Estimation of Pulmonary Pressures and Diagnosis of Pulmonary Hypertension by Doppler Echocardiography: A Retrospective Comparison of Routine Echocardiography and Invasive Hemodynamics

Stéphane Lafitte, MD, PhD, Xavier Pillois, PhD, Patricia Reant, MD, PhD, Francois Picard, MD, Florence Arsac, MD, Marina Dijos, MD, Pierre Coste, MD, PhD, Pierre Dos Santos, MD, PhD, and Raymond Roudaut, MD, PhD, *Bordeaux, France*

Background: To date, Doppler echocardiography is the most widespread and well-recognized technique for the noninvasive evaluation of systolic pulmonary artery pressure (sPAP). However, recent studies have reported reservations about the relevance of Doppler echocardiography or the tool's reliability in the diagnosis and follow-up of patients with pulmonary hypertension (PH). Thus, the aim of this dedicated retrospective study was to address the questions of Doppler echocardiography's relevance and accuracy for PH diagnosis in the routine activity of a conventional echocardiography department.

Methods: Institutional databases were used to extract and analyze the records of 310 patients who underwent both hemodynamic and echocardiographic investigations within a single hospitalization period.

Results: Despite an underestimation of absolute Doppler sPAP values compared with measurements on right heart catheterization, data analysis revealed a strong correlation ($r = 0.80$, $P < .00001$, $n = 310$). Targeting a mean pulmonary pressure on right heart catheterization of 25 mm Hg for the definition of PH, receiver operating characteristic curve analysis demonstrated a strong association between sPAP and PH diagnosis (area under the curve, 0.82; $n = 155$). The cutoff obtained for sPAP was 38 mm Hg, and when applied on a second-test subgroup population ($n = 155$), sensitivity, specificity, and accuracy were 88%, 83%, and 86%, respectively. When patients with examination intervals of <2 days were selected ($n = 115$), sensitivity and specificity reached 89% and 89%, respectively. No combination of parameters produced an improvement on the initial results.

Conclusions: In the real-world practice of a conventional echocardiography department, Doppler echocardiography is associated with high accuracy, sensitivity, and specificity for PH evaluation, thus confirming its major position as a primary noninvasive tool. (J Am Soc Echocardiogr 2013;26:457-63.)

Keywords: Pulmonary pressure, Echocardiography, Pulmonary hypertension diagnosis

Doppler echocardiography is the most widespread and well-recognized technique for the noninvasive evaluation of systolic pulmonary artery pressure (sPAP). Since its validation by Berger *et al.*[1] and Currie *et al.*[2] in 1985, multiple experiences have been published confirming the Doppler method's reliability,[3-5] independently of cardiac disease.[6-10] On the basis of publications reporting correlations with invasive measurement data, Doppler echocardiography is still recommended as the primary tool for early screening and assessment of patients with clinical suspicion of pulmonary hypertension (PH).[11,12] The Doppler approach's limitations have previously been highlighted,[13] with some restrictions pertaining to patients with pulmonary disease.[14,15] Other heart diseases, such as chronic heart failure, have been targeted as good models for Doppler evaluations of pulmonary pressures (PPs).[16]

More recently, focus has been given to patients with PH. Pursuant to this, and after a large prospective study, Rich *et al.*[17] found Doppler echocardiography an unreliable technique for diagnosis and follow-up of patients with PH. Such reservations have been similarly addressed in a meta-analysis,[18] introducing doubt with regard to the relevance of Doppler echocardiography, despite its wide and routine use for noninvasive cardiac investigations.

Therefore, we conducted a retrospective study examining Doppler echocardiography's performance in real-world practice in a large population from our echocardiography department. We aimed both to assess the reliability of Doppler echocardiography

From Université de Bordeaux, CHU de Bordeaux, CIC 0005, Bordeaux, France.

Reprint requests: Stéphane Lafitte, MD, PhD, Hôpital Cardiologique Haut-Lévêque, Avenue de Magellan, F-33605 Pessac, France (E-mail: *stephane.lafitte@chu-bordeaux.fr*).

