled all the data from the published studies and recalculated the determination coefficient (r^2) with linear regression determined by using GraphPad Prism version 4.00 for Windows (GraphPad Software, San Diego, CA, USA, www.graphpad.com). The r^2 gives the fraction of variability in one variable explained by the other variable, in this case the prediction of portal venous pressure by measuring WHVP and PPG by measuring HVPG. Thus, the r^2 , as compared to the more commonly used r (regression coefficient), which was used in the individual articles correlating portal pressure to WHVP and HVPG, is the most appropriate expression of the correlation we wished to test.

We evaluated the agreement between the two measurements using the method described by Bland and Altman [18], i.e. by plotting the difference between the two measurements against their mean. As this method does not allow a quantification of the degree of agreement, we evaluated it by describing the absolute number and percentage of values outside 1.96S.D. (i.e. commonly referred to as 2S.D.). We considered less than 10% of the values being outside 1.96S.D. as a good agreement.

We also evaluated the difference between the two methods in relation to basal PVP in order to assess if there was an increasing error dependent on the degree of PVP.

3. Results

We identified a total of 320 comparative measurements of WHVP and PVP and 75 comparative measurements of HVPG and PPG; 102 comparative measurements of WHVP and portal pressure were performed in patients with alcoholic liver disease and 88 in patients with non-alcoholic liver disease. In the latter group, 53 had HCV-related liver disease (an additional 14 had both alcoholic liver disease and HCV-related liver disease), other aetiologies included in this group were HBV-related liver disease, primary biliary cirrhosis (PBC)

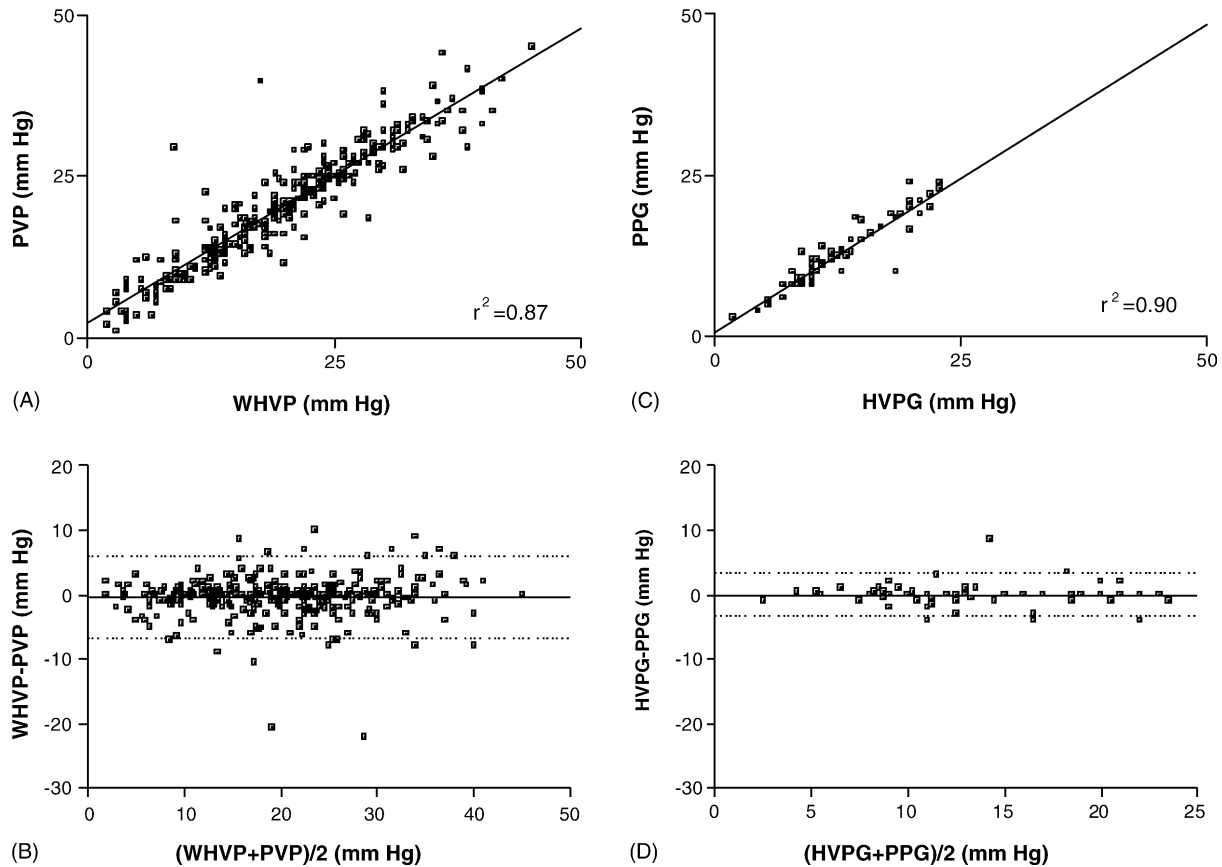


Fig. 1. Data of measurements in all patients. (A) Correlation between WHVP and PVP ($n=320$); (B) corresponding agreement between WHVP and PVP according to Altman and Bland; (C) correlation between HVPG and PPG ($n=75$); (D) corresponding agreement between HVPG and PPG according to Altman and Bland. Dotted lines: 1.96S.D.

