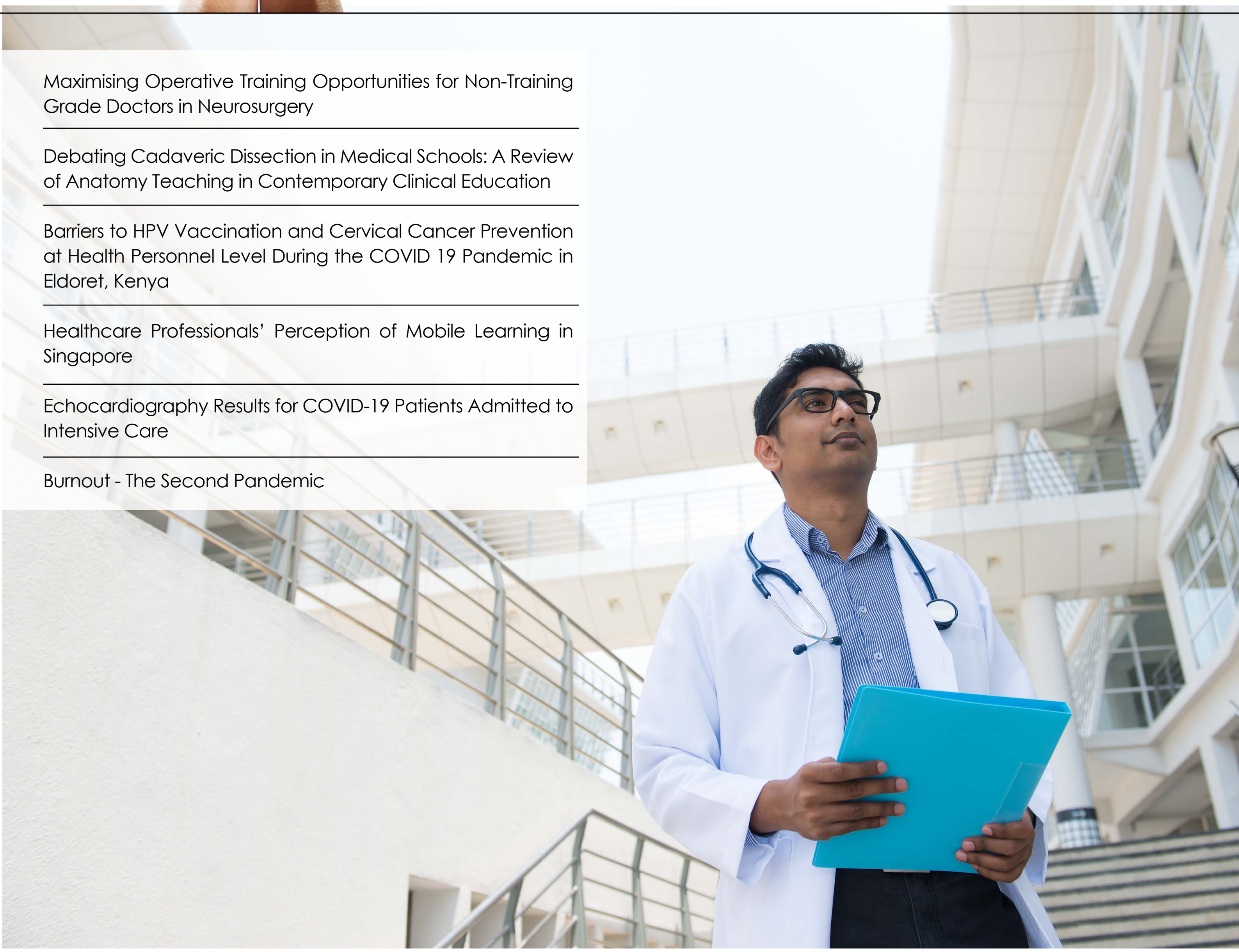
Echocardiography Results for COVID-19 Patients Admitted to Intensive Care

Tolson OW, Ashok Raj S

WJMER

World Journal of Medical Education and Research
An Official Publication of the Education and Research Division of Doctors Academy



DOCTORS ACADEMY
BETTER EDUCATION. BETTER HEALTH.