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Abbreviations

ACC = American College of Cardiology

AHA = American Heart Association

IVC = Inferior vena cava

PH = Pulmonary hypertension

PP = Pulmonary pressure

RAP = Right atrial pressure

RHC = Right heart catheterization

sPAP = systolic Pulmonary artery pressure

UERD = University echocardiographic regional diploma

compared with the invasive and referent pulmonary blood pressure evaluation method and to test its accuracy in PH diagnosis, all in the context of a conventional echocardiography department's routine practice.

METHODS

Study Design

Data was collected from the cardiac catheterization department, which performs approximately 4,500 right heart catheterization (RHC) procedures every year, and from the echocardiography department, which conducts >15,000 transthoracic Doppler echocardiographic studies every year. In the latter department, including seven rooms, operators with different profiles perform five to 15 examinations per half day.

The operators' team consisted of two nurses (working as sonographers) equivalent to level 2 in the American Heart Association (AHA) and American College of Cardiology (ACC) guidelines[19] and level 1 of our university echocardiographic regional diploma (UERD) program, three cardiology fellows (level 2 in the AHA and ACC guidelines, level 2 of the UERD program), and six senior cardiologists (level 3 in the AHA and ACC guidelines, level 2 of the UERD program). The UERD program is a 2-year teaching course consisting of an initial 155 hours of theory and 120 transthoracic echocardiographic studies performed and interpreted in the course of the first year (level 1) and an additional 155 hours of theory, 120 transthoracic echocardiographic studies, and 60 transesophageal echocardiographic studies performed and interpreted in the course of the second year (level 2). All examinations performed by nurses or fellows were considered secondary and underwent systematic validation by one of the senior cardiologists.

All echocardiographic measurements were performed according to American Society of Echocardiography and European Association of Echocardiography recommendations,[20,21] in line with UERD standard operating procedure. Accordingly, tricuspid regurgitant maximum velocities were measured on the basis of adequate acquisitions, and estimated sPAP levels were determined using the modified Bernoulli equation when tricuspid regurgitant jets were analyzable, in conjunction with echocardiographic estimation of right atrial pressure (RAP) (Figure 1). No contrast methods were used. In case of atrial fibrillation, five to 10 beats were used for averaging velocities. Echocardiographic RAP estimation was performed on the basis of inferior vena cava (IVC) size and collapsibility. RAP was estimated to be 3 mm Hg when the IVC diameter was <21 mm with >50% collapsibility, 8 mm Hg when the IVC diameter was <21 mm with <50% collapsibility, and 15 mm Hg when the IVC diameter was >21 mm with <50% collapsibility.[21]

Senior physicians specializing in invasive techniques performed the catheterizations according to standard procedures. Fluid-filled catheters were used for patients not sedated. Systolic, diastolic, and mean PPs were averaged and calculated over five beats. Systolic RHC PP was used for direct comparison with sPAP using echocardiography and mean PP for the diagnosis definition of PH using catheterization.

Our institution's databases were used for this retrospective analysis. To this end, measurement data from the RHC and echocardiography departments were automatically transferred to the Structured Query Language database, which was copied into the central institutional database. Only new records from the site were automatically added to this central database every night. Patient records, including diagnoses and treatments, laboratory results, and hemodynamic and echocardiographic investigations, were extracted from this central database using dedicated software for database queries (SAP Business Object Enterprise XI version 12.3.6, version 601; SAP AG, Walldorf, Germany).

The inclusion criterion for patient enrollment was having undergone both hemodynamic and echocardiographic investigations (with estimation of PP by Doppler on tricuspid regurgitant flow) between June 2011 and March 2012, irrespective of the causal disease, during a single hospitalization period. The exclusion criterion was a lack of PP estimation on the basis of tricuspid regurgitant flow using Doppler echocardiography.

The local ethics committee approved the study. All patients hospitalized at our institution were informed that their personal medical data might be used for research purposes.

Statistical Analysis

Continuous variables are expressed as mean ± SD and categorical variables as percentages and numbers of patients. Chi-square tests or Fisher's exact tests were performed for qualitative variable comparison. Two-tailed paired *t* tests or nonparametric Mann-Whitney *U* tests were used for comparisons of quantitative data from Doppler echocardiographic and RHC examinations.

Systolic PP comparisons between RHC and Doppler echocardiography were performed on the entire selected population, using paired two-tailed *t* tests or nonparametric Mann-Whitney *U* tests, linear regression with coefficient correlation calculation, and Bland-Altman analysis.

