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Review article

Recommendations for risk stratified use of cardiac computed tomography for congenital heart disease during the COVID-19 pandemic



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ABSTRACT

The impact of the coronavirus disease (COVID-19) pandemic in the United States and around the world has required significant changes to medical practice. Amidst the rapidly evolving public health emergency, hospital centers have been required to postpone elective procedures, preserve personal protective equipment (PPE), practice social distancing and limit staff exposures. Patients with congenital heart disease (CHD) often need urgent evaluation, most commonly for preprocedural evaluation. We have stratified the most common indications for cardiac computed tomography (CCT) imaging in patients with CHD to help guide care for these patients during the COVID-19 pandemic including considerations for reopening.

1. Introduction

Cardiac computed tomography (CCT) is used to define cardiac anatomy in patients with known or suspected congenital heart disease (CHD) primarily to determine optimal timing of surgical or catheter based intervention, and to guide medical management.¹ During the COVID-19 pandemic, elective diagnostic testing has been deferred for many patients. The use of CCT in CHD patients requires stratification to protect patients and staff, optimization of use of personal protective equipment (PPE)² and minimizing risk of adverse outcome from deferred testing. The use of CCT amidst the COVID-19 pandemic for adult cardiac indications is outlined in recently published guidelines from the Society of Computed Tomography (SCCT).³ These recommendations have limited applicability in the CHD population, but should be followed for adult CHD (ACHD) patients who may require CCT to assess for coronary artery disease in the setting of symptomatic COVID-19 infection.⁴ Cases of a multisystem inflammatory syndrome resulting from COVID-19 infection with similarities to Kawasaki disease are recently being identified in children, but the degree of coronary involvement and use of CCT in this setting is not yet well defined.⁵ This brief report outlines a strategy for prioritizing of CCT in the CHD

population during the current COVID-19 pandemic when diagnostic capacity remains limited.

2. Screening strategies and precautions to ensure patient and staff safety

Based on current knowledge, newborns with critical CHD needing CCT have a low likelihood of active COVID-19 infection. Many hospital centers have maternal testing at the time of admission for delivery and vertical transmission of maternal infection to the fetus in utero is considered to be rare.^{6,7} Nevertheless, a robust screening process for COVID-19 must be in place for CHD patients of any age presenting for CCT. Asymptomatic infection is common in young patients and recommendations are made with staff safety considered paramount.⁸ Pre-procedure and day of procedure screening for illness should be implemented for all patients and accompanying adults, which will vary by institution. Depending on the local prevalence and availability of testing, strong consideration should be given to pre-procedural COVID-19 testing as governed by institutional and regional infectious disease specialists. If testing capacity is limited, cases requiring anesthesia should be prioritized given the potential for aerosolization with airway

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support. Appropriate use of PPE is vital in minimizing the risk of exposure to the imaging staff. Social distancing should be maintained in the waiting room and imaging suite, with appropriate mask utilization for patients and accompanying adults, according to CDC guidelines. Appropriate time should be allotted between scans to allow for sanitization of the scanner. These processes should remain in place as long as there is community spread of infection. Only cases that can be safely postponed 4–6 months without adverse effect are considered elective. Optimally, the care team would determine urgency of imaging for complex CHD patients as outlined. Institutional radiation dose optimization and CHD scan protocols should be maintained during the pandemic⁹

3. Classifications of CCT level of urgency in CHD patients

3.1. Urgent

Patient requires imaging to plan intervention within days to weeks or to optimize management.

Timing of Scan: < 7 days

1. Neonate with ductal dependent systemic blood flow requiring assessment of cardiac and vascular anatomy prior to intervention (e.g. interrupted aortic arch, complex hypoplastic left heart syndrome (HLHS))
2. Neonate with ductal or collateral dependent pulmonary blood flow requiring assessment of pulmonary arterial (PA) supply prior to intervention (e.g. severe tetralogy of Fallot (TOF), pulmonary atresia)
3. Patients with shunt (aortopulmonary or Sano) dependent pulmonary blood flow with increasing cyanosis
4. Neonate with obstructed total anomalous pulmonary venous return or patient with symptomatic pulmonary venous obstruction after intervention
5. Patient with symptomatic vascular airway compromise (vascular ring, TOF with absent pulmonary valve)
6. Assessment of other venous or arterial abnormalities needing definition for urgent intervention
7. Patient with symptomatic or high risk coronary artery anomaly (e.g. anomalous left coronary artery from the pulmonary artery (ALCAPA) or Left anomalous aortic origin of a coronary artery (AAOCA))
8. Assessment of coronary abnormalities in neonates with complex transposition of the great arteries
9. Assessment of main or branch PA anatomy after intervention with change in clinical status
10. CHD patient with change in symptoms or clinical status requiring hospitalization
11. CHD patient with symptoms of ischemia requiring coronary imaging
12. CHD patient with aortopathy and clinical concern for enlarging aneurysm or dissection
13. CHD patient with clinical concern for endocarditis and other imaging is insufficient for assessment of valvar vegetation or abscess
14. CHD patient with change in clinical status requiring urgent evaluation as determined by the managing team.

3.2. Semi-urgent

Patient requires imaging to plan intervention within 1–3 months or to optimize management.