ISSN 2052-1715

World Journal of Medical Education and Research:
An Official Publication of the Education and Research Division of Doctors Academy

Clinical Research
DAUIN 20220201

Echocardiography Results for COVID-19 Patients Admitted to Intensive Care

Tolson OW, Ashok Raj S

Institution
Croydon University Hospital, 530 London Road, CR7 7YE

WJMER, Vol 28: Issue 1, 2022

Abstract
The coronavirus disease 2019 (COVID-19) pandemic has led to a significant number of critical care admissions worldwide, and the cardiac complications of severe disease are increasingly recognised. We reviewed the bedside transthoracic echocardiogram results of all patients admitted to our intensive care facility between March and May 2020.
All patients admitted to our intensive care unit who received an echocardiogram were included in the study. Scans were performed by experienced sonographers according to the guidelines of the British Society of Echocardiography. Demographic characteristics, ventilation settings during the echocardiogram, and patient outcomes, such as the need for mechanical ventilation and survival data, were also recorded.
Of the 40 patients included (mean age 58.1±9.3, 31 male), significant left ventricle (LV) dysfunction was only seen in 7.5% of patients (n=3). However, right ventricle (RV) dysfunction was highly prevalent and observed in 55.0% (n=22), with RV dilation seen in 33% (n=12). RV systolic pressures consistent with at least an intermediate probability of pulmonary hypertension were observed in 47.5% (n=19).
RV dysfunction and raised pulmonary pressures are common in COVID-19 patients in intensive care, with relative LV sparing. Intensivists managing coronavirus patients should obtain prompt echocardiograms to help identify right-sided dysfunction early and tailor management to protect the RV.

Key Words
COVID-19; Intensive Care Unit; RV Dysfunction

Corresponding Author:
Dr Oliver W Tolson; E-mail: oliver.tolson@nhs.net

Introduction

The pandemic caused by coronavirus disease 2019 (COVID-19) has led to a large number of critical care admissions worldwide. Whilst severe respiratory failure is by far the most common reason for admission to a critical care facility, as the pandemic has evolved, clinicians' understanding of the multisystemic nature of severe COVID-19 has become increasingly apparent.

The cardiac manifestations of COVID-19 are varied. Of hospitalised patients, a quarter have raised troponin assays on admission, with worse associated outcomes.[1] Early case reports detailed young patients developing a phenotype of illness similar to viral myocarditis, with preceding gastrointestinal symptoms followed by severe left sided ventricular failure and inotrop dependence. Other reported manifestations include ischaemia, arrythmias and, rarely, pericardial disease including tamponade.

However, the cardiac phenomena probably most familiar to intensive care physicians are the twin problems of raised pulmonary pressures and RV failure. Such is the prevalence amongst COVID-19 patients that recognition and treatment of these issue have evolved significantly. Echocardiography is now a routine investigation for those with critical care COVID-19. Treatments to reduce pulmonary vascular resistance such as sildenafil and prostanoids are now commonplace and the impact on the right ventricle (RV) from PEEP and vasopressors is increasing considered.

Despite this the prevalence and pattern of cardiac abnormalities in intensive care patients are not well documented. Studies in hospitalised COVID-19 patients have found that RV failure is common and associated with increased mortality.[2] Fewer studies have been conducted in the critical care setting. Given the greater severity of illness and use of mechanical ventilation, it is likely that abnormalities

World Journal of Medical Education and Research:
An Official Publication of the Education and Research Division of Doctors Academy

are higher in this cohort of patients. One study of 52 intensive care patients found significant abnormalities during echocardiography.[3] However, given the small size of studies in this area, further research clarifying the extent and degree of cardiac dysfunction is warranted.

The aim of our study was to retrospectively review the echocardiogram results of patients admitted to Croydon's Intensive Care Unit during the first wave (between March and May 2020).

Methods

All patients admitted to the ICU (and its satellite units) with a positive SARS-CoV-2 polymerase chain reaction test (from a nasopharyngeal swab) between March 2020 and May 2020 were included in the study. Details of patients were obtained from the database used to inform the Intensive Care National Audit & Research Centre (ICNARC) audits. Patients were included in the study if they had a transthoracic echocardiogram (TTE) performed during their Intensive Care Unit (ICU) admission.

All TTEs were performed according to the British Society of Echocardiography (BSE) COVID-19 guidelines, with Level 1 scans performed. The scans were performed by a group of experienced BSE-accredited sonographers who were equipped with full personal protective equipment (PPE) including visors, FFP masks, gloves, and gowns. All scans were performed in the supine position. Left ventricular ejection fraction (LVEF) was calculated using the biplane Simpson's method. Echocardiographic assessment was performed according to the minimum data set for BSE scans.