and autoimmune hepatitis, as well as cryptogenic cirrhosis. A total of 194 measurements were performed with a wedge catheter and 113 with a balloon catheter.

3.1. All patients

Evaluating the 320 measurements comparing WHVP and PVP, WHVP was greater than PVP in 113 measurements and PVP was greater in 138 measurements. The range of difference between WHVP and PVP was from -22.1 to 10 mmHg (mean -0.48 ± 3.23 mmHg, median 0 mmHg). We found a coefficient of determination (r^2) of 0.87 . From the graph (Fig. 1A), it can be seen that two cases, both from the same author [15], are outliers. By excluding these two cases as outliers the r^2 is 0.90 and the range of difference was from -10.5 to 10 mmHg. The agreement according to Bland and Altman is good (Fig. 1B), with only 16 cases (5%) lying outside 1.96S.D.

If only the 101 measurements for which individual numerical values were available (predominantly earlier studies) are considered, the r^2 is 0.68 (0.70 excluding the outliers) and the agreement is still good with only three cases (3%) lying outside 1.96S.D. Considering only the 219 measurements

for which values were extracted from graphs (predominantly later studies), the r^2 was 0.91 and the agreement was good with 19 cases (8.7%) outside 1.96S.D.

Evaluating the 75 measurements comparing HVPG and PPG [6,10,12,22], HVPG was greater than PPG in 21 measurements and PPG was greater in 23 measurements. The range of difference between WHVP and PVP was from -4 to 8.5 mmHg (mean -0.05 ± 1.73 mmHg, median 0 mmHg). The r^2 was 0.90 ; the agreement is good with only five values (7%) outside 1.96S.D. (Fig. 1C and D).

3.2. Alcoholic liver disease

Evaluating the 102 measurements [7,8,10–12,16] comparing WHVP and PVP, WHVP was greater than PVP in 33 measurements and PVP was greater in 45 measurements. The range of difference between WHVP and PVP was from -8 to 9 mmHg (mean -0.4 ± 2.67 mmHg, median 0 mmHg). There was a r^2 of 0.93 ; the agreement is good with seven values (7%) outside 1.96S.D. (Fig. 2A and B).

Amongst the 13 measurements [10,12] comparing HVPG and PPG, the r^2 is 0.84 ; the agreement is good with no values outside 1.96S.D. (Fig. 2C and D).

