Impact of the COVID Pandemic on Quality Measures in a Pediatric Echocardiography Lab

Anna-Claire Marrone¹, Gemma Morrow², Michael Kelleman¹, Joan Lipinski³, William Border⁴, and Ritu Sachdeva¹

¹Emory University School of Medicine

²Children's Health Care of Atlanta

³Division of Cardiology, Children's Healthcare of Atlanta

⁴Children's Healthcare of Atlanta

October 4, 2021

Abstract

Background: The risks for exposure to suspected and confirmed COVID patients during transthoracic echocardiograms (TTE) led us to endorse an abbreviated scanning protocol. We sought to determine whether this impacted the TTE quality measures that were being followed in our lab prior to the pandemic. Methods: Data were collected retrospectively for four quality measures reported quarterly in our lab: Diagnostic error rate, Appropriateness of initial outpatient TTE orders and American College of Cardiology Initial TTE Image Quality Metric (IQM) and Comprehensive Exam Metric (CEM). These measures were compared between two similar quarters in pre-COVID (2019) and COVID era (2020) for non-COVID patients. Additionally, IQM and CEM of 40 TTEs in COVID patients were compared with those of non-COVID patients. Results: The IQM and CEM scored significantly less in COVID patients compared to non-COVID patients ($p < 0.001$ for both). Systemic and pulmonary veins, pulmonary arteries and arch were not adequately evaluated in COVID patients. In non-COVID patients, there were no significant differences in the IQM and diagnostic error rate but improvement in CEM and appropriateness of TTE orders from 2019 to 2020. There was no significant change in TTEs ordered for Rarely Appropriate indications, but the proportion of those ordered for syncope, palpitations and arrhythmias increased in 2020 compared to 2019. Conclusion: Though the diagnostic error rate did not change during the pandemic and the proportion of TTEs ordered for appropriate indications increased, the imaging quality in COVID patients was significantly compromised, especially for systemic and pulmonary veins, pulmonary arteries, and arch.

Impact of the COVID Pandemic on Quality Measures in a Pediatric Echocardiography Lab

Anna-Claire Marrone, MD¹

Gemma Morrow, RDCS¹

Michael S Kelleman, MSPH²

Joan Lipinski, RDCS, MHS¹

William Border MBChB, MPH¹

Ritu Sachdeva, MBBS¹

^a Division of Cardiology, Children's Healthcare of Atlanta, Atlanta, GA, USA.

^b Department of Biostatistics, Emory University, Atlanta, GA, USA

Address for correspondence:

Anna-Claire Marrone MD
Emory University School of Medicine
1405 Clifton Road
Atlanta, GA 30322
Phone: 716.713.7015
Fax: 770.488.9481
Email: marronea@kidsheart.com

Brief Title: Echo Quality in the COVID Pandemic

Disclosures: The authors do not have any relationships relevant to the content of this paper to disclose. All authors have approved the final version of the article.

Abstract

Background: The risks for exposure to suspected and confirmed COVID patients during transthoracic echocardiograms (TTE) led us to endorse an abbreviated scanning protocol. We sought to determine whether this impacted the TTE quality measures that were being followed in our lab prior to the pandemic.

Methods: Data were collected retrospectively for four quality measures reported quarterly in our lab: Diagnostic error rate, Appropriateness of initial outpatient TTE orders and American College of Cardiology Initial TTE Image Quality Metric (IQM) and Comprehensive Exam Metric (CEM). These measures were compared between two similar quarters in pre-COVID (2019) and COVID era (2020) for non-COVID patients. Additionally, IQM and CEM of 40 TTEs in COVID patients were compared with those of non-COVID patients.

Results: The IQM and CEM scored significantly less in COVID patients compared to non-COVID patients ($p < 0.001$ for both). Systemic and pulmonary veins, pulmonary arteries and arch were not adequately evaluated in COVID patients. In non-COVID patients, there were no significant differences in the IQM and diagnostic error rate but improvement in CEM and appropriateness of TTE orders from 2019 to 2020. There was no significant change in TTEs ordered for Rarely Appropriate indications, but the proportion of those ordered for syncope, palpitations and arrhythmias increased in 2020 compared to 2019.

