

Poor Tricuspid Regurgitation Signal on Echocardiogram: How Does It Correlate with Pulmonary Artery Pressure as Measured by Right Heart Catheterization?

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Research

Keywords: Poor Tricuspid Regurgitation, Pulmonary Hypertension, Indeterminate Pulmonary Artery Pressure, Right Heart Catheterization

Posted Date: May 7th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-493662/v1>

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Abstract

Background

Tricuspid Regurgitation (TR) gradient on echocardiogram is used to approximate pulmonary artery pressure (PAP) on echocardiography. A common dilemma is encountered when PAP measurement is indeterminate due to poor TR signal. We hypothesized that patients with poor TR signal would be unlikely to have pulmonary hypertension (PH) on right heart catheterization (RHC).

Methods

We performed a retrospective analysis of 141 patients who underwent RHC and had a corresponding echocardiogram showing poor TR signal within 2 months of RHC. A cutoff of 25 mm Hg was used as the upper limit of normal to define PH.

Results

Fifty percent of patients had mean PAP (mPAP) greater than 25 mm Hg. 82% of values were 35 mm Hg or below.

Conclusions

Poor TR signal does not rule out PH but may indicate lower likelihood of severe PH.

Background

Pulmonary hypertension (PH) is a cause of significant morbidity and mortality and accurate assessment is imperative to gauge burden of disease and prognosis. The echocardiogram-derived value for pulmonary artery pressure (PAP) often serves as a starting point for further evaluation. The benefits of echocardiography over right heart catheterization (RHC) include being non-invasive, having widespread availability, lower cost, and less time consuming. If high clinical suspicion remains for PH after echocardiogram, RHC should be pursued.

Tricuspid regurgitation (TR) gradient on echocardiogram has been validated as a means of estimating PAP based on comparison studies to the gold standard, right heart catheterization RHC [1, 2]. The Bernoulli equation is used to derive the right ventricular systolic pressure (RVSP) from peak TR jet velocity, which, when added to the estimated right atrial pressure (RAP) (determined by size and respiratory variation of the inferior vena cava) correlates well to systolic PAP (sPAP); in the absence of pulmonary valve stenosis [3, 4]. The TR signal seen on continuous wave doppler can also be traced to determine the mean TR pressure gradient, which, when added to the RAP, gives a mean PAP (mPAP).

A common dilemma is encountered when PAP cannot be determined due to poor TR signal on continuous wave doppler. Given the correlation between TR and PAP, a guideline on the topic classifies unmeasurable TR jet velocity as having a low or intermediate risk for pulmonary hypertension [5]. In light of this, we hypothesized that patients with poor TR signal on echocardiogram would be unlikely to have PH found on RHC.

Methods

Data was collected from echocardiograms and RHC procedures performed at Scripps Memorial Hospital in La Jolla, California, between 2018 and 2020. We used a time frame of 2 months between RHC and echocardiogram. If the overall quality of the echocardiogram was deemed poor, the study was excluded. Thus, our cohort is comprised of patients with overall good quality images and yet, poor TR signal.

The following echocardiogram reporting codes corresponding to poor TR signal were used to identify our intended cohort: "Tricuspid regurgitation (TR) jet envelope is poor for pulmonary artery systolic pressure assessment." "TR doppler signal not adequate for accurate assessment." "Unable to estimate peak or mean pulmonary arterial pressure due to inadequate doppler TR signal." "Pulmonary arterial pressure is at least xx mmHg however, TR Doppler signal is not adequate for accurate assessment".

Exclusion criteria included overall poor imaging quality on echocardiogram, and severe pulmonic stenosis (defined as peak velocity > 4 m/s and/or peak gradient > 64 mm Hg).

The primary endpoint was the presence of pulmonary hypertension defined as mPAP greater than 25 mmHg on RHC.

Results

141 cases met the above inclusion criteria. Average age was 73, with range of 35 to 95 years old. 54% of patients were male. Of note, 75% of cases had echo and RHC done within one month.

Fifty percent of patients had mPAP greater than 25 mmHg. Mean value for mPAP was 25.7 mmHg (95% CI: 24.2–27.4), median 25 mmHg, with a range of 8 mmHg to 53 mmHg. Further stratification based on tiers of mmHg showed values represented by Fig. 1 for mPAP.