Potential confounding parameters that could influence PP estimation, such as time between echocardiography and catheterization or operator's skill, were sought by multivariate linear regression analysis.

Receiver operating characteristic curve analyses were performed on a randomly selected subgroup of 155 patients for different echographic parameters, including the maximum velocity of tricuspid regurgitation, PP, acceleration time on pulmonary flow, and right chamber and IVC dimensions, to determine cutoffs for PH diagnosis (defined as a pulmonary mean pressure >25 mm Hg on catheterization[12]). Parameter cutoffs were then applied to the second subgroup of 155 patients to determine the tests' sensitivity, specificity, and accuracy. Finally, an algorithm combining selected parameters was tested to optimize sensitivity and specificity levels for PH diagnosis.

RESULTS

Population Characteristics

The selected population consisted of 310 patients, 162 of whom were men, with a mean age of 64.8 ± 15.9 and a mean body mass index of 26.3 ± 5.7 kg/m^2 (Table 1).

In total, 136 patients underwent echocardiographic investigation specifically for cardiac evaluation (27% for valvulopathy, 18% for heart failure, 16% for ischemic cardiomyopathy, and 11% for dilated cardiomyopathy), and 80 did so for pulmonary evaluation (15% for respiratory failure, 12% for primary PH, and 12% for secondary PH). Two-dimensional ultrasound window quality (from the parasternal or apical views) was good in 61% of examinations, medium in

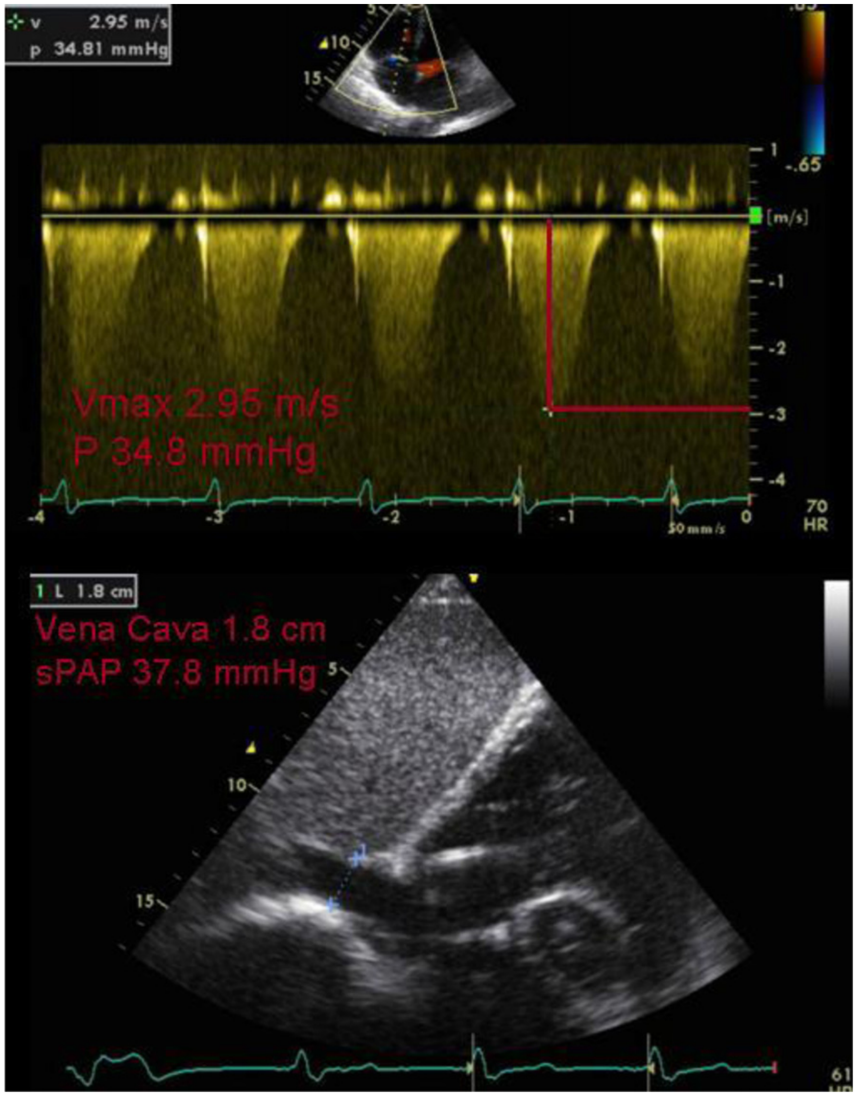

Figure 1 Example of measurement and calculation of sPAP.

