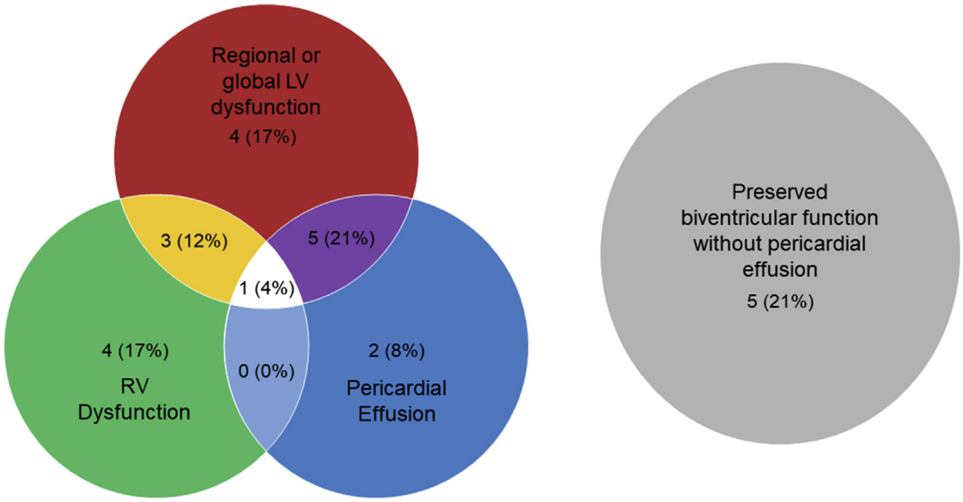

Figure 1 Venn diagram depicting the pattern distribution of echocardiographic findings in patients with COVID-19 with significant myocardial injury. *RV*, Right ventricular.

echocardiographic finding, which suggests that ischemia due to large- or small-vessel obstruction and prothrombotic state may be a common mechanism of injury.

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Tricuspid Longitudinal Annular Displacement for the Assessment of Right Ventricular Systolic Dysfunction during Prone Positioning in Patients with COVID-19

To the Editor:

During the coronavirus disease 2019 (COVID-19) pandemic, many patients have developed severe acute respiratory distress syndrome (ARDS), often requiring prone positioning. Despite "lung-protective" ventilation, the pulmonary vascular dysfunction associated with COVID-19-related ARDS[1] can lead to right ventricular (RV) dilatation and dysfunction, both associated with poor outcomes. RV global longitudinal strain (GLS) assessed on transthoracic echocardiography was recently found to predict mortality more accurately than RV fractional area change (FAC) in patients with COVID-19.[2] However, during prone positioning, the assessment of RV function using transthoracic echocardiography can be very challenging,[3] and transesophageal echocardiography is often necessary. To date, RV FAC is still considered the best parameter for assessing RV systolic function on transesophageal echocardiography,[4] but like RV GLS, it requires that the entire endocardium be clearly visible, which is sometimes difficult in the setting of acute cor pulmonale related to mechanical ventilation.

Tricuspid longitudinal annular displacement (TMAD) is an emerging bidimensional strain echocardiographic parameter, tracking tricuspid annular tissue motion toward the RV apex (Figure 1), allowing an objective quantitative assessment of RV systolic function.[5] TMAD is also angle independent, but its main advantage compared with RV GLS is that it is unaffected by endocardial definition.

Our objective was to assess the feasibility of TMAD and RV GLS and to evaluate their respective performance to diagnose RV dysfunction (defined as RV FAC $< 35\%$) during prone positioning for severe ARDS related to COVID-19. TMAD measurements were performed in the apical four-chamber view, as recommended. Three points were placed, and the software (QLAB CMQ; Philips Medical Systems, Andover, MA) automatically tracked and calculated TMAD at the

Conflicts of interest: None.