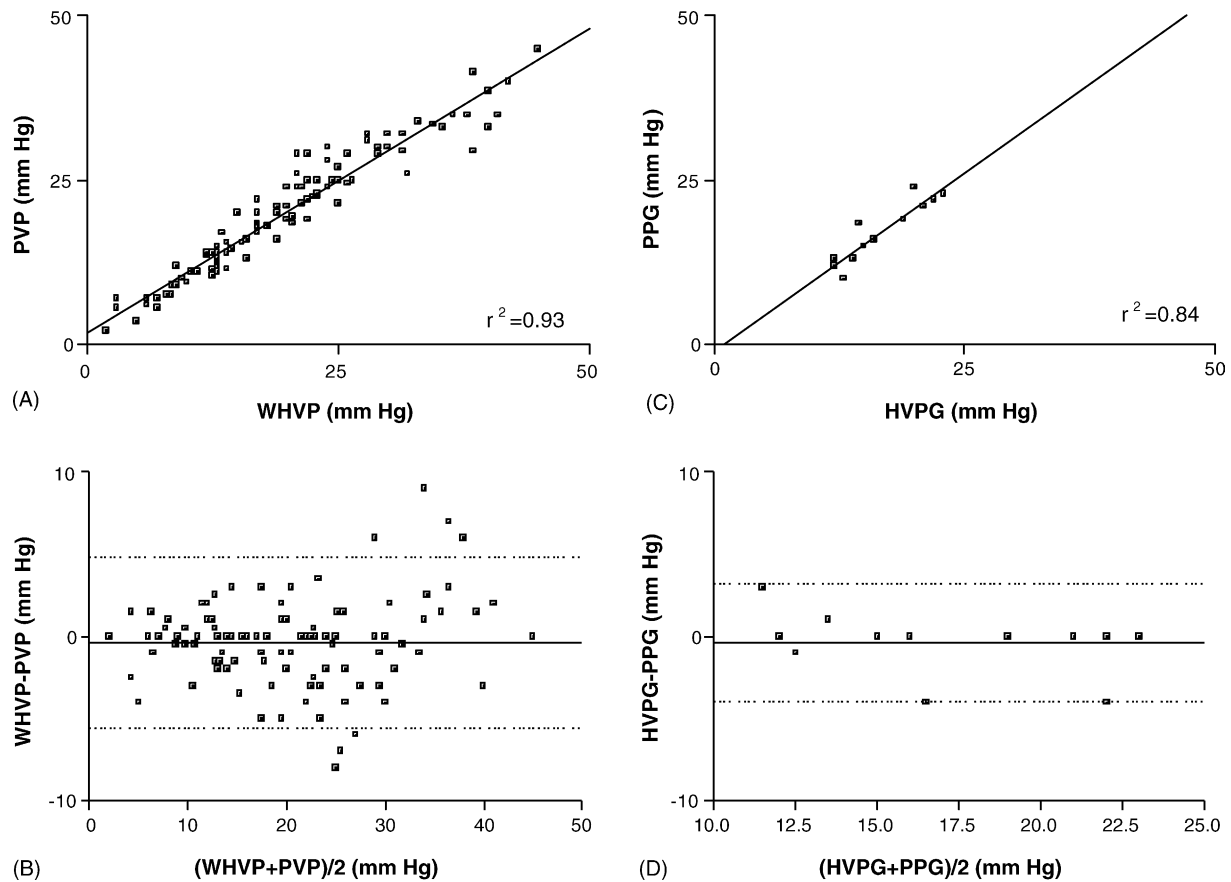


Fig. 2. Data of measurements in patients with alcoholic liver disease. (A) Correlation between WHVP and PVP ($n = 102$); (B) corresponding agreement between WHVP and PVP according to Altman and Bland; (C) correlation between HVPG and PPG ($n = 13$); (D) corresponding agreement between HVPG and PPG according to Altman and Bland. Dotted lines: 1.96S.D.

3.3. Non-alcoholic liver disease

Amongst the 88 measurements [7,8,11,13,14] comparing WHVP and PVP, WHVP was greater than PVP in 38 measurements and PVP was greater in 41 measurements. The range of difference between WHVP and PVP was from -10.5 to 10 mmHg (mean -0.39 ± 3.29 mmHg, median 0 mmHg). The r^2 is 0.83 ; the agreement is good with six values (7%) outside 1.96S.D. (Fig. 3A and B).

In particular, in the 53 measurements [8,14] comparing WHVP and PVP in patients with HCV-related liver disease, WHVP was greater than PVP in 23 measurements and PVP was greater in 22 measurements. The difference between WHVP and PVP ranged from -10.5 to 10 mmHg (mean -0.08 ± 3.77 mmHg, median 0 mmHg). The r^2 is 0.75 ; the agreement is good with four values (8%) outside 1.96S.D. (Fig. 3C and D).

No measurements comparing HVPG and PPG were available in this subgroup.

3.4. Wedge catheter measurement

Evaluating the 194 measurements [6,7,10–12,16,22], WHVP was greater than PVP in 59 measurements and PVP

was greater in 82 measurements. The range of difference between WHVP and PVP was from -9 to 8.5 mmHg (mean -0.55 ± 2.44 mmHg, median 0 mmHg). The r^2 is 0.85 ; the agreement is good with 11 values (6%) outside 1.96S.D. (Fig. 4A and B).

As all the measurements comparing HVPG and PPG were performed using a wedge catheter, the results are the same as reported for the whole series.

3.5. Balloon catheter measurement

Amongst the 113 measurements [8,13,14], WHVP was greater than PVP in 49 measurements and PVP was greater in 41 measurements. The range of difference between WHVP and PVP was from -10.5 to 10 mmHg (mean -0.19 ± 3.15 mmHg, median 0 mmHg). The r^2 is 0.90 ; the agreement is good with five values (4%) outside 1.96S.D. (Fig. 4C and D).

