AMERICAN JOURNAL OF PHYSIOLOGY
HEART AND CIRCULATORY PHYSIOLOGY

Am J Physiol Heart Circ Physiol 330: H1479–H1480, 2026.
doi:10.1152/ajpheart.00141.2026

LETTER TO THE EDITOR

Integrative Cardiovascular Physiology and Pathophysiology

Beyond TAPSE: clinical and methodological perspectives on 3D-derived right ventricular

Francesco Sbarra,[1] Francesca Coppi,[2] and Gianluca Pagnoni[1]

[1]*Cardiologic Unit, Specialistic Medicine Department, Guglielmo da Saliceto Hospital, Piacenza, Italy and* [2]*Department of Medical and Surgical Sciences for Children and Adults, University of Modena and Reggio Emilia, Modena, Italy*

TO THE EDITOR: We read with great interest the article by Oakland et al. (1) describing the correlation between maximum principal surface strain (PS_{Max}) and its corresponding angle (Θ_{Max}) of right ventricular (RV) surface deformation in patients with pulmonary arterial hypertension (PAH), with and without right heart failure, compared with control subjects. Conventional two-dimensional echocardiographic parameters, such as tricuspid annular plane systolic excursion (TAPSE), S′ velocity, and longitudinal strain, have well-recognized methodological limitations in estimating RV systolic function, as they do not fully account for the ventricle's complex asymmetric geometry and predominantly assess longitudinal shortening (2). In this context, parameters derived from three-dimensional assessment, such as PS_{Max} and Θ_{Max} of RV surface deformation, may theoretically provide greater accuracy and reproducibility in evaluating RV contractility compared with traditional two-dimensional indices. In the present study, PS_{Max} values differed significantly between controls and patients with PAH and, within the PAH cohort, further discriminated between those with and without right heart failure. Moreover, Θ_{Max} demonstrated a progressively more longitudinal orientation in the presence of right heart failure. In their prospective observational study, the authors highlight three clinically relevant concepts. First, PS_{Max} and Θ_{Max}, derived from three-dimensional analysis, not only identify RV dysfunction but may also contribute to grading its severity—addressing an important limitation of two-dimensional parameters such as TAPSE. Second, these indices correlate with short-term clinical outcomes, suggesting a potential prognostic role in addition to their diagnostic value. Third, they may enable the detection of early and subclinical RV dysfunction, thereby supporting earlier therapeutic interventions and more targeted follow-up in patients who truly require it—an approach previously suggested for certain laboratory biomarkers in patients with rheumatologic diseases associated with pulmonary hypertension (3). Given their potentially higher diagnostic accuracy, these parameters might also play a role in monitoring RV function throughout the different phases of cardiac rehabilitation (4). This study therefore provides important preliminary confirmation while also raising relevant questions. One key issue concerns the incremental value of PS_{Max} and Θ_{Max} compared with other established three-dimensional techniques, such as three-dimensional RV ejection fraction, with which direct comparative analyses appear warranted (5). In addition, comparison with the TAPSE/PAPs ratio in patients with pulmonary hypertension would be of interest, as this parameter has been shown to predict mortality and cardiovascular events in patients with pulmonary hypertension secondary to systemic sclerosis (6). Further investigation is needed to confirm the potential prognostic value of PS_{Max} and Θ_{Max} for medium- and long-term cardiovascular outcomes and to define and validate optimal cutoff values in larger populations and across different clinical settings, including right ventricular myocardial infarction, pulmonary embolism, and the various forms of pulmonary hypertension. Beyond these considerations, integration of PS_{Max} and Θ_{Max} into multiparametric models of RV assessment may further enhance risk stratification. Current international guidelines on pulmonary hypertension emphasize a comprehensive approach combining clinical, functional, imaging, and hemodynamic variables for prognostic evaluation (7). In this framework, advanced three-dimensional deformation indices could represent an additional layer of phenotypic characterization, particularly in patients whose conventional parameters appear borderline or discordant. Moreover, the pathophysiological rationale underlying changes in principal strain direction deserves further mechanistic exploration. Progressive longitudinal reorientation of Θ_{Max} in advanced disease may reflect maladaptive remodeling, fiber disarray, and altered myocardial stress distribution under chronic pressure overload, phenomena already described in experimental and clinical studies of RV adaptation (8). From a methodological perspective, issues of intervendor variability, acquisition time, feasibility in suboptimal acoustic windows, and learning curve should also be systematically addressed before widespread implementation. Standardization initiatives, similar to those undertaken for two-dimensional strain imaging (9), would be essential to ensure reproducibility across centers and to facilitate the incorporation of these parameters into future multicenter trials.

Correspondence: F. Sbarra (sbarra93@outlook.it).
Submitted 27 February 2026 / Revised 2 March 2026 / Accepted 2 March 2026

0363-6135/26 Copyright © 2026 The Authors. Licensed under Creative Commons Attribution CC-BY 4.0.
Published by the American Physiological Society.

Downloaded from journals.physiology.org/journal/ajpheart (2001:0B07:0A12:18C3:4BC6:8F10:3DB5:969C) on October 29, 2026.

DISCLAIMERS

The content and any opinions expressed in this article are those of the authors and do not necessarily represent the views of the American Physiological Society.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

F.S. drafted manuscript; F.S., F.C., and G.P. edited and revised manuscript; F.S., F.C., and G.P. approved final version of manuscript.