Conclusion: Though the diagnostic error rate did not change during the pandemic and the proportion of TTEs ordered for appropriate indications increased, the imaging quality in COVID patients was significantly compromised, especially for systemic and pulmonary veins, pulmonary arteries, and arch.

Key Words: Transthoracic echocardiography, quality metrics, appropriate use criteria, COVID

Introduction :

Early during the coronavirus diseases (COVID) pandemic, the American Society of Echocardiography made recommendations for performing transthoracic echocardiograms (TTE) in pediatric patients that had suspected or confirmed COVID infection.(1) The guidelines emphasized the need to minimize the duration of exposure to these patients, performing problem-focused studies, paying attention to the established Appropriate Use Criteria for initial and follow-up examinations when applicable, and maintaining quality of images during the scans.(1-3) These guidelines led us to adopt a more focused and abbreviated protocol for TTEs on patients with confirmed or suspected COVID. However, the impact of these changes on various components of quality of TTEs remains unknown. In our echocardiography lab, we aim at performing a comprehensive TTE examination during the initial evaluation and follow the standards defined by the American Society of Echocardiography (4,5) and the American College of Cardiology Quality Network cardiovascular imaging metrics(6). In addition, the 2014 Appropriate use Criteria for Initial Outpatient evaluation is integrated with our electronic TTE ordering system since 2017.(7)

The purpose of this study was to determine the impact of changes made during COVID pandemic on the TTE imaging quality, comprehensiveness, diagnostic error rate and appropriateness of TTE orders in patients with and without COVID infection.

Methods :

The study was approved by the Institutional Review Board of Children’s Healthcare of Atlanta. Data were retrospectively collected for four quality measures that were reported on a quarterly basis in our lab prior to the pandemic: 1) diagnostic error rate based on the number of major diagnostic errors on TTE for all patients that undergo cardiac surgery; 2) appropriateness of indication for initial outpatient TTE evaluation based on the 2014 Appropriate Use Criteria document (6), which has been integrated into the electronic health system at our center since May 2017 and incorporated into feedback for physicians on the appropriateness of TTE orders(7); 3) initial TTE Image Quality Metric (IQM) and 4) Comprehensive Echocardiographic Exam (CEM).(6) IQM and CEM have been defined by the Quality Network of the American College of Cardiology and were adopted by our center in Jan 2019. For IQM and CEM we evaluate 20 randomly selected TTEs performed on patients with structurally normal hearts during each quarter. The components of IQM scoring are comprised of image orientation, 2D imaging, color flow imaging and spectral Doppler display, with a maximum total score of 23. CEM scoring is based on imaging of vessels, valves, ventricles, veins, atria and situs, with a maximum total score of 30. TTEs performed by trainees were excluded.

All four quality measures were compared between two similar quarters (April to June, and July to September) in pre-COVID (2019) and COVID era (2020). Additionally, IQM and CEM of 40 randomly selected TTEs in patients with suspected or confirmed COVID were compared with those of non-COVID patients during the same timeframe. Records were reviewed to look for any missed echocardiographic findings if a follow-up TTE was performed on these patients. The location in which the TTEs were performed in patients with suspected or confirmed COVID was also recorded.

Statistical Analyses

Statistical analyses were performed using SAS software version 9.4 (SAS Institute, Cary, North Carolina), and statistical significance was assessed at the 0.05 level. Normality of continuous variables was assessed using the histogram, normal probability plots and Anderson-Darling test for normality. Descriptive statistics are presented as counts and percentages for categorical variables and as median (25th, 75th percentile) for continuous data with skewed distributions or mean + standard deviation for those with normal distributions. Non-normal continuous data were compared using Wilcoxon rank-sum tests, normal continuous data were compared using t-tests and comparisons between categorical variables were performed using chi-square tests, or the Fisher exact test when expected cell counts were <5.