3.6. Assessment of the variability between direct and indirect portal pressure measurement according to basal portal pressure

The assessment of the absolute difference between the two types of measurement, in all measurements and in those per-

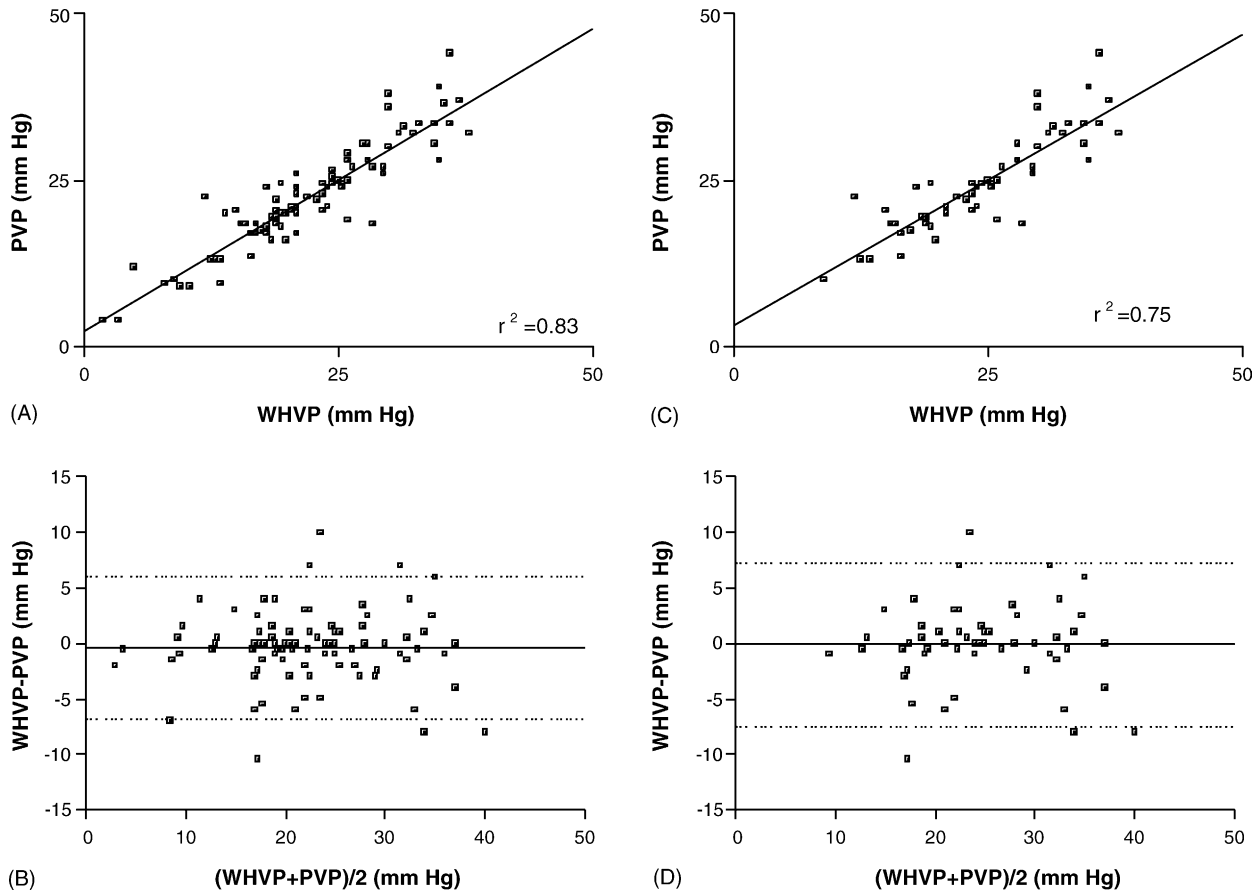


Fig. 3. (A) Correlation between WHVP and PVP in patients with non-alcoholic liver disease ($n = 88$); (B) corresponding agreement between WHVP and PVP according to Altman and Bland in patients with non-alcoholic liver disease; (C) correlation between WHVP and PVP in patients with HCV-related liver disease ($n = 53$); (D) corresponding agreement between WHVP and PVP according to Altman and Bland in patients with HCV-related liver disease. Dotted lines: $1.96S.D.$

formed with a balloon catheter, plotted against the basal PVP showed that the variability was constant for a range of PVP from 1 to 45 mmHg (Fig. 5A and C). A similar distribution was seen for measurements performed with a wedge catheter and in separate subgroups of patients with and without alcoholic liver disease.

The difference between the two measurements, as a change in percentage from WHVP measurement, plotted against the PVP, showed a tendentially greater change in percentage for lower PVP pressures (<20 mmHg) (Fig. 5B), but this was not observed when only the measurements performed with a balloon catheter were considered (Fig. 5D).