30%, and poor in 8% (defined by the failure to visualize major heart structures). Three different operators' skills were identified: 13% of examinations were performed by nurses, 4% by fellows, and 83% by senior physicians. The mean time between the two examinations was 2.0 ± 2.9 days.

Systolic and diastolic blood pressures from echocardiography and catheterization measurements were not significantly different (122 ± 20 vs 122 ± 19 mm Hg, $P = .14$, and 67 ± 12 vs 68 ± 13 mm Hg, $P = .42$, respectively). Other parameters are listed in Table 1.

PP Correlation

Systolic PP Correlation. Systolic PP from RHC was significantly higher than that from Doppler echocardiography (53.2 ± 25.7 vs 49.7 ± 21.9 mm Hg, *t*-test $P < .01$). However, a significant, strong, and positive correlation was found between the two measurements ($r = 0.80$, $P < .00001$; Figure 2A). The mean difference was 3.6 ± 15.3 mm Hg, with 95% limits of agreement ranging from −26 to 33.4 mm Hg (Figure 2B). Graphically, the highest differences were found for high pathologic systolic PP values, with an underestimation of echocardiographic sPAP values compared with the referent RHC measurements. When focusing analysis on PP values <60 mm Hg (159 values), the mean error measurement was reduced to −2.09 mm Hg, with 95% limits of agreement ranging from −22.5 to 18.3 mm Hg.

RAP Correlation. The estimated mean RAP on echocardiography was 8.25 ± 4.23 mm Hg, compared with 7.39 ± 5.27 mm Hg on RHC (*t*-test $P < .01$). A significant but modest correlation was found ($r = 0.43$, $P < .001$).

Analysis of Confounding Parameters. To evaluate the potential impact of parameters such as the interval between the two examinations or operators' training, a multivariate linear regression analysis was performed, using as the dependent variable the absolute difference of systolic PPs obtained by the two methods. Independent variables were body mass index, heart rate, systolic blood pressure, time interval between the two examinations, operator's skill, and sonographic window quality. As shown in Table 2, only the time interval was shown to be positively associated with the absolute difference of systolic PPs, without reaching statistical significance.

Table 1 General characteristics of the global population (n = 310)

Variable	Value
Age (y)	64.8 ± 15.9
Men	52.3% (162)
Weight (kg)	73.0 ± 18.4
Height (cm)	166.1 ± 10.8
BMI (kg/m^2)	26.3 ± 5.7
HR (beats/min)	74.6 ± 15. 7
SBP (mm Hg)	118.7 ± 36.0
DBP (mm Hg)	66.0 ± 20.6
Systolic PP on RHC (mm Hg)	53.2 ± 25.7
Mean PP on RHC (mm Hg)	32.7 ± 15.3
sPAP on echocardiography (mm Hg)	49.6 ± 21.7
Delay (d)	2.0 ± 2.9
Skill	
Grade 1	12.9% (40)
Grade 2	3.9% (12)
Grade 3	83.2% (258)
Ultrasound window	
Good	61.4% (183)
Medium	30.2% (90)
Poor	8.4% (25)
Valvulopathy	27% (82)
Heart failure	18% (55)
Ischemic cardiomyopathy	16% (50)
Respiratory failure	15% (46)
PH grade I	12% (37)
PH grade II	12% (37)
Dilated cardiomyopathy	11% (35)

BMI, Body mass index; *DBP*, diastolic blood pressure; *HR*, heart rate; *SBP*, systolic blood pressure.
Continuous variables are expressed as mean ± SD and categorical variables as percentage (number).

