Cardiac point-of-care ultrasound in hospitalized coronavirus disease-2019 patients: findings and association with outcome

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Keywords: coronavirus, coronavirus disease-2019, echocardiography, left ventricle, point-of-care ultrasound, right ventricle

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To the Editor

Coronavirus disease (COVID-19), caused by novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), rapidly spread worldwide becoming a pandemic.\textsuperscript{1,2} Whereas most clinical manifestations of COVID-19 are related to respiratory distress, cardiovascular involvement has been reported, showing association with worse outcome and higher mortality.\textsuperscript{3–5}

Given consistent limitations and risks for echocardiography in COVID-19, both American and European echocardiography societies released recommendations to limit systematic echocardiography examination to problem-tailored and time-limited examination, also known as ‘point-of-care ultrasound’ (POCUS).\textsuperscript{6,7} We aimed to describe cardiac POCUS findings in COVID-19 patients admitted to a tertiary Italian university hospital, stratified according to respiratory distress grade, and to assess the association of cardiac POCUS findings with outcome.

The names of members of the GECOVID-19 Study group are mentioned in the Acknowledgements section.

Methods

All laboratory-confirmed COVID-19 patients admitted to our hospital, San Martino Hospital, Genoa, Italy, between 1 March 2020 and 30 April 2020 who underwent cardiac POCUS during hospital stay were analysed. According to the respiratory distress degree,\textsuperscript{3} patients were classified into mild, moderate, and severe respiratory distress grade.

All methods were extensively described in Supplemental Digital Content S1, http://links.lww.com/JCM/A366.

Results

The final population included 138 patients. Table 1 depicts the patients’ characteristics and findings. POCUS findings are described in Fig. 1, and outcomes are described in Fig. 2, both stratified according to respiratory distress grade at time of POCUS execution.

At multivariate logistic regression analysis, left ventricular (LV) hypertrophy ($P = 0.030$) was significantly associated with severe respiratory distress and right ventricular (RV) dilatation ($P = 0.036$) was significantly associated with longer in-hospital stay. No cardiac POCUS parameter was associated with cardiovascular outcomes (all $P > 0.05$) (Table 2).

Comment

Our study has the following main findings: most common cardiac POCUS abnormalities in COVID-19 patients were LV hypertrophy, mild pericardial effusion and RV dilatation, with LV and RV systolic functions mostly preserved; LV hypertrophy was independently associated with severe respiratory distress; RV dilatation was independently associated with longer hospital stay; no cardiac POCUS parameter was associated with inhospital mortality.

Arterial hypertension, highly prevalent within our cohort (53.6%), is the most common cause for LV hypertrophy.\textsuperscript{9} Hypertensive heart disease is characterized by cardiac fibrosis, increased myocardial stiffness, microvascular dysfunction, abnormal ventricular–vascular interactions and progressive diastolic dysfunction.\textsuperscript{10}
Diastolic dysfunction was demonstrated as a major predictor of mortality in patients with sepsis and septic shock, and recent reports showed a higher degree of diastolic dysfunction associated with poorer prognosis in COVID-19 patients. Multiple extracardiac mechanisms may induce RV dilatation in COVID-19 patients: extensive lung damage, hypoxic vasoconstriction, excessive positive end-expiratory pressure, high-pressure mechanical ventilation, pulmonary vascular diseases, and pulmonary embolism. Whereas RV dilatation was a common finding, RV dysfunction was infrequent (5.1%) in our cohort. Although our results are in contrast to previous reports, conventional RV functional parameters (TAPSE, Tei index and

Table 1  Baseline clinical features, point-of-care ultrasound findings, and outcome