Results:

The quarterly volume of TTEs performed at the hospital during pre-COVID and COVID study period were similar (2687 ± 37 vs 2700 ± 425 , $p=0.97$). The average quarterly volume of initial outpatient TTEs performed in our clinics was also similar (1524 ± 130 vs 1170 ± 524 , $p = 0.45$). A comparison of quality measures between the pre-COVID and COVID era is shown in Table I. There was no statistically significant difference in the mean IQM score between pre-COVID and COVID era in non-COVID patients with structurally normal hearts. However, the mean CEM score improved from pre-COVID to COVID era, specifically for imaging of coronary sinus ($29/40$ vs $38/40$, $p = 0.006$), tricuspid regurgitation jet evaluation by Doppler in two views if available ($34/40$ vs $40/40$, $p = 0.011$) and evaluation adequate for measurement of aortic valve, aortic root, and aortic sinotubular junction diameters measured in parasternal long-axis view ($30/40$ vs $37/40$, $p = 0.034$). There was no significant change in major diagnostic error rate between the pre-COVID and COVID era (0.02% vs 0.01% , $p=0.18$). Overall, there was an improvement in appropriateness of TTE orders in the COVID era, with the proportion of TTEs with indications rated Appropriate increasing from 90.3% to 92.1% , $p = 0.028$ (Table I). There was no significant change in the TTEs ordered for indications rated Rarely Appropriate. Among the TTEs ordered for indications related Rarely Appropriate, there was an increase in the proportion of those related to syncope, ($5/37$ (13.5%) vs $7/17$ (41.2%), $p=0.035$) and pal-

pitations and arrhythmias (8/37) 21.6% vs 10/17 (58.8%), $p=0.007$) in COVID era compared to pre-COVID era, and a decline in those related to chest pain (10/37 (27%) vs 0/17 (0%), $p=0.02$).

In the COVID era, the initial TTE IQM mean score was significantly less in COVID patients compared to non-COVID patients, 18.6 ± 2.5 vs 21.3 ± 1.5 , $p<0.001$, (Table II). The specific components of IQM that were worse in COVID patients included image orientation for subcostal sagittal view, brightness level, balanced penetration resolution, presentation of region of interest, frame rate and gain level for color-Doppler, scale adjustment and gain level for spectral-Doppler. The mean CEM score was also significantly lower in COVID patients compared to non-COVID patients, 27.7 ± 3.7 vs 29.5 ± 0.8 , $p<0.001$, (Table III). Imaging of the systemic and pulmonary veins, pulmonary arteries and aortic imaging (arch sidedness and branching, arch imaging by Doppler, and abdominal aorta by Doppler) scored significantly lower in COVID patients compared to non-COVID patients. Of the 40 studies in COVID patients, 5 were performed in the emergency department, 20 in the acute care floor and 15 in the critical care unit. The study location was not associated with IQM or CEM results. A complete follow-up TTE was available in 20 out of 40 COVID patients and no pathology was noted on these TTEs.

Discussion :

In this study from a large tertiary care pediatric center, the image quality and comprehensiveness of TTEs performed in COVID patients were significantly impacted by the changes adopted during the pandemic. However, the quality was maintained in non-COVID patients receiving initial complete evaluation at our center.

It is known that severe acute respiratory syndrome coronavirus-2 infection that causes COVID has rapid transmission and is associated with high morbidity and mortality. Given this concern, cardiovascular imaging societies have recommended considering the use of focused and abbreviated protocols and using laptop size echocardiography machines in these patients.(1) In addition, there have been other system-wide changes that were continuously evolving during the pandemic including closure of the clinics, lack of sedation for TTEs in uncooperative infants and toddlers, changes in staffing, telemedicine and remote reading that could have impacted quality of care in non-COVID patients. Therefore, this study not only evaluated patients with suspected or confirmed COVID, but also non-COVID patients who had initial complete evaluation with TTE. Studying the effect of each of these factors on various quality measures would have been quite challenging as these are hard to objectively capture in a retrospective manner. Fortunately, we did not find any significant changes in IQM in non-COVID patients during the pandemic and noted improvement in CEM. These two metrics were implemented at our center in Jan 2019 and since then, the sonographers have been receiving quarterly feedback on their studies. The improvement in CEM may be reflective of our educational efforts regarding these metrics.