PH Diagnosis

Echocardiographic PP for PH Diagnosis. Targeting a mean RHC PP limit value of 25 mm Hg for PH definition,[12] receiver operating characteristic curve analysis revealed a strong association between echocardiographic sPAP and PH diagnosis (area under the curve, 0.82). The cutoff obtained for echocardiographic sPAP with the highest sensitivity and specificity was 38 mm Hg (Figure 3). When applied to the second subgroup population, sensitivity, specificity, and accuracy were 88%, 83%, and 86%, respectively. Positive predictive value was 91% and negative predictive value 78.2%.

When patients with examination intervals of <2 days were selected (n = 115), there were 69 true-positives, 32 true-negatives, nine false-negatives, and four false-positives. Sensitivity was 89%, specificity 89%, positive predictive value 94%, and negative predictive value 78%. Accuracy (patients classified correctly) was 89%. Characteristics and a comparison of misclassified patients are presented in Table 3.

Regurgitant Flow Maximal Velocity. The use of the maximum velocity of tricuspid regurgitation for PH diagnosis, although effective, did not exceed sPAP, with slightly lower values of sensitivity and specificity (cutoff, 2.9; sensitivity, 82%; specificity, 72%).

Other Parameters. Prepulmonary flow delay, time to peak pulmonary flow, right chamber diameter, and right ventricular S′ for right ventricular function exhibited weaker accuracies in PH diagnosis, with an average area under the curve of 0.5 ± 0.1.

Parameter Combination. Because Doppler sPAP underestimation could result in misclassification and decreased sensitivity, we sought to optimize Doppler echocardiography for PH detection. To that end, we devised an algorithm combining sPAP estimation and parameters of time to peak pulmonary flow. Thus, patients with Doppler sPAP levels >38 mm Hg were classified as affected patients. Those with Doppler sPAP estimations >35 mm Hg and <38 mm Hg, in conjunction with a time to peak pulmonary flow <90 msec, were classified as having PH. However, this approach did not yield improved results.

DISCUSSION

This retrospective study, designed as a response to recent criticism of Doppler echocardiography's accuracy, was performed to evaluate the effectiveness of this most widespread noninvasive tool for heart hemodynamic evaluation in the real-world practice of a conventional echocardiography department. Although statistically significant differences in absolute measurements were observed, especially for high values, we also found a strong correlation between Doppler PP measurements and RHC measurements (r = 0.80, P < .00001). Moreover, Doppler echocardiography provided high levels of accuracy, sensitivity, and specificity (86%, 88%, and 83%, respectively), confirming its position as a primary tool for PH evaluation. With the sole exception of the time delay between evaluations, none of the parameters tested, including operators' echocardiographic skills and sonographic window quality, were found to limit cardiac hemodynamic evaluation and PH diagnosis.

This study is not the first to address the question of Doppler echocardiography's effectiveness for PP assessments. Analysis of the literature revealed two phases in the treatment of this issue. The first featured some positive validations when comparing Doppler echocardiographic with RHC data. In general, these studies were conducted in selected groups of patients with heart disease, with limited sample sizes (n < 100). However, the correlations obtained in these studies were high, establishing Doppler echocardiography as a relevant tool for primary or secondary PH diagnosis and for patient follow-up.

The second period, which started 5 years ago, asserted Doppler echocardiography's lack of accuracy and robustness for PP assessments. These studies were mainly prospective studies based on larger patient populations. Their authors highlighted weak correlations and elevated mean measurement errors between the two techniques (standard deviations >30 mm Hg), resulting in low confidence in echocardiography and prompt performance of RHC in patients with suspected PH.

We conducted a retrospective study using data collected during 6 months in a conventional echocardiography department at a cardiology hospital. The motivation behind the choice of a retrospective study design was the necessity to obtain a real statement of echocardiography's capabilities in routine activity, independently of a structured prospective protocol that might generate bias, thus limiting extrapolation to routine clinical practice.