Discussion

Based on our results, poor TR signal does not rule out PH, as almost equal distribution of mPAP values were seen on either side of the upper limit of normal defined as 25 mmHg. When mPAP greater than 36 mmHg was used as a cutoff for more severe pulmonary hypertension, only 18% of our patients with inadequate TR signal met criteria. We used mPAP to report our results since most universal definitions of PH are defined by mPAP instead of sPAP.

Several prior studies have explored the correlation between echocardiogram derived measurements of PAP when compared to RHC. After initial validation by Yock and Popp in 1984 [1], several prospective studies confirmed their results [2, 6, 7]. Yet, other prospective studies found less favorable correlations [8–10]. A large retrospective analysis showed good correlation between echocardiogram and RHC derived PAP in a group of 1695 patients with time matched (within 5 days of either study) analysis [11]. However, patients with absent TR were excluded from this analysis. It was further noted that 227 out of 424 or 53.5% of patients with absent TR jets had PH as defined by mPAP greater than or equal to 25 mm Hg measured by RHC.

Given that unmeasurable TR jets are frequently excluded from correlation analyses mentioned above, O’Leary et al [12] performed a large retrospective analysis to address this population. They identified 459 patients with no reported TR jet and compared to mPAP measured by RHC within 2 days. Their results are in concordance with our study as 47% of patients had PH, as defined by mPAP greater than or equal to 25 mm Hg, compared to 50% in our study. Furthermore, 20% of patients had mPAP greater than 35 compared to 18% in our study. Of note, this study did not exclude technically inadequate or limited echocardiograms as was done in our analysis but they did have a shorter time frame for comparison between echocardiogram and RHC; 2 days versus 2 months in our study. Their analysis also includes a larger timeframe from 1998–2014 versus 2018–2020 in our study which may further reflect better echocardiogram quality in our assessment.

To improve study quality, echocardiographic evaluation should encompass at least five different views when determining PAP [13]. This approach increases sensitivity without compromising specificity in the estimation of PAP. These multiple views are assessed in our echocardiography laboratory which is certified by the Intersocietal Accreditation Commission, in accordance with the American Society of Echocardiography (ASE) guidelines.

An additional method to screen for PH on echocardiogram is by using the pulmonary valve regurgitation signal on continuous wave doppler [14]. Real world application of this method is rare compared to the TR-gradient method. Unfortunately, very few of our patients had an adequate pulmonary valve regurgitation signal to perform this analysis.

Limitations

A limitation is the time interval between RHC and echocardiogram, up to two months. While most of our data was gathered within a one-month period (75%), it is possible that hemodynamics may vary significantly even within that timeframe.

Also, by performing our analysis retrospectively, we selected only for patients that obtained RHC. This cohort likely had reasons for higher clinical suspicion for pulmonary hypertension, and thus may not be representative of all patients with poor TR signal on echocardiogram. Perhaps a prospective study of all such patients would find a significantly lower likelihood of pulmonary hypertension. However, subjecting all comers with poor TR signal to an invasive procedure like RHC may not be feasible.

Conclusion

Echocardiography remains an essential primary modality in the evaluation of patients with pulmonary hypertension. Poor quality TR signal should not be used to rule out a diagnosis of pulmonary hypertension, however it may portend a low likelihood of more severe pulmonary hypertension.

Abbreviations

TR (Tricuspid regurgitation), PAP (Pulmonary artery pressure), PH (Pulmonary hypertension), RHC (Right heart catheterization), sPAP (systolic pulmonary artery pressure), mPAP (mean pulmonary artery pressure), RVSP (Right ventricular systolic pressure), RAP (Right atrial pressure)

Declarations

Ethics approval and consent to participate

IRB approval was obtained through Scripps Office for the Protection of Research Subjects via protocol number 14-7474 and approved on December 31, 2019.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no competing interests

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author's Contributions

MA compiled the data and drafted the manuscript.

SR designed the hypothesis, reviewed data and manuscript.

MP helped in hypothesis design, data and manuscript review.

RM helped in hypothesis design and manuscript review.