4. Discussion

Our reassessment of the data published to date on comparative measurements of wedged hepatic pressures and portal pressures clearly shows that WHVP reflects PVP in a cohort of patients with alcoholic liver disease, HBV and HCV-

related liver disease, PBC and autoimmune hepatitis, irrespective of the use of a wedge or a balloon catheter. However, there was a trend towards greater differences between the wedge technique and PVP at lower PVP pressures but this did not reach statistical significance. In particular, it is important to note that this also holds true for the main aetiologies of liver cirrhosis, alcoholic liver disease and HCV-related liver disease, despite some claims to the opposite [14]. Furthermore, we also confirmed that HVPG correlates significantly with PPG.

These findings are of great importance, as measurement and monitoring of hepatic pressure measurements (HVPG and WHVP) are increasingly recommended in clinical trials and clinical practice regarding the pharmacological prevention of portal hypertension-related bleeding [25–27]. Moreover, a higher HVPG measurement is known to be an independent factor associated with mortality in liver cirrhosis [1] and one study has linked pharmacological reduction in HVPG to a decreased long-term risk of complications related to portal hypertension, such as variceal bleeding, ascites,

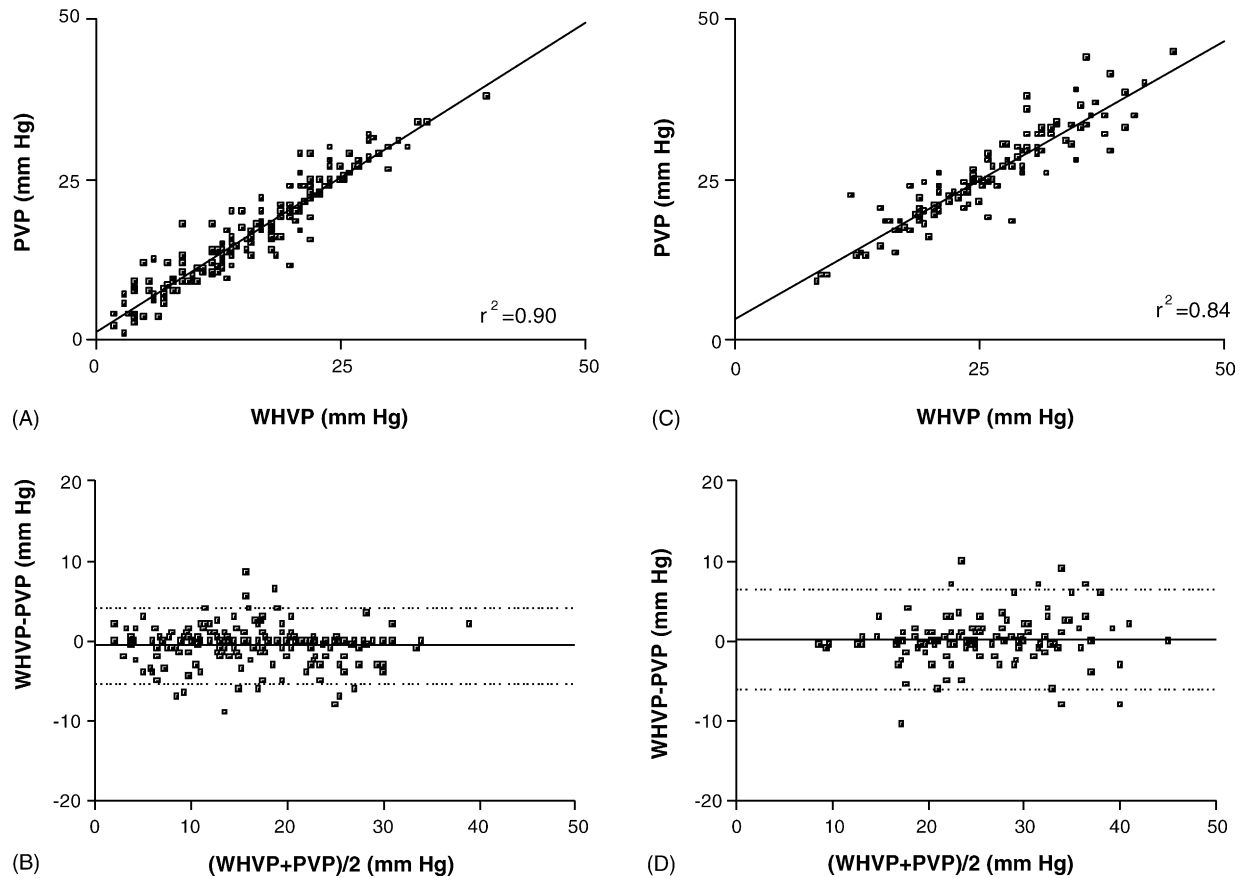


Fig. 4. (A) Correlation between WHVP and PVP measurements performed with a wedge catheter ($n = 194$); (B) corresponding agreement between WHVP and PVP according to Altman and Bland measurements performed with a wedge catheter; (C) correlation between WHVP and PVP measurements performed with a balloon catheter ($n = 113$); (D) corresponding agreement between WHVP and PVP according to Altman and Bland measurements performed with a balloon catheter. Dotted lines: 1.96S.D.