It was not surprising that the CEM was affected in COVID patients given the use of abbreviated protocols. Initial evaluation in COVID patients had significantly deficient imaging of pulmonary veins, pulmonary arteries, arch situs, arch Doppler, and abdominal aorta Doppler. If a subsequent study was performed on these patients, attempt was made to image the structures that were not captured on the initial scan. IQM was lower in COVID patients due to suboptimal image orientation, brightness level, improper adjustment of Doppler gains and scale. At our center, we did not use laptop size machines to perform TTEs in COVID patients included in this study. One could speculate that the need to complete the study quickly to reduce exposure to the patient could have resulted in lack of effort for image optimization and hence the lower IQM. Though no pathology was noted in the COVID patients who had a subsequent study, it was a small sample size (20/40). A study in 171 adult patients with suspected or confirmed COVID, evaluated the scanning time and acquisition of minimum data set, and compared it to 50 controls from the pre-pandemic period.(8) They reported a significant reduction in median scanning time from 14 min (IQR 10-16 min) to 6 min (IQR 4-8 min) while following the abbreviated protocol. The number of images also reduced from a median of 55 (IQR 39-66) to 25 (17-36). Importantly, there was no difference in the proportion of studies that met the minimum data set (47/50 (94%) in controls vs 158/171 (92.4%) in COVID patients).

Quality of cardiovascular imaging can impact patient outcomes(9,10). Fortunately, we did not observe any change in the diagnostic error rate. One of the steps in providing quality care with TTE is appropriateness of the study indications. Though overall there was an improvement in appropriateness of TTE orders for initial outpatient evaluation, there was an increase in the proportion of TTEs ordered for the Rarely Appropriate indications related to syncope, palpitations and arrhythmias. During the pandemic, no TTEs were ordered for chest pain indications rated R. While these findings achieved statistical significance, we are unable speculate a reason behind these findings.

This study is limited by its retrospective nature and restriction of the data to two quarters of the ongoing COVID pandemic. The factors that could have influences the imaging metrics were difficult to capture objectively for statistical analysis. The representative sampling of TTEs assessed for IQM and CEM quality metrics was relatively small since we used the existing data from our quality assurance process for the echocardiography lab. Nevertheless, some important differences were noted in COVID patients compared to non-COVID patients that have been helpful in our educational efforts to improve quality of care during the pandemic.

Conclusion

During the COVID pandemic, the diagnostic error rate has not changed and the proportion of TTEs ordered for appropriate indications has increased. However, unlike non-COVID patients, the image quality as well as the exam comprehensiveness has decreased in those with suspected or confirmed COVID. In these patients, attention should be paid to imaging of the systemic and pulmonary veins, pulmonary arteries and the aorta on the initial or subsequent study to avoid any diagnostic errors.

Table I: Comparison of Quality Measures Between Pre-COVID and COVID Era

Metric	Pre-COVID Era April-Sept 2019	COVID Era April-Sept 2020	P-Value
Image Quality Metric Mean (SD), (Total score 23)	21.5 (2.0)	21.3 (1.5)	0.529
Comprehensive Exam Metric Mean (SD), (Total score 30)	28.4 (1.7)	29.0 (0.9)	<0.001
Diagnostic Errors N (%)	15/665 (0.02%)	9/694 (0.01%)	0.180
Appropriateness Ratings N (%)			
<i>Appropriate</i>	2753/3048 (90.3%)	2153/2339 (92.05%)	0.028
<i>May be Appropriate</i>	258/3048 (8.46%)	169/2339 (7.23%)	0.095
<i>Rarely Appropriate</i>	37/3048 (1.21%)	17/2339 (0.73%)	0.075

Table II: Comparison of Initial Transthoracic Echocardiogram Image Quality Metric between non-COVID and COVID patients in 2020

Variable	Scale	Non-COVID		
N=40	COVID			
N=40	P-Value			
Mean (SD) Score		21.3 (1.5)	18.6 (2.5)	<0.001
Image orientation				
Parasternal long axis	Yes	35 (87.5%)	40 (100.0%)	0.021
Parasternal short axis	Yes	39 (97.5%)	40 (100.0%)	0.314
Apical 4 chamber	Yes	36 (90.0%)	38 (95.0%)	0.396