In our study, we observed a stronger correlation than that obtained in some prospective studies (0.80 vs an average of 0.65), despite a large confidence interval of mean error measurements, as already mentioned by others (−26 to 33.4 mm Hg).[15,18] This may be accounted for underestimation of PP value using the Doppler method as opposed to RHC. This underestimation appears larger

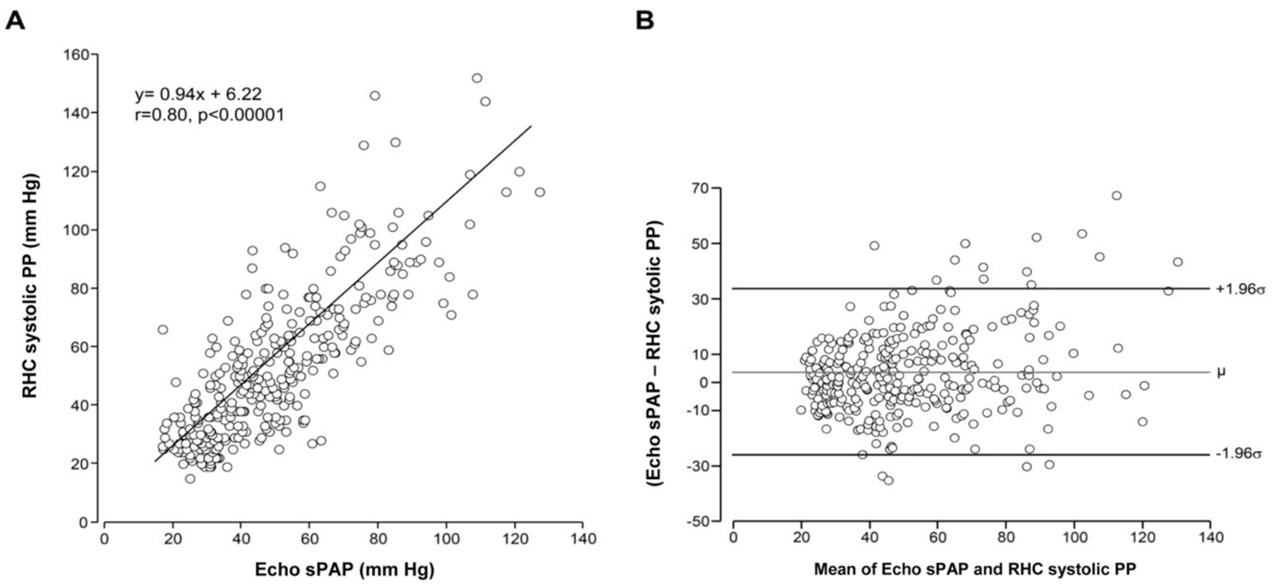

Figure 2 Correlation **(A)** and comparability **(B)** (Bland-Altman representation) between Doppler echocardiographic and RHC methods for systolic PP evaluation. Measurements from the 310 examinations of RHC and Doppler echocardiography were plotted.

Table 2 Multivariate linear regression analysis

Independent Variable	$\beta \pm$ SD	*t*	*P*
Constant	13.25 ± 19.96	0.664	.51
BMI	0.003 ± 0.066	0.045	.96
HR	−0.047 ± 0.060	−0.774	.44
SBP	0.0006 ± 0.026	0.023	.98
Delay	0.574 ± 0.313	1.831	.07
Skill	0.974 ± 1.365	0.714	.48
Ultrasound window	2.588 ± 1.571	1.648	.10

BMI, Body mass index; *HR*, heart rate; *SBP*, systolic blood pressure. The dependent variable was the absolute difference between systolic PP values from RHC and echocardiography. Independent variables were BMI, HR, SBP, the time interval between the two examinations, operator's skill, and sonographic window quality.

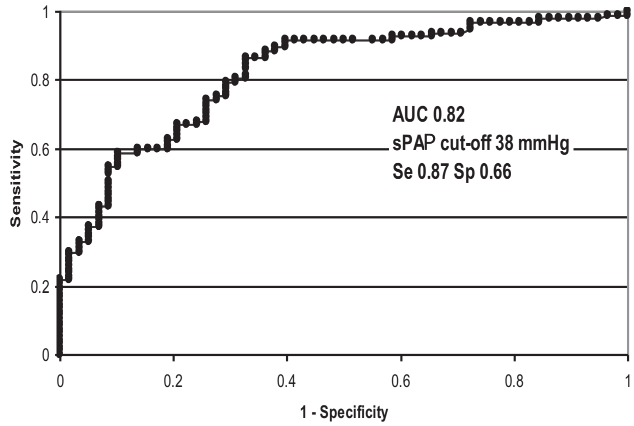

Figure 3 Receiver operating characteristic curve of echocardiographic sPAP for RHC PH diagnosis (*n* = 155). *AUC*, Area under the curve; *Se*, sensitivity; *Sp*, specificity.