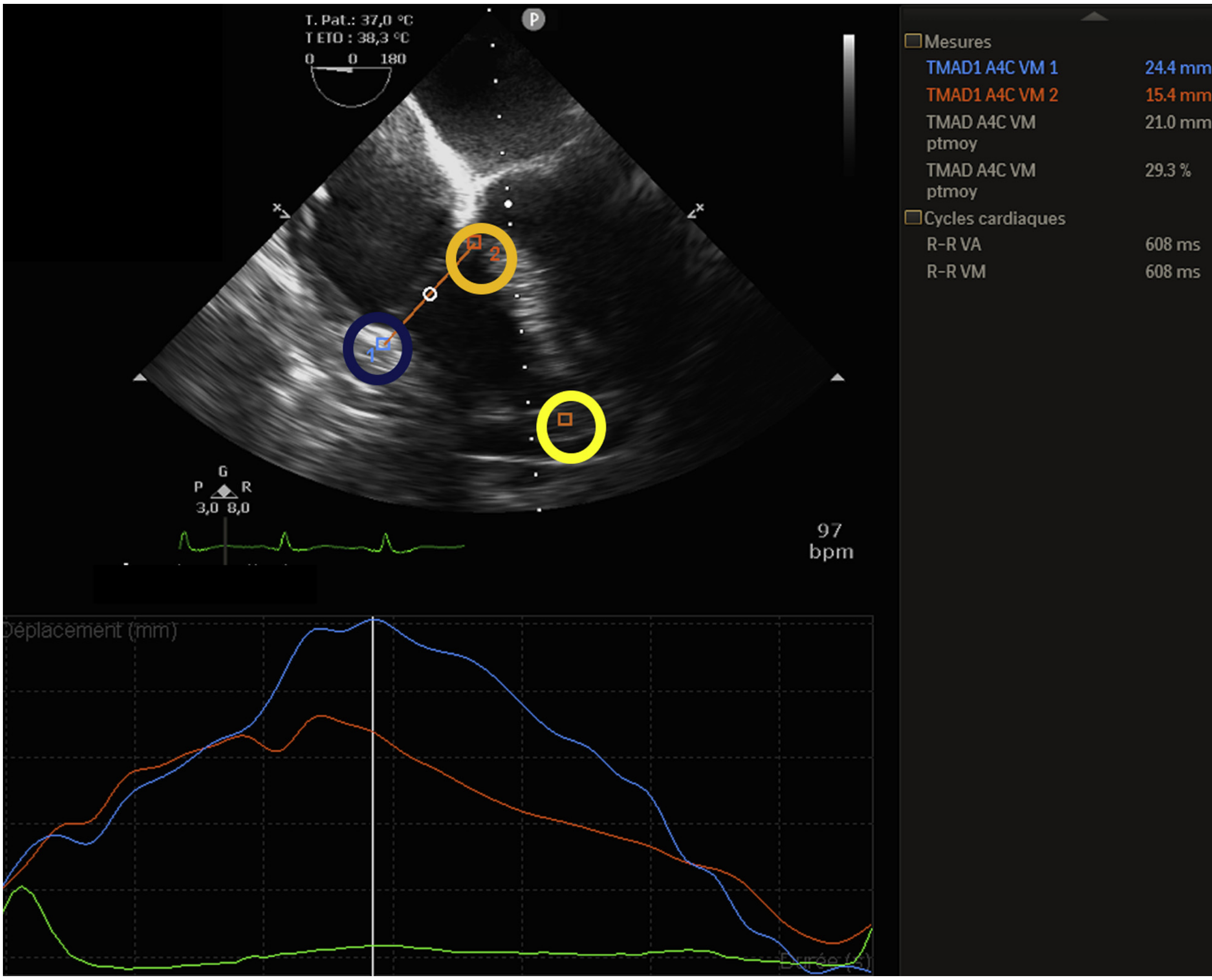

Figure 1 TMAD on transesophageal echocardiography. In a midesophageal four-chamber view, the user-defined anatomic landmarks lateral point (*blue circle*) and septal point (*orange circle*) were placed at the bottom of the RV free wall and the bottom of the interventricular septum, and another point was placed at the apex (*yellow circle*). $TMAD_{lat}$, TMAD at the at the interventricular septum, and RV longitudinal shortening (%) are displayed.

RV free wall ($TMAD_{lat}$) and at the interventricular septum. RV longitudinal shortening was also calculated.[5] This was an ancillary study of a cohort of critically ill patients with COVID-19 (ClinicalTrials.gov identifier NCT04354558).

During the COVID-19 outbreak, 54 patients requiring mechanical ventilation were admitted to our intensive care unit for COVID-19-related ARDS (diagnosed by reverse transcriptase polymerase chain reaction), and 17 (32%) needed prone positioning for severe hypoxia. Transesophageal echocardiography was feasible in prone positioning for the 17 patients, with no related side effects. RV FAC, TMAD, and RV GLS measurements were attainable in all patients. Ten patients (83%) presented moderate acute cor pulmonale under mechanical ventilation, and seven patients (41%) had RV dysfunction (RV FAC < 35%). Median $TMAD_{lat}$ was 23.5 mm (19.0 to 27.9 mm), median TMAD at the interventricular septum was 8.9 mm (7.0 to 11.0 mm), median RV longitudinal shortening was 28.1% (22.2% to 32.6%), median RV GLS was −24.7% (−22.6% to −28.5%), and median RV FAC was 43.6% (33.3% to 52.8%). $TMAD_{lat}$ had the higher area under the curve (0.88 [0.73 to 1.00; $P = .008$] vs only 0.66 [0.38 to 0.92; $P = .28$] for RV GLS) for identifying RV systolic dysfunction, with a cutoff value of 18.5 mm (sensitivity, 0.8; specificity, 0.7). Intraobserver reproducibility of $TMAD_{lat}$ was excellent (intraclass correlation coefficient = 0.98 [0.93 to 0.99]).