| Variable                                      | Respiratory distress grade |
|-----------------------------------------------|----------------------------|
| Overall (n = 138)                             | Mid (n = 38)               | Moderate (n = 35) | Severe (n = 65) |
| Age                                           | 65.5 (12.9)                | 69.3 (16.2)       | 67.1 (11.1)     | 62.5 (10.8) |
| Sex (male)                                    | 100 (72.5)                 | 21 (55.3)         | 24 (68.6)       | 55 (84.6)  |
| Caucasian                                     | 125 (90.6)                 | 34 (89.5)         | 30 (85.7)       | 61 (93.8)  |
| Hypertension                                  | 74 (53.6)                  | 21 (55.3)         | 22 (62.9)       | 31 (47.7)  |
| Diabetes                                      | 23 (16.7)                  | 7 (18.4)          | 9 (25.7)        | 7 (10.8)   |
| Respiratory disease                           | 23 (16.7)                  | 8 (21.1)          | 5 (14.3)        | 10 (15.4)  |
| Chronic kidney disease                       | 21 (15.2)                  | 7 (18.4)          | 10 (28.6)       | 4 (6.2)    |
| Inflammatory disease                          | 22 (15.9)                  | 4 (10.5)          | 11 (31.4)       | 7 (10.8)   |
| Ischemic heart disease                        | 21 (15.2)                  | 10 (26.3)         | 8 (22.9)        | 3 (4.6)    |
| Previous LV dysfunction                       | 10 (7.2)                   | 5 (13.2)          | 5 (14.3)        | 0 (0.0)    |
| Atrial fibrillation                           | 16 (11.6)                  | 10 (26.3)         | 4 (11.4)        | 2 (3.1)    |
| D-dimer (µg/l)                                | 2108.0 (1246.8–6914.8)     | 1424.00 (858.0–2688.3) | 1757.0 (1359.5–3619.5) | 4406.0 (1673.0–13553.0) |
| CRP (mg/l)                                    | 90.0 (36.0–177.0)          | 46.0 (11.8–73.9)  | 80.0 (91.4–143.0) | 136.0 (62.5–262.5) |
| Troponin (µg/l)                               | 0.02 (0.01–0.12)           | 0.01 (0.01–0.08)  | 0.01 (0.01–0.06) | 0.03 (0.01–0.15) |
| NT-proBNP (mg/l)                              | 674.0 (166.0–2036.0)       | 904.5 (221.0–2786.5) | 369.0 (114.3–2114.5) | 674.0 (168.0–1396.0) |
| LV dilatation                                 | 7 (5.1)                    | 2 (5.3)           | 5 (17.1)        | 3 (4.6)    |
| LV hypertrophy                                | 53 (38.4)                  | 8 (21.1)          | 15 (42.9)       | 30 (46.1)  |
| EF                                            | 120 (87.0)                 | 33 (86.8)         | 30 (85.7)       | 57 (87.7)  |
| Mild dysfunction                              | 12 (8.7)                   | 3 (7.9)           | 5 (14.3)        | 4 (6.2)    |
| Moderate dysfunction                          | 3 (2.2)                    | 1 (2.6)           | 0 (0.0)         | 2 (3.1)    |
| Severe dysfunction                            | 3 (2.2)                    | 1 (2.6)           | 1 (2.9)         | 1 (1.5)    |
| LV regional dysfunction                       | 17 (12.3)                  | 6 (15.8)          | 6 (17.1)        | 5 (7.7)    |
| Prophylaxis valve                             | 6 (4.3)                    | 1 (2.6)           | 2 (5.7)         | 3 (4.6)    |
| Valve disease                                 | 20 (14.5)                  | 6 (15.8)          | 5 (14.3)        | 9 (13.8)   |
| LA enlargement                                | 20 (14.5)                  | 9 (22.7)          | 6 (17.1)        | 5 (7.7)    |
| RV dilatation                                 | 37 (26.8)                  | 5 (13.2)          | 6 (17.1)        | 26 (40.0)  |
| RV dysfunction                                | 7 (5.1)                    | 1 (2.6)           | 1 (2.9)         | 5 (7.7)    |
| Tricuspid regurgitation                       | 14 (10.1)                  | 4 (10.5)          | 3 (8.5)         | 7 (10.7)   |
| Moderate                                     | 2 (1.4)                    | 0 (0)             | 1 (2.8)         | 1 (1.5)    |
| Augmented sPAP                                | 32 (23.1)                  | 9 (23.7)          | 5 (14.3)        | 18 (27.6)  |
| Pericardial effusion                          | 30 (23.6)                  | 13 (34.2)         | 12 (34.3)       | 25 (38.5)  |
| Mild                                         | 48 (35.6)                  | 13 (34.2)         | 12 (34.3)       | 23 (34.3)  |
| Moderate                                     | 2 (1.5)                    | 0 (0.0)           | 0 (0.0)         | 2 (3.1)    |
| Severe                                       | 0 (0.0)                    | 0 (0.0)           | 0 (0.0)         | 0 (0.0)    |
| Tamponade                                     | 0 (0.0)                    | 0 (0.0)           | 0 (0.0)         | 0 (0.0)    |
| Intracardiac thrombosis                      | 2 (1.5)                    | 0 (0.0)           | 0 (0.0)         | 2 (3.1)    |
| All-cause death                              | 37 (26.8)                  | 5 (13.2)          | 6 (17.1)        | 26 (40.0)  |
| Myocardial injury                            | 51 (37.0)                  | 10 (26.3)         | 11 (31.4)       | 30 (46.2)  |
| Pulmonary embolism                            | 37 (26.8)                  | 6 (15.8)          | 8 (22.9)        | 23 (35.4)  |
| Macro                                        | 22 (15.9)                  | 4 (10.5)          | 6 (17.1)        | 12 (18.5)  |
| Micro                                        | 15 (10.9)                  | 2 (5.3)           | 2 (5.7)         | 11 (16.9)  |
| Venous thromboembolism                       | 4 (2.9)                    | 0 (0.0)           | 1 (2.9)         | 3 (4.6)    |
| Thrombolysis                                 | 6 (4.3)                    | 0 (0.0)           | 0 (0.0)         | 6 (9.2)    |
| Myocardial infarction                         | 4 (2.9)                    | 1 (2.6)           | 1 (1.9)         | 2 (3.1)    |
| New onset LV dysfunction                     | 5 (3.6)                    | 0 (0.0)           | 0 (0.0)         | 5 (7.7)    |
| Myocarditis                                  | 15 (10.9)                  | 2 (5.3)           | 2 (5.7)         | 11 (16.9)  |
| Atrial                                       | 14 (10.1)                  | 2 (5.3)           | 2 (5.7)         | 10 (15.4)  |
| Ventricular                                  | 1 (0.7)                    | 0 (0.0)           | 0 (0.0)         | 1 (1.5)    |
| Myocarditis                                  | 1 (0.7)                    | 0 (0.0)           | 0 (0.0)         | 1 (1.5)    |
| Pulmonary embolism                            | 1 (0.7)                    | 0 (0.0)           | 0 (0.0)         | 0 (0.0)    |