for elevated PP values. Hence, the calculated confidence interval was diminished when limiting the comparison to PP values <60 mm Hg (22.5–18.3 mm Hg). Reasons for the differences observed with prospective studies, such as the study of Rich *et al.*,[17] could include patient disease profiles (preferentially patients with PH in prospective studies), operators' skill (sonographers, compared with a majority of physicians in our study), and equipment quality. A specific typology of patients has been involuntarily excluded from the analysis, which could also account for the differences observed between studies. Because of this, patients admitted to intensive care units whose echocardiographic systems were not connected to our database were not considered for analysis.

Because the underestimation of PP values using the Doppler method could influence the method's relevance in PH diagnosis, we tested more specifically the efficacy of Doppler echocardiography in PH diagnosis. Of note is that we observed a high level of accuracy with a cutoff value slightly lower than the one generally used (38 mm Hg), resulting in sensitivity of 88% and specificity of 83%. The accuracy was further increased when selecting patients with examinations performed within a 2-day interval. As supported by our data analysis, echocardiography was largely sufficient for PH diagnosis. It is surprising that this distinction between correlations and accuracy analyses was not made in those studies that found Doppler echocardiography to be inaccurate.[17] Furthermore, calculated sensitivity and specificity values were lower than those obtained in our study,[18] despite these studies' use of prospective designs. Again, the level of operator training could explain this difference, along with equipment quality. Indeed, examinations performed in our laboratory were obtained using high-level echographic platforms. Finally, some authors have argued that pulmonary pathologies could limit measurement accuracy compared with those taken in patients with cardiac disease.[18] In our study, we found that window quality or disease profile (pulmonary vs heart disease) had no impact.

Because the major risk for error has been shown to stem from PP estimation, we sought more robust Doppler parameters for PH diagnosis. Some authors have proposed estimating PP from the tricuspid

Table 3 Characteristics of correctly classified and misclassified patients

Variable	Correctly classified (*n* = 134)	Misclassified (*n* = 21)	*P*	False-positive (*n* = 9)	False-negative (*n* = 12)	*P*
Age (y)	65.8 ± 13.7	63.7 ± 18.8	NS	66.7 ± 22.3	61.4 ± 16.3	.24
Men	50.0% (67)	57.1% (12)	NS	33.3% (3)	75.0% (9)	.09
Weight (kg)	74.2 ± 19.3	66.9 ± 17.26	.09	58.6 ± 16.0	73.1 ± 16.0	.06
Height (cm)	165.8 ± 9.2	165.3 ± 10.1	NS	160.2 ± 8.8	169.2 ± 9.5	.05
BMI (kg/m^2)	26.9 ± 5.8	24.2 ± 4.7	.03	22.7 ± 5.6	25.3 ± 3.7	.20
HR (beats/min)	73.6 ± 13.5	73.9 ± 14.6	NS	76.5 ± 10.5	72.0 ± 17.3	.20
SBP (mm Hg)	125.8 ± 27.2	125.8 ± 22.8	NS	130.6 ± 30.6	122.7 ± 17.3	.44
DBP (mm Hg)	69.2 ± 14.7	71.3 ± 17.9	NS	69.1 ± 15.8	72.6 ± 19.7	NS
Delay (d)	1.9 ± 3.0	2.5 ± 3.7	NS	2.1 ± 1.6	2.7 ± 4.8	.2
Skill						
Grade 1	13% (18)	10% (2)	NS	22% (2)	0% (0)	.17
Grade 2	4% (6)	0% (0)	NS	0% (0)	0% (0)	—
Grade 3	82% (110)	90% (19)	NS	78% (7)	100% (12)	.17
Ultrasound window						
Good	57% (77)	67% (14)	NS	56% (5)	75% (9)	.40
Medium	31% (42)	30% (6)	NS	30% (4)	17% (2)	.33
Poor	11% (15)	5% (1)	NS	0% (0)	8% (1)	NS
Valvulopathy	24% (32)	43% (9)	.07	33% (3)	50% (6)	NS
Heart failure	16% (22)	19% (4)	NS	11% (1)	25% (3)	NS
Ischemic cardiomyopathy	12% (16)	24% (5)	.14	22% (2)	25% (3)	NS
Respiratory failure	19% (25)	10% (2)	.30	22% (2)	0% (0)	.17
PH grade I	20% (27)	10% (2)	.25	10% (1)	8% (1)	NS
PH grade II	14% (19)	5% (1)	.23	0% (0)	8% (1)	NS
Dilated cardiomyopathy	7% (9)	10% (2)	NS	0% (0)	17% (2)	.49