spontaneous bacterial peritonitis, hepatorenal syndrome and hepatic encephalopathy [2,28]. A recent report also suggests that changes in HVPG could be considered as an adjunctive end point for the therapeutic evaluation of antiviral therapy in chronic hepatitis C, and HCV-related cirrhosis [29].

Our findings do not confirm a recently reported high variability in HVPG measurements [17], as the correlation with PPG measurements was highly significant, across eight different centres reporting data, given that direct portal pressure measurement has very little variability. The paper by Keiding and Vilstrup [17] used a wedge catheter technique and did not compare WHVP with PVP. On the whole, WHVP measurement seems to slightly underestimate PVP, but the difference is small (mean -0.48 ± 3.23 mmHg).

We also assessed the agreement between portal pressures and WHVP and HVPG with the method proposed by Bland and Altman [18]. This is important since this method has been suggested to be more appropriate for assessing agreement between two methods of clinical measurements, as the use

of correlation coefficients in this setting may be misleading. Even with this evaluation the agreement between WHVP and HVPG, and PVP and PPG, respectively, was shown to be remarkably good, with only 4–8% of measurements outside 2S.D., which confirms the numerical 1:1 correlation of portal pressure with WHVP in cirrhosis.

One possible bias in our evaluation is that studies included were performed over a 44-year time span with consequent variation in equipment and technique of measuring pressure. However, the distinction between studies performed using the wedge technique (1955–1985) and those using the balloon technique (1989–1999) takes into account most of these differences.

Although the comparison of the mean and median pressure values is reassuring, the range of difference between WHVP and PVP measurements was from -10.5 to 10 mmHg. Thus, in some patients these measurements are not accurate. This is true of every biological measurement but the variability of agreement as assessed by the Bland and Altman method is acceptable, but nevertheless must be taken into account