In addition, electronic medical records were accessed and data extracted from them. Details obtained included basic demographic data, BMI, ethnicity, and comorbidities. Patient outcomes, such as the need for mechanical ventilation or filtration, as well as survival and discharge from the ICU at 28 days, were recorded. The hospital database was also accessed to explore whether patients had had previous echocardiograms prior to their admission. Ventilation details were also obtained from the records, where they were updated hourly.

The study was ethically approved by the Health Research Authority (REC: 21/HRA/2010), and informed consent was not considered necessary as the data had already been collected as part of patient care.

Statistics

Data were reported as mean (+-SD), unless nonparametric in which case they were expressed as median (+- IQR). Proportions were compared using the Chi-squared test (Fisher's exact), and values in two groups were compared using the Student's t-test, with statistical significance set as $p<0.05$ (two-sided value).

Results

Seventy-three patients were admitted to the unit over the observed period, and their clinical characteristics are summarised in Table 1. Of these patients, 40 received an echocardiogram during their intensive care admission (mean age 58.1±9.3, 31 male).

Patients who did not receive an echocardiogram during their admission were of similar age and BMI to those who did. Pre-existing comorbidities were common in both groups, with hypertension and obesity being the most prevalent. Significant differences were seen in the outcomes amongst the two groups, particularly in regards to mortality. Patients who did not receive an echocardiogram were less likely to survive ICU admission ($p=0.04$), and the time between ICU admission and death was significantly shorter ($p<0.0001$).

Table 1: *Characteristics of the First Wave COVID-19 Cohort*

Characteristic	Echo in ICU	No echo in ICU
Demographics		
Number (n=)	40	33
Age (years) (mean, (±SD)	58.1 (±9.3)	58.4 (±9.4)
BMI (kg/m^2)	30.1 (±5.2)	33.2 (±8.9)
Co-morbidities		
No co-morbidity	5 (12.5%)	2 (6.1%)
HTN	20 (50.0%)	19 (57.6%)
DM	13 (32.5%)	15 (45.5%)
Obesity	17 (42.5%)	18 (54.5%)
CKD	3 (7.5%)	0 (0%)
IHD	3 (7.5%)	0 (0%)
COPD	1 (2.5%)	0 (0%)
Outcomes		
Mechanically ventilated	39 (97.5%)	33 (100%)
Renal replacement therapy	31 (77.5%)	12 (36.4%)
Survived 28 days	16 (40.0%)	6 (18.2%)
Survived ICU admission	17 (42.5%)	6 (18.2%)
Days from ICU admission to death (median, ±IQR)	16.0 (±15.0)	5.0 (±4.0)
Discharged 28 days	6 (15.0%)	4 (12.1%)

BMI: Body Mass Index; HTN: Hypertension; CKD: Chronic Kidney Disease; IHD: Ischaemic Heart Disease; COPD: Chronic Obstructive Pulmonary Disease

Echocardiography data for the cohort are shown in Table 2. The majority of patients were invasively ventilated at the time of echocardiography (n=37, 92.5%).

Left ventricle

Overall, the majority of patients in the study did not have observable LV dysfunction. Significant LV dysfunction (severe or moderate) was seen in only three (7.5%) of our patients. Furthermore, LV regional wall motion abnormalities were rare and seen only in a single patient (2.5%).

Table 2: *Echocardiogram Results of COVID-19 Cohort*

Characteristic	Number	Percentage
Left ventricle		
LV impairment		
Normal (LVEF≥55%)	35	87.5%
Borderline (LVEF50-<55%)	2	5.0%
Moderate (LVEF35-≤50%)	2	5.0%
Severe (LVEF≤35%)	1	2.5%
Regional wall motion abnormalities	1	2.5%
Right ventricle		
RV dilation	12	30.0%
RV dysfunction	22	55.0%
TAPSE		
Mean TAPSE (±SD)	17.2 mm (±3.7)	
TAPSE <17mm	9	22.5%
RV systolic pressure (from TR max)		
Mean RSVP (±SD)	35.4 mmHg (±15.0)	
No TR jet	6	15.0%
Low RVSP/no TR jet (TRmax ≤ 2.8m/s or ≤31.4mmHg)	15	37.5%
Medium RVSP (TRmax 2.8-≤3.4m/s or 31.4-≤46.2 mmHg)	10	25%
High RVSP (TRmax >3.4m/s or >46.2mmHg)	9	22.5%
Other		
Pericardial effusion	1	2.5%
LV: Left Ventricle; RV: Right Ventricle; TAPSE: Tricuspid Annular Plane Excursion; TR: Tricuspid Regurgitation; RVSP: Right Ventricular Systolic Pressure		

Right Ventricle

RV abnormalities were highly prevalent in the study. Approximately 30% (n=12) of patients were observed to have a dilated RV on their initial echocardiogram. RV dysfunction was observed over half of the cohort (n=22, 55.0%). The high prevalence of RV dysfunction was also illustrated by the Tricuspid Annular Plane Excursion (TAPSE) findings, an established marker of RV systolic function. The mean TAPSE was only 17.2mm, with values less than 17mm signifying RV impairment.