All authors read and reviewed the final manuscript.

Acknowledgements

Ashley Jaravata and Samantha Bagsic for their assistance in data gathering and statistical analysis.

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Figures

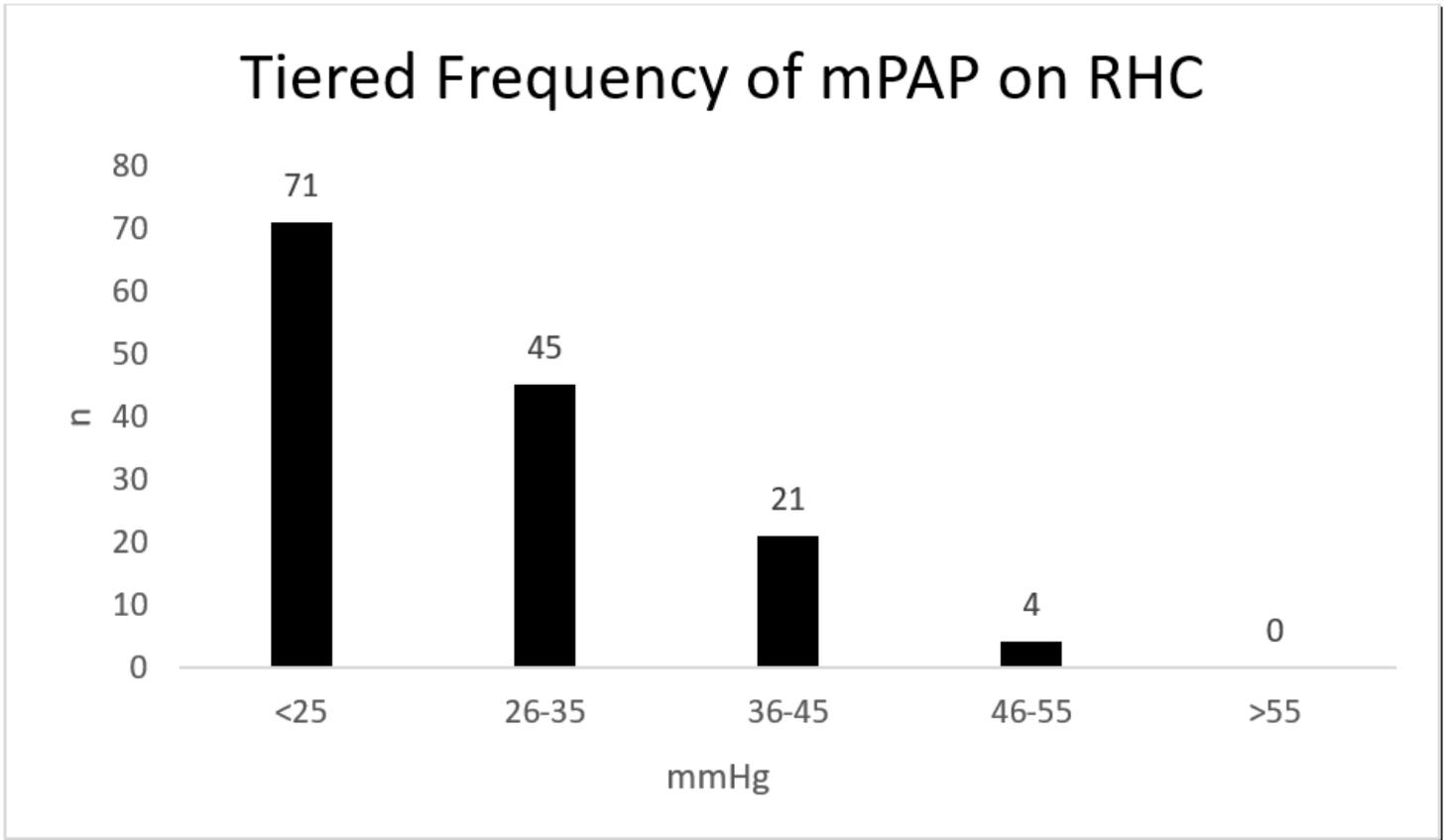


Figure 1

Tiered frequency of mPAP on RHC