All measures expressed as n (%), mean (SD) or median with IQR (quartile 1 to quartile 3). CRP, C-reactive protein; EF, ejection fraction; LV, left ventricular; NT-proBNP, N-terminal pro-B-type natriuretic peptide; POCUS, point-of-care ultrasound; RV, right ventricular; sPAP, systolic pulmonary artery pressure. Bold face reports significant p values (<0.05).

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Cardiac POCUS in hospitalized COVID-19 patients

**Fig. 1**

POCUS findings

- Severe RD
- Moderate RD
- Mild RD

- LV dilatation
- LV hypertrophy
- Reduced EF
- LV regional dysfunction
- Valve disease
- LA enlargement
- RV dilatation
- RV dysfunction
- Tricuspid regurgitation
- Augmented sPAP
- Pericardial effusion
- Intracardiac thrombosis

Point-of-care ultrasound findings according to respiratory distress grade. EF, ejection fraction; LA, left atrium; LV, left ventricle; RD, respiratory distress; RV, right ventricle; sPAP, systolic pulmonary artery pressure.

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**Fig. 2**

Outcomes

- Severe RD
- Moderate RD
- Mild RD

- All-cause in-hospital death
- Myocardial injury
- Pulmonary embolism
- Venous thromboembolism
- Myocardial infarction
- New onset LV dysfunction
- Arrhythmia
- Pericarditis
- Myocarditis

Outcomes according to respiratory distress grade. LV, left ventricle; RD, respiratory distress.
RV S’ velocity) resulted within normal ranges both by Szekely et al.\textsuperscript{13} and Li et al.\textsuperscript{14} for which RV dysfunction was determined by short pulmonary acceleration time and reduced RV strain, respectively. These results suggest that RV dysfunction in COVID-19 patients is generally modest and that conventional RV function parameters may be insufficient for risk stratification in this population.

Left ventricle dysfunction was uncommon (13%) and the vast majority of patients had only mild LV dysfunction (66.6%), similar to D’Andrea et al.’s\textsuperscript{15} findings. Moreover, whereas myocardial injury was frequent and independently associated with in-hospital mortality, most patients had minimal troponin I increase.

Limitations to our study are principally related to the particular situation in which we were operating: the retrospective design, the potential selection bias as only selected COVID-19 patients underwent cardiac POCUS, the lack of prior echocardiographic data for comparison, the lack of systematic diastole assessment, the small sample size, and the large confidence intervals of the estimates.