REFERENCES

1. **Oakland HT**, **Bellumkonda L**, **Sugeng L**, **Joseph P**, **Kundu P**, **Izzi D**, **Zalik F**, **McCabe S**, **Raza A**, **Amendola R**, **Heerdt PM**, **Hunter KS**, **Singh I.** 3D echo derived right ventricular principal surface strain in pulmonary arterial hypertension. *Am J Physiol Heart Circ Physiol* 330: H729–H736, 2026. doi:10.1152/ajpheart.00923.2025.
2. **Wang JMH**, **Rai R**, **Carrasco M**, **Sam-Odusina T**, **Salandy S**, **Gielecki J**, **Zurada A**, **Loukas M.** An anatomical review of the right ventricle. *Transl Res Anat* 17: 100049, 2019. doi:10.1016/j.tria.2019.100049.
3. **Coppi F**, **Sbarra F**, **Vicenzi A**, **Campani C**, **Moretti M**, **Giuggioli D**, **Vacchi C**, **Spinella A**, **Aschieri D**, **Mattioli AV**, **Fedele F**, **Baccarani A**, **Pinti M**, **Dei Cas A**, **Fantuzzi F**, **Bigdelu L**, **Pagnoni G**, **Darroudi S.** Hemoglobin-to-red cell distribution width ratio and vitamin D status as early predictors of cardiovascular risk in primary Sjögren's syndrome. *Life (Basel)* 16: 190, 2026. doi:10.3390/life16020190.
4. **Pagnoni G**, **Vicenzi A**, **Darroudi S**, **Maini A**, **Sbarra F**, **Marangi F**, **Loffi M**, **Nasi M**, **Pinti M**, **Selleri V**, **Baccarani A**, **Carnevale G**, **Lombardi CM**, **Aschieri D**, **Mattioli AV**, **Fedele F**, **Coppi F.** Adherence to exercise and functional rehabilitation programs in patients with cardiovascular diseases: barriers and strategies. *J Cardiovasc Dev Dis* 13: 8, 2025. doi:10.3390/jcdd13010008.
5. **Tolvaj M**, **Kovács A**, **Radu N**, **Cascella A**, **Muraru D**, **Lakatos B**, **Fábián A**, **Tokodi M**, **Tomaselli M**, **Gavazzoni M**, **Perelli F**, **Merkely B**, **Badano LP**, **Surkova E.** Significant disagreement between conventional parameters and 3D echocardiography-derived ejection fraction in the detection of right ventricular systolic dysfunction and its association with outcomes. *J Am Soc Echocardiogr* 37: 677–686, 2024. doi:10.1016/j.echo.2024.04.005.
6. **de Pinto M**, **Coppi F**, **Spinella A**, **Pagnoni G**, **Morgante V**, **Macripò P**, **Boschini M**, **Guerra AF**, **Tampieri F**, **Secchi O**, **Orlandi M**, **Amati G**, **Lumetti F**, **Sandri G**, **Rossi R**, **Boriani G**, **Mattioli AV**, **Ferri C**, **Giuggioli D.** The predictive role of the TAPSE/sPAP ratio for cardiovascular events and mortality in systemic sclerosis with pulmonary hypertension. *Front Cardiovasc Med* 11: 1430903, 2024. doi:10.3389/fcvm.2024.1430903.
7. **Humbert M**, **Kovacs G**, **Hoeper MM**, **Badagliacca R**, **Berger RMF**, **Brida M**, **Carlsen J**, **Coats AJS**, **Escribano-Subias P**, **Ferrari P**, **Ferreira DS**, **Ghofrani HA**, **Giannakoulas G**, **Kiely DG**, **Mayer E**, **Meszaros G**, **Nagavci B**, **Olsson KM**, **Pepke-Zaba J**, **Quint JK**, **Rådegran G**, **Simonneau G**, **Sitbon O**, **Tonia T**, **Toshner M**, **Vachiery JL**, **Vonk Noordegraaf A**, **Delcroix M**, **Rosenkranz S**; **ESC/ERS Scientific Document Group.** 2022 ESC/ERS guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Heart J* 43: 3618–3731, 2022 [Erratum in *Eur Heart J* 44: 1312, 2023]. doi:10.1093/eurheartj/ehac237.
8. **Vonk Noordegraaf A**, **Westerhof BE**, **Westerhof N.** The relationship between the right ventricle and its load in pulmonary hypertension. *J Am Coll Cardiol*. 69: 236–243, 2017. doi:10.1016/j.jacc.2016.10.047.
9. **Voigt J-U**, **Pedrizzetti G**, **Lysyansky P**, **Marwick TH**, **Houle H**, **Baumann R**, **Pedri S**, **Ito Y**, **Abe Y**, **Metz S**, **Song JH**, **Hamilton J**, **Sengupta PP**, **Kolias TJ**, **d'Hooge J**, **Aurigemma GP**, **Thomas JD**, **Badano LP.** Definitions for a common standard for 2D speckle tracking echocardiography: consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging. *Eur Heart J Cardiovasc Imaging* 16: 1–11, 2015. doi:10.1093/ehjci/jeu184.

Downloaded from journals.physiology.org/journal/ajpheart (2001:0B07:0A12:18C3:4BC6:8F10:3DB5:969C) on October 29, 2026.