RV pressures were also elevated in the cohort. RV pressures were calculated using the modified Bernouli equation to relate the maximum velocity of the TR jet to the pressure gradient in the RV.[4] The gold standard diagnosis of pulmonary hypertension is via right-heart catheter, but echocardiography provides a useful noninvasive marker of the likelihood of raised pulmonary pressures.[5]

The mean RVSP was 35.4mmHg. A total of 47.5% of patients had estimated pressures of greater suggesting at least an intermediate risk of pulmonary hypertension (TRmax >2.8m/s, RSVP >31.4mmHg). Nine of the 40 patients (22.5%) had observable RV pressures consistent with a high probability of pulmonary hypertension (TRmax >3.4m/s, RVSP >46.2mmHg).

Associations

RV dysfunction was not associated with lower survival rates (p=0.35) or reduced survival time on intensive care (p=0.49) in the study.

Similarly, elevated RVSPs were not associated with lower intensive care survival (>46.2mmHg, p=0.16; >31.4mmHg, p=0.99). No correlations were observed between RVSP values and PEEP (p=0.65, r=0.09), age (p=0.30, r=0.28) or BMI (p=0.58, r=0.10).

Discussion

The results of this simple study largely confirm what clinicians have already surmised from experienced gained working in critical care units caring for COVID-19 patients.

First, the burden of COVID-19 critical illness appears to be minimal on LV for the majority of patients. Our study illustrated that a relatively small proportion of patients had moderate to severe LV impairment as measured by ejection fraction. There are, of course, multiple caveats to this finding in our study. The concomitant use of vasopressors and inotropes was not measured in the study and, given that most patients would have been on at least noradrenaline infusions, this may have augmented the LV ejection fraction. It is worth pointing out this is a common issue experienced during critical care echocardiography, but it still certainly suggests significant LV impairment is only seen in a minority of patients.

Conversely, the impact on the RV is significant and highly prevalent. Features in keeping with elevated RV pressures were seen in almost half of our patients, with a quarter automatically having a high probability of pulmonary hypertension based on their RVSP values alone. The issues, however, with echocardiographic RV pressure measurement are myriad. RVSP measurement relies on obtaining the maximum velocity of the tricuspid regurgitant main jet (TRmax), and this value is subsequently squared and then multiplied, significantly enhancing the capacity for error. Furthermore, the association between TRmax and RVSP with free-flowing TR is poor. An absent TR jet does not even exclude raisedpressures.[4] Beyond this, the potential for confounders preventing the ascertainment of true RSVP values in critical care is huge. Varying driving pressures, positive-end expiratory pressures (PEEP), and multiagent vasopressor or inotrope use will undoubtedly influence RVSP. Furthermore, the mode of mechanical ventilation is likely to be a significant factor affecting RVSP, and there will be intrathoracic pressures differences between fully paralysed, mandatory-ventilated patients, and those with positive pressure-assisted spontaneous triggered breathing, even for the equivalent driving pressures and PEEPs.

However, while RVSP values obtained from echocardiography must be treated with caution, they still hold significant value in this population. The definitive investigation for pulmonary hypertension - pulmonary artery catheters (PAC) - have largely fallen out of favour in UK ICUs due to their high complication rate and a lack of evidence they improve patient care, even in units familiar them.[6] Notwithstanding the overall move away from PACs in critical care, their widespread use during the pandemic is clearly not feasible or desirable. Thus, for all its flaws, echocardiography remains the most useful modality in assessing the prevalence of pulmonary hypertension in the COVID-19 critical care cohort, and our study shows it highly prevalent.

Furthermore, this study also illustrates that RV dysfunction is also very common, seen in 55% of our patients. Whilst this represents a significant percentage of patients, the true proportion may in fact be higher. Echocardiograms were only performed in 40 of the 73 patients and, in large part, this was due to the fact that these patients died early in their admission before intensive care echocardiography was performed and spent many hours proned. Thus, it is probable the true burden of RV dysfunction may be somewhat higher.