Acknowledgements

GECOV\textsuperscript{12}D-19 Study group: Anna Alessandri; Marco Camera; Emanuele Delfino; Andrea De Maria; Chiara Dentone; Antonio Di Biaggio; Ferdinando Dodi; Antonio Ferrazin; Giovanni Mazzarello; Malgorzata Mikulska; Laura Nicolini; Federica Toscanini; Daniele Roberto Giacobbe; Antonio Vena; Lucia Taramasso; Elisa Balleto; Federica Fortunato; Eva Schenone; Nirmala Rossetti; Federico Baldi; Marco Beretti; Federica Biondo; Silvia Dettori; Laura Labate; Laura Magnasco; Michele Mirabella; Rachele Pinzino; Chiara russo; Giovanni Sarteschi; Chiara sepulcri; Stefania Tutino (Clinica di Malattie Infettive); Roberto Pontremoli; Valentina Beccati; Salvatore Casciaro; Massimo Casu; Francesco Gavaudan; Maria Ghinatti; Elisa Gualco; Giovanna Leoncini; Paola Pitto; Kassem salam (Clinica di Medicina interna 2); Angelo Gratarola; Mattia Bixio; Annalisa Amelia; Andrea Balestra; Paola Ballarino; Nicholas Bardi; Roberto Boccafogli; Francesca Caserza; Elisa Calzolari; Marta Castelli; Elisabetta Cenni; Paolo Cortese; Giuseppe Cuttone; Sara Feltrin; Stefano Giovannozzo; Patrizia Giuntini; Letizia Natale; Davide Orsi; Matteo Pastorino; Tommaso Perazzo; Fabio Pescetelli; Federico Schenone; Maria Grazia Serra; Marco Sottano (Anestesia e Rianimazione; Emergenza Covid padiglione 64 ‘Fagiolone’); Roberto Tallone; Massimo Amelotti; Marie Jeanne Majabò; Massimo Merlini; Federica Perazzo (Cure intermedie); Nidal Ahamd; Paolo Barbera; Marta Bovio; Paola

| Variable                      | OR     | 95% CI      | P value | OR     | 95% CI      | P value |
|-------------------------------|--------|-------------|---------|--------|-------------|---------|
| Severe respiratory distress   |        |             |         |        |             |         |
| Age                           | 0.96   | 0.94–0.99   | 0.010   | 0.96   | 0.92–0.99   | 0.041   |
| Sex (male)                    | 3.42   | 1.54–8.10   | 0.003   | –      | –           | –       |
| CRP                           | 1.01   | 1.01–1.02   | <0.001  | 1.02   | 1.01–1.04   | <0.001  |
| Myocardial injury             | 8.20   | 3.69–19.66  | <0.001  | 2.49   | 1.77–9.19   | 0.024   |
| Previous ischemic heart disease | 0.15  | 0.03–0.47   | 0.003   | 0.35   | 0.13–0.91   | 0.012   |
| Atrial fibrillation           | 0.13   | 0.02–0.51   | 0.010   | 0.18   | 0.06–0.52   | 0.095   |
| RV dilatation                 | 3.76   | 1.71–8.74   | 0.001   | –      | –           | –       |
| LV hypertrophy                | 3.18   | 1.38–8.09   | 0.010   | 3.59   | 1.20–12.40  | 0.030   |
| Length of hospital stay       |        |             |         |        |             |         |
| Age                           | 1.03   | 1.00–1.05   | 0.027   | 1.03   | 1.01–1.12   | 0.038   |
| Sex (male)                    | 1.34   | 0.63–2.86   | 0.447   | –      | –           | –       |
| Respiratory failure of severe grade | 2.26 | 1.14–4.56 | 0.020  | 2.83  | 1.22–6.79  | 0.027   |
| D-Dimer                       | 1.01   | 1.01–1.02   | 0.024   | –      | –           | –       |
| Troponin elevation            | 3.65   | 1.59–8.23   | 0.004   | –      | –           | –       |
| RV dilatation                 | 5.22   | 3.14–27.05  | 0.038   | 2.80   | 1.43–24.06  | 0.036   |
| LV regional dysfunction       |        |             |         |        |             |         |
|                              | 5.23   | 1.82–8.52   | 0.038   | –      | –           | –       |

Ci, confidence interval; CRP, C-reactive protein; HR, hazard ratio; LV, left ventricle; OR, odds ratio; RV, right ventricle. Bold face reports significant p values (<0.05).
Conflicts of interest
There are no conflicts of interest.

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