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ECG patterns to predict pulmonary arterial hypertension in patients with severe tricuspid regurgitation

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Highlights

- Underdiagnosis in Severe TR:
  - Echocardiography may miss pulmonary hypertension, emphasizing the need for comprehensive assessment.
- ECG Insight in TR Patients:
  - ECG proves pivotal in identifying pulmonary hypertension in severe tricuspid regurgitation cases.
- $maxRV_{1,2}$+max $S_{I,aVL}$– S_{V1} > 3 mm offer high specificity in PAH diagnosis.
- S_I:R_I >0.71 provides heightened sensitivity, enhancing accuracy in tricuspid regurgitation identification.
- R:S_{V1} >1.5 mm yields a high positive predictive value, indicating likely PAH in the setting of severe tricuspid regurgitation.

Abstract

Introduction

Echocardiographic evaluation of tricuspid regurgitation (TR) velocity is a key measure in screening for pulmonary hypertension. Based on its value and additional features of right ventricle overload patients are classified into low, intermediate or high probability of pulmonary hypertension which transfers into decisions of further invasive evaluation. However, in the presence of severe TR echocardiography underestimates pulmonary artery pressure and therefore pulmonary hypertension may be overlooked in some patients. Accordingly, in the present study we aimed to assess the role of electrocardiography in predicting the presence of pulmonary arterial hypertension (PAH) in patients with severe TR.

Results

We analysed 83 consecutive patients with severe TR who were diagnosed in our centre between February 2008 and 2021 and who underwent right heart catheterization. Of them 58 had PAH while 25 had isolated TR (iTR).

We found that the following ECG criteria supported the diagnosis of PAH as opposed to the diagnosis of iTR: R:S_{V1}>1.0, max $R_{V1\ or\ 2}$+max $S_{I\ or\ aVL}$ −S_{V1}>6 mm, S_I/R_I>1 in I. For these parameters using ROC analysis we found that the optimal thresholds suggesting the presence of pulmonary hypertension were: R:S_{V1}>1.5 (AUC=0.74, p=0.0004, sensitivity 57.1%,specificity of 85%), max $R_{V1\ or\ 2}$+max $S_{I\ or\ aVL}$ − S_{V1}>3 mm (AUC=0.76, p<0.0001, sensitivity 91.4%, specificity of 60%) and for S_I:R_I>0.71 (AUC=0.79, p<0.0001, sensitivity 82.5%,specificity of 70.8%). Presence of atrial fibrillation predicted iTR with 76% sensitivity and 81% specificity.

Conclusions

ECG analysis can improve the diagnostic process for patients with severe TR. The presence of atrial fibrillation facilitates the diagnosis of isolated tricuspid regurgitation (iTR), while increased values of R:S_{V1}, R:S_I, and increased max $RV_{1\ or\ 2}$+max $S_{I\ or\ aVL}$ − S_{V1} favor the diagnosis of TR secondary to PAH.

Introduction

Tricuspid valve regurgitation (TR) of moderate or high severity affects approximately 0.55% of the general population [1]. TR can be classified based on the underlying mechanisms as primary, secondary or isolated TR (iTR).

Primary tricuspid regurgitation can occur in the course of various conditions affecting valve apparatus such as infective endocarditis, congenital abnormalities, carcinoid heart disease [2], or injury/trauma and accounts for approximately 5% of TR cases. In some cases iatrogenic cause or pacemaker leads wires impinging on leaflets may cause severe tricuspid regurgitation.

On the other hand, the majority (approximately 90%) of TR are functional (also called secondary) [3] which means that they are caused by the dilation and remodelling of the right ventricle (RV) or right atrium and subsequent tricuspid annulus distention with anatomically normal leaflets and chords. This mostly happens due to right ventricle overload in the course of pulmonary hypertension (PH) of various origin. However, in some cases with normal leaflets and tricuspid apparatus, no pulmonary hypertension, an idiopathic tricuspid annulus dilatation may occur leading to isolated tricuspid regurgitation (iTR). It was given more attention in recent years, with novel therapeutic options, as previously TR was considered either rarely primary or ‘secondary’ to pulmonary hypertension [4].