It is worth highlighting that the number of patients from this cohort who did not have an echocardiogram is a significant limitation of this study. The retrospective nature of the project may have also led to a lack of consistency in the protocol used to obtain the images. An important additional point is that, as a single centre study with a disproportionately comorbid population, our findings may not be fully representative of ICU patients with COVID-19 nationwide. Overall, despite its limitations, this study has clearly demonstrated that RV dysfunction and pulmonary hypertension are extremely common features of COVID-19 critical illness, which is consistent with previous studies.[3]

In itself, recognition that around half of these patients have RV dysfunction and/or pulmonary hypertension is of huge clinical importance. A comprehensive discussion about management of right heart failure in critical care is beyond the scope of this article, but what it does suggest is there is an important subset of COVID-19 patients for whom concern for the RV should be at the very centre of their care. On the most basic level, this should involve close monitoring of central venous pressure (CVP) trends, an accessible marker of RV preload. The process of PEEP titration should not solely focus on oxygenation and recruitment but consider the impact on RV, with a precipitous CVP rise in this context likely reflecting the right heart's inability to deal with this additional afterload. Furthermore, the choice of vasopressor agent should reflect a strategy designed to minimise any increase in pulmonary vascular resistance (PVR) whilst preserving perfusion pressures, with the early introduction of vasopressin, use of phosphodiesterase inhibitors and reasonable limits on noradrenaline where possible. It is crucial to recognise that progressive multi-organ dysfunction (rising lactates, oligo-anuria and hepatic dysfunction) in the context of a known failing RV may be far worsened by liberal fluid administration and increasing noradrenaline. Alternatively, aggressive fluid removal and reducing pulmonary pressures may provide a solution to this notorious 'cycle of death'. RV failure in critical illness is extremely challenging to treat but the path towards improving its treatment, and better patient outcomes most likely starts with prompt recognition of the problem.

References

1. Tersalvi G, Vicenzi M, Calabretta D, Biasco L, Pedrazzini G, Winterton D. Elevated troponin in patients with coronavirus disease 2019: possible mechanisms. Journal of cardiac failure. 2020 Jun 1;26(6):470-5.
2. Szekely Y, Lichter Y, Taieb P, Banai A, Hochstadt A, Merdler I, Gal Oz A, Rothschild E, Baruch G, Peri Y, Arbel Y. Spectrum of cardiac manifestations in COVID-19: a systematic echocardiographic study. Circulation. 2020 Jul 28;142(4):342-53.
3. Jain R, Salinas PD, Kroboth S, Kaminski A, Roemer S, Moreno AC, Khandheria BK. Comprehensive Echocardiographic Findings in Critically Ill COVID-19 Patients with or Without Prior Cardiac Disease. Journal of patient-centered research and reviews. 2021;8 (1):68.
4. Zaidi A, Knight DS, Augustine DX, Harkness A, Oxborough D, Pearce K, Ring L, Robinson S, Stout M, Willis J. Education Committee of the British Society of Echocardiography: Echocardiographic assessment of the right heart in adults: A practical guideline from the British Society of Echocardiography. Echo Res Pract. 2020; 7:G19-41.
5. Augustine DX, Coates-Bradshaw LD, Willis J, Harkness A, Ring L, Grapsa J, Coghlan G, Kaye N, Oxborough D, Robinson S, Sandoval J. Echocardiographic assessment of pulmonary hypertension: a guideline protocol from the British Society of Echocardiography. Echo research and practice. 2018 Sep 1;5(3):G11-24.
6. Harvey S, Harrison DA, Singer M, Ashcroft J, Jones CM, Elbourne D, Brampton W, Williams D, Young D, Rowan K. Assessment of the clinical effectiveness of pulmonary artery catheters in management of patients in intensive care (PAC-Man): a randomised controlled trial. The Lancet. 2005 Aug 6;366 (9484):472-7.

The World Journal of Medical Education & Research (WJMER) is the online publication of the Doctors Academy Group of Educational Establishments. It aims to promote academia and research amongst all members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from all parts of the world. The journal intends to encourage the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting-edge technology and those who need to innovate within their resource constraints. It is our hope that this interaction will help develop medical knowledge & enhance the possibility of providing optimal clinical care in different settings all over the world.

WJMER

World Journal of Medical Education and Research

An Official Publication of the Education and Research Division of Doctors Academy

9 789380 573830