

Concerns Regarding Impedance Cardiography's Reliability in Pulmonary Arterial Hypertension Assessment

To the Editor,

I read with interest the article by Zhang et al,¹ titled "Impedance Cardiography Is a Potent Non-Invasive Method in Cardiac Output Measurement and Pulmonary Arterial Hypertension Risk Assessment" (*Anatol J Cardiol.* 2025;29(7):347-354).¹ The study's exploration of impedance cardiography (ICG) as a non-invasive alternative for measuring cardiac output (CO) and stroke volume (SV) in pulmonary arterial hypertension (PAH) is commendable. However, I noted several inconsistencies, gaps, and discrepancies with the literature that merit discussion, and I pose questions to the authors to clarify these points.

The study reports a moderate correlation between CO measured by ICG and thermodilution (COTD) ($r=0.49$, $P < .001$), with a Bland-Altman analysis showing a bias of 0.52 L/min, limits of agreement (LoA) from -1.76 to 2.80 L/min, and a high percentage error of 49.89%.¹ This wide LoA and error rate question ICG's reliability as a substitute for right heart catheterization (RHC). How do the authors justify the clinical acceptability of this variability, and what measures could enhance ICG's accuracy? Additionally, the weaker correlation in chronic thromboembolic pulmonary hypertension (CTEPH) patients compared to Group 1 PAH patients is noted (Supplementary Figures 1 and 2),¹ but the reasons are underexplored. Could CTEPH-specific vascular pathology or right heart geometry contribute, and what are ICG's limitations in this subgroup?

The lack of simultaneous ICG and RHC measurements is a significant limitation, given the rapid hemodynamic changes in PAH.¹ How was the impact of this time gap assessed, and what steps minimized its effect? Previous studies, such as Yung et al² and Tonelli et al,³ reported lower ICG accuracy in PAH. Despite claiming "acceptable correlation," the high error rates (49.89% for CO, 54.38% for SV) align with these concerns.¹ How do the authors reconcile this, and are further validation studies planned? The study also suggests ICG-derived cardiac index (CIICG) and stroke volume index (SVIICG) for PAH risk stratification,¹ yet the 2022 European Society of Cardiology/European Respiratory Society guidelines recommend RHC or cardiac magnetic resonance imaging.^{4,5} Can additional data support ICG's reliability here? No predictors of ICG accuracy were identified despite examining factors like skin condition or thoracic morphology.¹ Are further analyses planned to explore right heart volume or pulmonary artery dilation's impact on thoracic impedance? The ROC analysis for clinical deterioration (AUC 0.76 for CIICG, 0.81 for SVIICG) relies on a small cohort ($n=54$).¹ Are larger studies planned to validate these findings? Given the high error rate, in which clinical scenarios (e.g., low-risk patient follow-up) is ICG most suitable?

I suggest simultaneous ICG and RHC measurements to reduce time-related errors, a broader literature review under the new PAH criteria (mean pulmonary arterial pressure > 20 mm Hg),⁴ subgroup analyses for CTEPH, and extended follow-up with larger cohorts to validate ICG's prognostic value. The study highlights ICG's potential, but high error rates and wide LoA, especially in CTEPH, limit its clinical

LETTER TO THE EDITOR

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Cite this article as: Zorlu Ç. Concerns regarding impedance cardiography's reliability in pulmonary arterial hypertension assessment. *Anatol J Cardiol.* 2026;30(2):135-136.



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DOI:10.14744/AnatolJCardiol.2025.5604

utility. Clarifications could enhance its relevance. I look forward to the authors' responses.

Declaration of Interests: The author has no conflicts of interest to declare.

Funding: The author declares that this study received no financial support.

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