Timing of Scan: < 4 weeks

1. Patients with shunt (aortopulmonary or Sano) dependent pulmonary blood flow in preparation for stage 2 palliation (Bidirectional Glenn, Hemi-Fontan) or complete repair (severe TOF)

2. Assessment of complex anatomy prior to definitive repair (e.g. double outlet right ventricle, complex arterial switch operation)
3. Assessment of progressive aortic arch obstruction, or aneurysm in an asymptomatic patient
4. Evaluation of coronary anatomy prior to right ventricular outflow tract (RVOT) intervention in a patient with signs of right heart failure or change in right ventricular function
5. Coronary CT angiogram (CTA) in an ACHD patient requiring other congenital cardiac surgery to exclude need for concomitant coronary artery bypass graft (CABG)
6. CHD patient meeting criteria for cardiac intervention where delay > 3 months has the potential for adverse outcome
7. CHD patient with change in symptoms or clinical status not requiring hospitalization

3.3. Non-urgent outpatient

Patient requires imaging to plan intervention in 3–6 months or optimize management.

Timing of Scan: < 3 months

1. Evaluation of coronary anatomy prior to RVOT intervention in an asymptomatic patient meeting criteria for intervention where delay of 3–6 months is acceptable
2. CHD patient needing evaluation for cardiac intervention where delay of 3–6 months has minimal potential for adverse event
3. Assessment of lower risk coronary artery anomaly in an asymptomatic patient (e.g. Right AAOCA)
4. Planning for other elective procedure as indicated in a patient without progressive symptoms

3.4. Routine surveillance

Patient requires imaging for disease surveillance without expectation of intervention.

Timing of Scan: Consider delaying > 6 months

1. Routine interval assessment of simple or complex CHD as indicated by pediatric cardiologist
2. Routine interval assessment of simple or complex CHD as indicated by ACHD cardiologist according to the 2018 ACHD guidelines⁴

Scenarios in which the clinical team feels an examination is indicated should be expedited on a case by case basis.

4. Considerations for reopening strategies

Ensuring safety of staff and patients is of utmost importance when planning for reintroduction of nonurgent cardiovascular services. The impact of delays in treatment due to deferred CHD cardiac procedures during this pandemic is undefined. Young patients with CHD undergo rapid somatic growth which changes the urgency of evaluation over a relatively short interval. Active and ongoing triage of CHD patients with delayed testing is essential. A change in clinical status may affect the urgency of evaluation. The leaders of several North American cardiovascular professional societies recently published guidance for the reintroduction of cardiovascular services.¹⁰ Recommendations are applicable to CHD CCT imaging and include maximizing benefits to those undergoing CCT, weighing the benefit of CCT with the risk of potential for further COVID-19 spread, and consistency in the availability of such services to patients regardless of factors that may impede their accessibility such as social class or ethnicity.

5. Conclusion

Urgent indications to perform CCT for patients with CHD often arise

in the setting of a preprocedural evaluation. We have summarized the most common indications in the setting of the COVID-19 pandemic. Since asymptomatic infection is common in young patients, a robust screening process and optimal use of PPE is needed to protect imaging staff. Recommendations are based on our current understanding of the pandemic, which is changing rapidly. Updated information should inform change in practice as it becomes available.

Declaration of competing interest

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References

1. Han BK, et al. Computed tomography imaging in patients with congenital heart disease Part I: rationale and utility. An expert consensus document of the society of cardiovascular computed tomography (SCCT): endorsed by the society of pediatric radiology (SPR) and the North American society of cardiac imaging (NASCI). *J Cardiovasc Comput Tomogr.* 2015;9(6):475–492.
2. Stephens EH, et al. COVID-19: crisis management in congenital heart surgery. *Ann Thorac Surg.* 2020;S0003-4975(20):30540–30543. <https://doi.org/10.1016/j.athoracsur.2020.04.001>.
3. Choi AD, et al. Society of cardiovascular computed tomography guidance for use of cardiac computed tomography amidst the COVID-19 pandemic endorsed by the American college of cardiology. *J Cardiovasc Comput Tomogr.* 2020;14(2):101–104. <https://doi.org/10.1016/j.jcct.2020.03.002>.
4. Stout KK, et al. AHA/ACC guideline for the management of adults with congenital heart disease: executive summary: a report of the American college of cardiology/American heart association task force on clinical practice guidelines. *Circulation.* 2018;139(14):e637–e697 2019.
5. Jones VG, et al. COVID-19 and Kawasaki Disease: Novel Virus and Novel Case. *Hosp Pediatr.* 2020.
6. Karimi-Zarchi M, et al. Vertical transmission of coronavirus disease 19 (COVID-19) from infected pregnant mothers to neonates: a review. *Fetal Pediatr Pathol.* 2020:1–5.
7. Breslin N, et al. COVID-19 infection among asymptomatic and symptomatic pregnant women: two weeks of confirmed presentations to an affiliated pair of New York City hospitals. *Am J Obstet Gynecol MFM.* 2020:100118.
8. Lu X, et al. SARS-CoV-2 infection in children. *N Engl J Med.* 2020;382(17):1663–1665.
9. Hill KD, et al. Radiation safety in children with congenital and acquired heart disease: a scientific position statement on multimodality dose optimization from the image gently alliance. *JACC Cardiovasc Imag.* 2017;10(7):797–818.
10. Wood DA, et al. Safe reintroduction of cardiovascular services during the COVID-19 pandemic: guidance from North American society leadership. *J Am Coll Cardiol.* 2020;S0735-1097(20) <https://doi.org/10.1016/j.jacc.2020.04.063> 35165-2.