TR velocity is the main echocardiographic marker used to screen patients for pulmonary hypertension (PH) and when it exceeds 3.4m/s the patient is assigned a high probability of PH regardless of other echocardiographic signs of PH [5]. High PH probability can also be assigned to patients who have TR flow velocity of 2.9–3.4 and additional echocardiographic signs of PH including among the others right atrial and/or ventricular enlargement. Based on echocardiographic probability of PH the patient is referred for further diagnostic tests including right heart catheterization to make a diagnosis of PH or exclude this disease.

However, as emphasized by the guidelines [5], echocardiography can significantly underestimate pulmonary artery pressure in the presence of severe TR which can pose a clinical challenge to differentiate severe iTR from TR due to PH, especially in the presence of other signs of RV overload which may be similar in these two distinct diseases.

In our previous work we have shown that the surface electrocardiogram can differentiate patterns of RV hypertrophy or RV dilatation [6] therefore we hypothesized that ECG patterns can also be useful to differentiate between patients with iTR and TR secondary to PH. Accordingly, in the present study we aimed to assess the utility of ECG to distinguish patients with severe TR, isolated or secondary to PH and consequently the role of ECG in predicting PAH in patients with severe TR.

Section snippets

Patients

All study participants were consecutively recruited adult patients diagnosed and treated in the Pulmonary Circulation Centre at John Paul II Hospital in Krakow, Poland. The inclusion criteria for patients involved the presence of severe tricuspid regurgitation either 1) isolated with mean pulmonary artery pressure (mPAP) <25mmHg and pulmonary vascular resistance (PVR)<3 Wood units or 2) secondary to pulmonary arterial hypertension (PAH) both idiopathic (IPAH) or associated with connective

Study group

Between February 2008 and 2021, a total of 201 patients were diagnosed with iPAH or CTD-PAH or severe iTR. Among them, there were 25 patients with iTR and 176 patients with PAH. Among patients with PAH, 58 (28.4%) had severe TR (IPAH, n=50, CTD-PAH, n=8). The characteristics of patients with severe TR with and without PH are described in Table 1.

Clinical characteristics of patients with severe TR stratified by the presence of PAH

Patients with iTR were older than those with PAH (Table 1). Furthermore, patients with iTR as compared to PAH patients exhibited lower WHO-FC,

Discussion

In the present study, we demonstrated that ECG analysis can improve the diagnostic process for patients with severe TR. The presence of atrial fibrillation facilitates the diagnosis of isolated tricuspid

regurgitation (iTR), while increased values of R:SV1, R:SI, and increased max $RV_{1\ or\ 2}$+max $S_{I\ or\ aVL}$ – S_{V1} favor the diagnosis of TR secondary to PAH.

Elevated chronic right ventricular workload can induce either right ventricular dilation or hypertrophy. Dilation can arise in the context of

Conclusions

This study demonstrates the utility of ECG in identifying PH in patients with severe TR. Patients with iTR and those with PAH exhibit distinct electrocardiogram patterns, with atrial fibrillation being more prevalent in iTR. Three ECG criteria such as R:S_{V1}, R:S in I, and increased max $R_{V1\ or\ 2}$+max $S_{I\ or\ aVL}$ – S_{V1} had good diagnostic performance, suggesting their potential use in identifying pulmonary arterial hypertension in patients with severe tricuspid regurgitation. Of them increased max

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CRediT authorship contribution statement

Marcin Waligóra: Conceptualization, Methodology, Formal analysis, Supervision, Data curation, Investigation, Project administration, Resources, Validation, Visualization, Writing - original draft, Writing - review & editing. **Maria Smorąg:** Formal analysis, Data curation, Investigation. **Natalia Bukała:** Investigation. **Marianna Zygmunt:** Investigation. **Natalia Kachnica:** Investigation. **Emilia Lis:** Investigation. **Klaudia Zaczyńska:** Investigation. **Łukasz Wilczek:** Investigation. **Barbara Wziątek:**

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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