Subcostal sagittal	Yes	29 (72.5%)	17 (42.5%)	0.007
Suprasternal notch	Yes	34 (85.0%)	36 (90.0%)	0.499
2D Imaging				
Brightness level appropriate	Agree	28 (70.0%)	13 (32.5%)	0.003
	Somewhat Agree	10 (25.0%)	25 (62.5%)	
	Disagree	2 (5.0%)	2 (5.0%)	
Balanced penetration: resolution	Agree	26 (65.0%)	23 (57.5%)	0.050
	Somewhat Agree	10 (25.0%)	17 (42.5%)	
	Disagree	4 (10.0%)	0 (0.00%)	
Region of interest presented well	Agree	39 (97.5%)	23 (57.5%)	<.001
	Somewhat Agree	1 (2.5%)	17 (42.5%)	
Color-flow imaging				
Frame rate appropriate	Agree	38 (95.0%)	11 (27.5%)	<.001
	Somewhat Agree	2 (5.0%)	29 (72.5%)	
Gain level appropriate	Agree	39 (97.5%)	30 (75.0%)	0.003
	Somewhat Agree	1 (2.5%)	10 (25.0%)	
Nyquist limit settings appropriate	Agree	37 (92.5%)	31 (77.5%)	0.060
	Somewhat Agree	3 (7.5%)	9 (22.5%)	
Spectral Doppler display				
Choice of Doppler appropriate	Agree	40 (100.0%)	40 (100.0%)	-
Gain level appropriate	Agree	40 (100.0%)	29 (72.5%)	<.001
	Somewhat Agree	0 (0.00%)	11 (27.5%)	
Scale adjusted to provide maximal signal size	Agree	38 (95.0%)	18 (45.0%)	<.001
	Somewhat Agree	0 (0.00%)	22 (55.0%)	
	Disagree	2 (5.0%)	0 (0.00%)	

Table III: Comparison of Comprehensive Echocardiogram Examination Quality Metric between non-COVID and COVID patients in 2020

Variable	Non-COVID N=40	COVID N=40	P-Value
Mean (SD) Score (Out of 30)	29.5 (0.8)	27.7 (3.7)	<0.001
Situs, Veins, Atria			
Liver and stomach shown	40 (100.0%)	37 (92.5%)	0.077
Cardiac position	40 (100.0%)	38 (95.0%)	0.152
IVC and aorta in relation to spine	40 (100.0%)	37 (92.5%)	0.077
IVC and SVC in imaging and color	40 (100.0%)	32 (80.0%)	0.003
IVC connection to atrium	40 (100.0%)	38 (95.0%)	0.152
Two left and two right pulmonary veins	37 (92.5%)	25 (62.5%)	0.001
Coronary sinus visualized	38 (95.0%)	38 (95.0%)	1.000
Atrial septum imaging	40 (100.0%)	37 (92.5%)	0.077
Ventricles			
Ventricular septum by color Doppler	40 (100.0%)	38 (95.0%)	0.152

Imaging for qualitative RV function	40 (100.0%)	38 (95.0%)	0.152
Imaging of LV function	40 (100.0%)	39 (97.5%)	0.314
LV end diastolic dimension or volume	40 (100.0%)	39 (97.5%)	0.314
LV end systolic dimension or volume	40 (100.0%)	39 (97.5%)	0.314
Evaluation for LV mass	40 (100.0%)	39 (97.5%)	0.314
LV Outflow by Doppler	40 (100.0%)	39 (97.5%)	0.314
RV Outflow by Doppler	40 (100.0%)	38 (95.0%)	0.152
Cardiac valves			
Tricuspid valve imaging	40 (100.0%)	40 (100.0%)	-
Tricuspid regurgitation jet by Doppler	40 (100.0%)	39 (97.5%)	0.314
Mitral valve imaging	40 (100.0%)	40 (100.0%)	-
Mitral valve in short axis	38 (95.0%)	36 (90.0%)	0.396
Pulmonary valve imaging	40 (100.0%)	39 (97.5%)	0.314
Aortic valve imaging	40 (100.0%)	37 (92.5%)	0.077
Coronary arteries imaging	39 (97.5%)	37 (92.5%)	0.305
Vessels			
Evaluation for aortic dimensions	37 (92.5%)	36 (90.0%)	0.692
Branch pulmonary artery imaging	39 (97.5%)	33 (82.5%)	0.025
Patent ductus arteriosus excluded	39 (97.5%)	39 (97.5%)	1.000
Ascending aorta imaging	31 (77.5%)	35 (87.5%)	0.239
Aortic arch sidedness and branching	40 (100.0%)	34 (85.0%)	0.011
Aortic arch imaging by Doppler	40 (100.0%)	36 (90.0%)	0.040
Abdominal aorta evaluated by Doppler	40 (100.0%)	36 (90.0%)	0.040