BMI, Body mass index; *DBP*, diastolic blood pressure; *HR*, heart rate; *SBP*, systolic blood pressure.
Continuous variables are expressed as mean ± SD and categorical variables as percentage (number).

regurgitant maximal velocity alone. A cutoff of 2.9 m/sec has been retained in the guidelines for PH diagnosis and management.[12] In our study, the complete approach to PP using both RAP and maximal velocity demonstrated a slightly higher level of accuracy compared with using maximal velocity alone. Our use of the latest guidelines for RAP estimation from the vena cava diameter explains this.[21] This new classification is quite different from its predecessor, simplifying the algorithm and reducing estimated RAP values. Finally, although we combined echocardiographic PP estimation and time to peak pulmonary flow to optimize Doppler echocardiography effectiveness for PH detection, no improvement in sensitivity or specificity was obtained.

The question as to the applicability of our results deserves to be raised. In fact, the crucial point of this study was not to find a correlation between both sPAP measurements, which, though higher than the published figures in the scientific literature, showed some level of inaccurateness. The Bland-Altman analysis confirmed a nonnegligible deviation (−26 to 33.4 mm Hg) from the mean error of measurement. Our study differed from previously published reports by achieving high levels of sensitivity, specificity, and reproducibility (88%, 83%, and 86%, respectively) in PH diagnosis, which was in fact the core of our work. Given this context, we highlighted the major role of echocardiography in the initial diagnosis of PH, along with its importance as a screening device. Regardless of whether secondary PH (to left heart failure, for example) or primary PH was taken into account, positive predictive values exceeded the threshold of 90%, with negative predictive values approaching 80%. Because of these thresholds, echocardiography should be considered a first-line screening device for PH, as stipulated in the recommendations pertaining to this subject.[12] In contrast, the follow-up of pulmonary artery pressures in patients with PH using echocardiography is still a matter of debate, because of the imperfect correlation between the two techniques. In this context, it appears preferable to assess the impact of right ventricular postcharge variations on the morphology and function of the right ventricle.

Limitations

This study had some limitations. First, a majority of patients enrolled in our analysis had cardiac disease, PH, or both. Second, we used a retrospective design, with no control over time between examinations, parameters measured, or examination conditions. These standard and well-known limitations usually play a role by decreasing the ultimate support of our conclusions. The major, and perhaps only, bias that could negatively affect our findings theoretically stems from the unblinded operator (a precaution that would have been imposed in a prospective study). From a practical perspective, however, catheterization systematically follows an echocardiography investigation. Third, the difference in results obtained by the correlation or Bland-Altman analysis and the receiver operating characteristic curve analysis could be questionable. However, these analyses are not comparable, because the first one is a direct comparison of the same parameter (systolic PP) obtained by two different techniques, whereas the second is a diagnostic test targeting PH identification defined by the mean RHC PP. Similarly, although the choice for PH definition tended toward mean pulmonary artery pressure values obtained from cardiac catheterization, we did not find it useful to perform a direct comparison between mean pulmonary artery pressure values obtained with both methods. Our retrospective study design did not provide sufficient data to perform such a comparison, with <20% of pulmonary regurgitant flow analysis reports retrieved, and not a single velocity-time integral value of the tricuspid regurgitant jet. Also, our aim was to validate exclusively the method that is routinely used in our department rather than investigate novel approaches, which would have required a prospective design.

Finally, echocardiographic studies did not involve contrast methods, which might have improved pulmonary artery pressure measurements in difficult cases.

CONCLUSIONS

We reinforce the relevance and accuracy of Doppler echocardiography for PP evaluation and confirm its major position as a primary noninvasive tool for PH diagnosis.

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