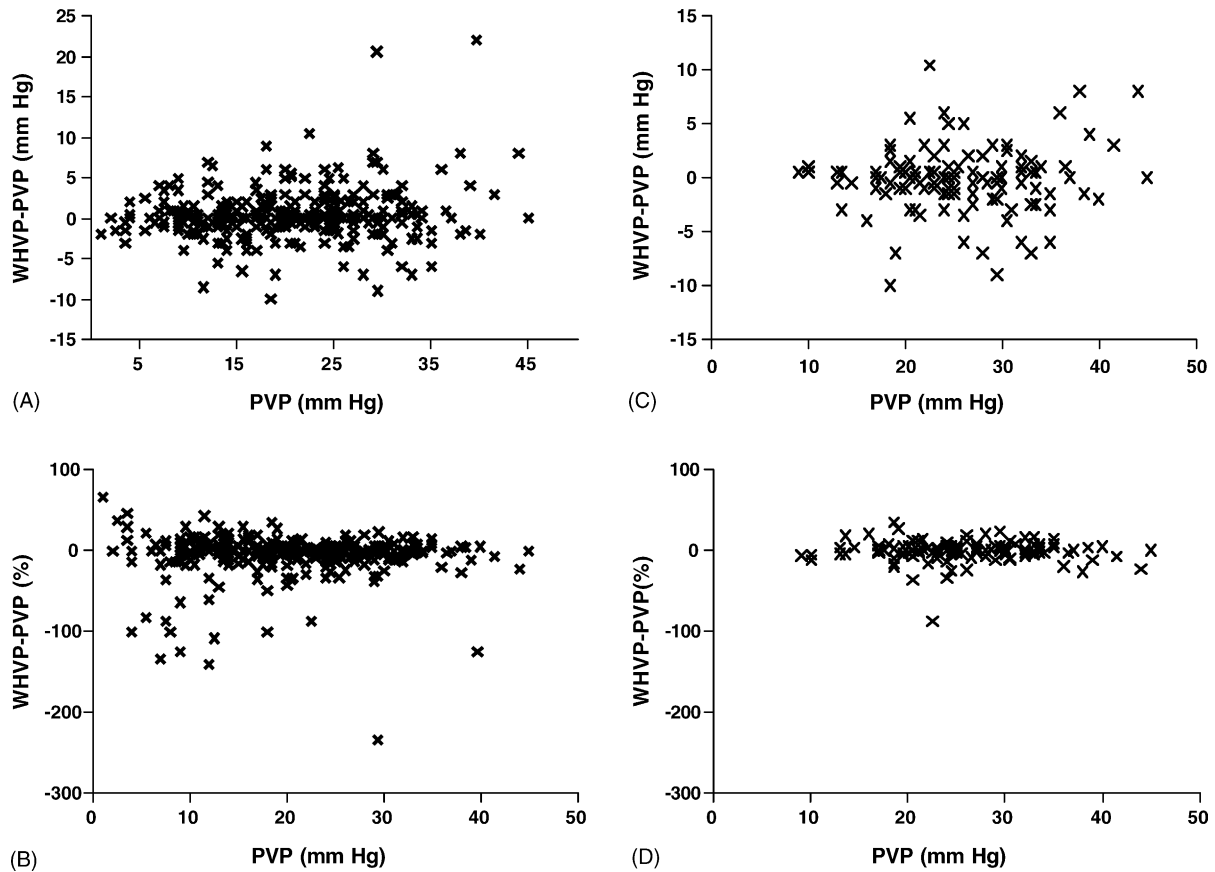


Fig. 5. Assessment of the difference between the two types of measurement plotted against PVP for measurements in all patients (absolute difference (A) and percentage change from WHVP (B)) and measurements with balloon catheter (absolute difference (C) and percentage change from WHVP (D)).

when interpreting data. Lastly, there is an issue of generalisability. All of these studies were performed in specialised centres, and thus these results may not be reproducible in a routine setting. However, recommendations for an accurate technique have been published recently [30], which could make accurate measurements achievable in every institution.

This analysis, although confirmatory of other studies, each with a small number of patients, does firmly establish the use of WHVP and HVPG measurements as surrogate measurements of PVP and PPG. To our knowledge, this is the first time that an assessment of more than 300 comparative measurements has been performed. The consistent accuracy of WHVP and HVPG as indirect indices of portal pressure confirmed here, should be, we believe, a further stimulus to a more widespread use of these measurements, performed with a correct technique [30] in the setting of chronic liver disease, both for prognostic estimation [1,2] and for researching the role of target reduction of portal pressure during pharmacological therapy of portal hypertension [25–27] and potentially as a surrogate marker of chronicity or fibrosis [29].

Conflict of interest statement

None declared.

List of abbreviations

FHVP, free hepatic venous pressure; HBV, hepatitis B virus; HCV, hepatitis C virus; HVPG, hepatic venous pressure gradient; PBC, primary biliary cirrhosis; PPG, portal pressure gradient; PVP, portal venous pressure; WHVP, wedge hepatic venous pressure.

References

- [1] Armonis A, Patch D, Burroughs A. Hepatic venous pressure measurement: an old test as a new prognostic marker in cirrhosis? *Hepatology* 1997;25:245–8.
- [2] Abralides JG, Tarantino I, Turnes J, Garcia-Pagan JC, Rodes J, Bosch J. Hemodynamic response to pharmacological treatment of portal hypertension and long-term prognosis of cirrhosis. *Hepatology* 2003;37:902–8.
- [3] Groszmann RJ, Glickman M, Blei AT, Storer E, Conn HO. Wedged and free hepatic venous pressure measured with a balloon catheter. *Gastroenterology* 1979;76:253–8.
- [4] Groszmann RJ. Reassessing portal venous pressure measurements. *Gastroenterology* 1984;86:1611–4.
- [5] Myers J, Taylor W. An estimation of portal venous pressure by occlusive catheterization of an hepatic venule. *J Clin Invest* 1951;30:662–3.