References:

1. Barker PCA, Lewin MB, Donofrio MT et al. Specific Considerations for Pediatric, Fetal, and Congenital Heart Disease Patients and Echocardiography Service Providers during the 2019 Novel Coronavirus Outbreak: Council on Pediatric and Congenital Heart Disease Supplement to the Statement of the American Society of Echocardiography: Endorsed by the Society of Pediatric Echocardiography and the Fetal Heart Society. J Am Soc Echocardiogr 2020;33:658-665.
2. Campbell RM, Douglas PS, Eidem BW, Lai WW, Lopez L, Sachdeva R. ACC/AAP/AHA/ASE/HRS/SCAI/SCCT/SCMR/SOPE 2014 appropriate use criteria for initial transthoracic echocardiography in outpatient pediatric cardiology: a report of the American College of Cardiology Appropriate Use Criteria Task Force, American Academy of Pediatrics, American Heart Association, American Society of Echocardiography, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic

Resonance, and Society of Pediatric Echocardiography. *J Am Coll Cardiol* 2014;64:2039-60.

3. Sachdeva R, Valente AM, Armstrong AK et al. ACC/AHA/ASE/HRS/ISACHD/SCAI/SCCT/SCMR/SOPE 2020 Appropriate Use Criteria for Multimodality Imaging During the Follow-Up Care of Patients With Congenital Heart Disease: A Report of the American College of Cardiology Solution Set Oversight Committee and Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, Heart Rhythm Society, International Society for Adult Congenital Heart Disease, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Pediatric Echocardiography. *J Am Coll Cardiol* 2020;75:657-703.
4. Lopez L, Colan SD, Frommelt PC et al. Recommendations for quantification methods during the performance of a pediatric echocardiogram: a report from the Pediatric Measurements Writing Group of the American Society of Echocardiography Pediatric and Congenital Heart Disease Council. *J Am Soc Echocardiogr* 2010;23:465-95; quiz 576-7.
5. Lai WW, Geva T, Shirali GS et al. Guidelines and standards for performance of a pediatric echocardiogram: a report from the Task Force of the Pediatric Council of the American Society of Echocardiography. *J Am Soc Echocardiogr* 2006;19:1413-30.
6. Cardiology ACo. Metric#26. Initial transthoracic echocardiogram image quality and Metric#27. Comprehensive echocardiographic examination. <https://cvqualityacc.org/initiatives/acpc-quality-network/quality-metrics> 2018.
7. Dasgupta S, Kelleman M, Sachdeva R. Improvement in Appropriateness of Pediatric Outpatient Echocardiography Orders Following Integration of the Appropriate Use Criteria within the Electronic Medical Record Ordering System. *J Am Soc Echocardiogr* 2020;33:1152-1153.
8. Jozsa C, Ussen B, Monteiro R, Bingcang R, Lloyd G, Bhattacharyya S. Impact of Focused Echocardiography on Scan Time and Diagnostic Quality in Patients with COVID-19. *J Am Soc Echocardiogr* 2020;33:1415-1416.
9. Douglas P, Iskandrian AE, Krumholz HM et al. Achieving quality in cardiovascular imaging: proceedings from the American College of Cardiology-Duke University Medical Center Think Tank on Quality in Cardiovascular Imaging. *J Am Coll Cardiol* 2006;48:2141-51.
10. Picard MH, Adams D, Bierig SM et al. American Society of Echocardiography recommendations for quality echocardiography laboratory operations. *J Am Soc Echocardiogr* 2011;24:1-10.