TMAD appears to be a feasible and reproducible strain parameter for assessing RV systolic function during prone positioning in ARDS related to COVID-19. Even if RV FAC and RV GLS were achievable in all patients, these measurements can be challenging in the setting of mechanical ventilation and prone positioning. Therefore, the use of a simple and effective angle-independent tool, such as TMAD, which is not affected by endocardial definition, may be of interest. Further larger studies investigating the prognostic impact of TMAD in patients with COVID-19 are mandatory.

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Transesophageal Echocardiography Remains Essential and Safe during Prone Ventilation for Hemodynamic Monitoring of Patients with COVID-19

We read with interest the letter by Giustiniano *et al.*,[1] who proposed a new approach for the echocardiographic assessment of patients with coronavirus disease 2019 (COVID-19) with acute respiratory distress syndrome (ARDS) during prone ventilation. Hemodynamic assessment using transthoracic echocardiography (TTE) is challenging in the prone position because acoustic windows are limited and difficult to obtain. Although the sole apical four-chamber view remains informative to evaluate central hemodynamics and identify ventricular dysfunction, it is intrinsically limited for the accurate identification of acute cor pulmonale (ACP), which affects about 20% of patients with ARDS.[2] In contrast, transesophageal echocardiography (TEE) maintains its full diagnostic capacity and can be used safely for hemodynamic assessment during prone ventilation.[3]

Using TEE, we monitored five patients ventilated for severe COVID-19-related ARDS who were deemed at risk for hemodynamic instability at the time of prone positioning. Initially, the transesophageal probe was introduced under direct laryngoscopic guidance to perform a comprehensive hemodynamic assessment in the supine position. Subsequently, the patient was turned to the prone position, with particular attention to preventing any inadvertent dislodgement of both the endotracheal tube and the transesophageal probe.[3] This allowed the assessment of potential hemodynamic consequences of body positioning due to abrupt changes in cardiac loading conditions and ventricular interactions. The transesophageal probe was removed in the presence of stable hemodynamics in the prone position. No complications were observed during or after transesophageal echocardiographic evaluations.

In 60% of these patients, image quality on TTE was suboptimal or poor in the semirecumbent supine position under high levels of positive end-expiratory pressure. ACP was depicted solely on TEE in one patient in the supine position. One hour after prone positioning, the eccentricity index measured in the transgastric short-axis view returned to normal, from 1.6 to 1.05. In another patient with severe hemodynamic instability at baseline, TTE was not contributory, while TEE depicted systolic anterior motion of the mitral valve associated with severe mitral regurgitation. Systolic anterior motion was ascribed to both hypovolemia and septal hypertrophy. A 1.5-L fluid loading resulted in reduction of the regurgitant volume, and both the systolic anterior motion and mitral regurgitation fully regressed in the prone position (Figure 1). The three remaining patients maintained a normal hemodynamic profile from the supine to the prone position during monitoring on TEE.

The short-axis view of the heart is essential for the diagnosis of ACP,[4] which is prognostic when severe,[2] because paradoxical septal motion is challenging to identify and the eccentricity index is not measurable in the four-chamber view. In addition, the greater diagnostic ability of TEE[4] remains operant in the prone position, as illustrated in our patient with dynamic severe mitral regurgitation. Finally, only TEE provides a constant window to the superior vena cava to assess preload responsiveness in ventilated patients,[5] even in the prone position.[3] Because assessment using TEE is more cumbersome to routinely perform than TTE, especially in the setting of COVID-19, TTE may be used to properly select those patients who require monitoring with TEE during prone ventilation.

In our experience, TEE is highly feasible, is safe, and allows unparalleled monitoring of hemodynamic changes induced by prone ventilation in patients with ARDS. Compared with TTE, only TEE provides short-axis images of the heart for the identification of ACP and maintains its full diagnostic capacity during prone ventilation.

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