- [6] Viallet A, Joly JG, Marleau D, Lavoie P. Comparison of free portal venous pressure and wedged hepatic venous pressure in patients with cirrhosis of the liver. *Gastroenterology* 1970;59:372–5.
- [7] Boyer TD, Triger DR, Horisawa M, Redeker AG, Reynolds TB. Direct transhepatic measurement of portal vein pressure using a thin needle. Comparison with wedged hepatic vein pressure. *Gastroenterology* 1977;72(4 Pt 1):584–9.
- [8] Perello A, Escorsell A, Bru C, Gilabert R, Moitinho E, Garcia-Pagan JC, et al. Wedged hepatic venous pressure adequately reflects portal pressure in hepatitis C virus-related cirrhosis. *Hepatology* 1999;30:1393–7.
- [9] Pomier-Layrargues G, Kusielewicz D, Willems B, Villeneuve JP, Marleau D, Cote J, et al. Presinusoidal portal hypertension in non-alcoholic cirrhosis. *Hepatology* 1985;5:415–8.
- [10] Rector Jr WG. Propranolol for portal hypertension. Evaluation of therapeutic response by direct measurement of portal vein pressure. *Arch Intern Med* 1985;145:648–50.
- [11] Reynolds TB, Ito S, Iwatsuki S. Measurement of portal pressure and its clinical application. *Am J Med* 1970;49:649–57.
- [12] Valla D, Bercoff E, Menu Y, Bataille C, Lebre C. Discrepancy between wedged hepatic venous pressure and portal venous pressure after acute propranolol administration in patients with alcoholic cirrhosis. *Gastroenterology* 1984;86:1400–3.
- [13] Lin HC, Tsai YT, Lee FY, Chang TT, Wang SS, Lay CS, et al. Comparison between portal vein pressure and wedged hepatic vein pressure in hepatitis B-related cirrhosis. *J Hepatol* 1989;9:326–30.
- [14] Deplano A, Migaleddu V, Pischedda A, Garruciu G, Gregu G, Multinu C, et al. Portohepatic gradient and portal hemodynamics in patients with cirrhosis due to hepatitis C virus infection. *Dig Dis Sci* 1999;44:155–62.
- [15] Okuda K, Suzuki K, Musha H, Arimuzu N. Percutaneous transhepatic catheterization of the portal vein for the study of portal hemodynamics and shunts. A preliminary report. *Gastroenterology* 1977;73:279–84.
- [16] Reynolds TB, Balfour D, Levinson D, Mikkelsen W, Pattison A. Comparison of wedged hepatic vein pressure with portal vein pressure in human subjects with cirrhosis. *J Clin Invest* 1955;34:213–8.
- [17] Keiding S, Vilstrup H. Intrahepatic heterogeneity of hepatic venous pressure gradient in human cirrhosis. *Scand J Gastroenterol* 2002;37:960–4.
- [18] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;1:307–10.
- [19] Bauret P, Mirouze D, Bories P, Mourrut C, Bruel JM, Michel H. Chronic hepatic encephalopathy in cirrhotic patients and spontaneous portacaval anastomosis. Portal angiographic and manometric study. *Gastroenterol Clin Biol* 1989;13:132–5.
- [20] Cohn R, Ordway G, Ellis E. Relation of portal venous pressure to occluded hepatic venous pressure. *Arch Surg* 1954;69:853–7.
- [21] Iwao T, Toyonaga A, Ikegami M, Sumino M, Oho K, Sakaki M, et al. Wedged hepatic venous pressure reflects portal venous pressure during vasoactive drug administration in nonalcoholic cirrhosis. *Dig Dis Sci* 1994;39:2439–44.
- [22] Joly JG, Bernier J, Lavoie P, Legare A, Viallet A. Hemodynamic and radiological evaluation of patients with hepatic or pancreatic disease by combined umbilico-portal and systemic venous catheterisation. *Can Med Assoc J* 1968;98:16–24.
- [23] Paton A, Reynolds TB, Sherlock S. Assessment of portal venous hypertension by catheterisation of hepatic vein. *Lancet* 1953;261:918–21.
- [24] Welch GE, Emmett R, Craighead CC, Hoeffler G, Browne DC, Rosen I. Simultaneous pressure measurements in the hepatic venule and portal venous system in man. *Am J Med Sci* 1954;228:643–5.
- [25] Bosch J, Garcia-Pagan JC. Prevention of variceal rebleeding. *Lancet* 2003;361:952–4.
- [26] Thalheimer U, Mela M, Patch D, Burroughs AK. Targeting portal pressure measurements: a critical reappraisal. *Hepatology* 2004;39:286–90.
- [27] Thalheimer U, Mela M, Patch D, Burroughs AK. Monitoring target reduction in hepatic venous pressure gradient during pharmacological therapy of portal hypertension: a close look at the evidence. *Gut* 2004;53:143–8.
- [28] Villanueva C, Lopez-Balaguer JM, Aracil C, Kolle L, Gonzalez B, Minana J, et al. Maintenance of hemodynamic response to treatment for portal hypertension and influence on complications of cirrhosis. *J Hepatol* 2004;40:757–65.
- [29] Burroughs AK, Groszmann R, Bosch J, Grace N, Garcia-Tsao G, Patch D, et al. Assessment of therapeutic benefit of antiviral therapy in chronic hepatitis C: is hepatic venous pressure gradient a better end point? *Gut* 2002;50:425–7.
- [30] Groszmann RJ, Wongcharatrawee S. The hepatic venous pressure gradient: anything worth doing should be done right. *Hepatology* 2004;39:280–2.