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Cardiac CT in Coronary Artery Anomalies in Tetralogy of Fallot

Research Article

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Abstract

Objective: Cardiac CT in preoperative evaluation of coronary artery anomalies in patients with tetralogy of Fallot.

Materials and methods: Forty-six patients diagnosed with tetralogy of Fallot by echocardiography underwent cardiac CT from Jan 2017 to Jan 2020 for coronary artery evaluation. CT findings were correlated with surgical findings.

Results: Three cases (6.5%) of anomalous coronary arteries were found in our study. One case showed anomalous origin of left anterior descending artery from right sinus of Valsalva. The second case revealed single coronary artery arising from left sinus of Valsalva and bifurcating into right coronary artery and left coronary artery. The third case showed anomalous origin of right coronary artery from left sinus of Valsalva with a malignant course.

Conclusion: Cardiac CT is an accurate and non-invasive modality in preoperative evaluation of coronary artery anomalies and avoiding damage during corrective surgery in patients with tetralogy of Fallot.

Introduction

The incidence of coronary artery anomalies in patients with tetralogy of Fallot is 2-14% [1,2]. The presence of coronary artery anomalies leads to a change in the approach of surgical correction in tetralogy of Fallot. Anomalous coronary artery crossing the right ventricular outflow tract may remain undetected during the surgical procedure due to the overlying myocardium, epicardial fat or adhesions from previous palliative surgery [3,4]. Thus, preoperative identification of coronary artery anomalies is recommended in these patients to avoid damage during the corrective surgery. Coronary artery evaluation on pediatric cardiac Computed Tomography (CT) before surgical intervention is possible due to high temporal resolution and Echocardiography (ECG) synchronized data acquisition [5-7].

Materials and Methods

Patient population

Forty-six patients diagnosed with tetralogy of Fallot by echocardiography underwent cardiac CT from Jan 2017 to Jan 2020 for preoperative evaluation. Male to female ratio was 1.7: 1 and the age range was 21 days to 18 years with a mean of 4 years.

Patient preparation

The laterality of the aortic arch as mentioned in the echocardiography report was useful for the site of intravenous access in the opposite cubital fossa. A peripheral intravenous cannula, 20G or 22G, was used according to the patient to accommodate the large volume, high pressure contrast injection. Preparations for sedation or anaesthesia were made as per requirement.

CT and image reformatting techniques

CT was done on 128 slice Dual Energy CT scanner (SOMATOM Definition Flash; Siemens, Erlangen, Germany). **CT data was obtained with the following parameters:** 3 mm slice thickness, 3 mm increment, 0.28 sec rotation time, 0.38 pitch and reconstructed images of 0.6 mm slice thickness and 0.6 mm increment. A low

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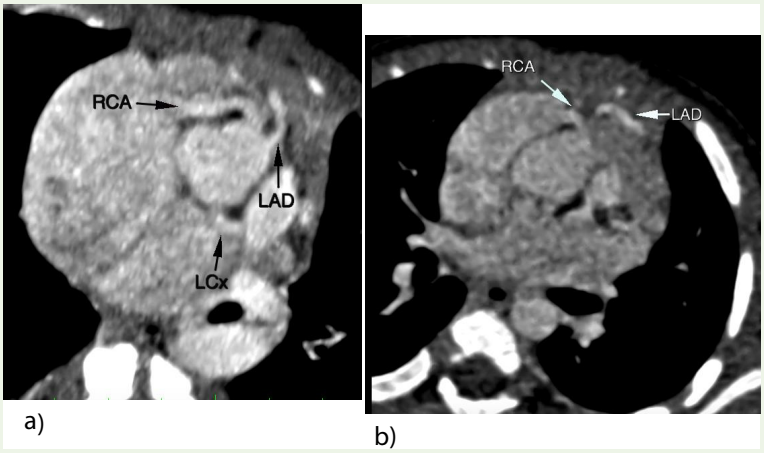

Figure 1a: Cardiac CT angiography showing anomalous origin of left anterior descending artery from right coronary sinus. Normal origin of right coronary artery from right coronary sinus and left circumflex artery from left coronary sinus. **Figure 1b:** Left anterior descending artery coursing anterior to right ventricle and right coronary artery coursing in anterior atrioventricular groove. RCA- right coronary artery, LAD- left anterior descending artery, LCx- left circumflex artery.

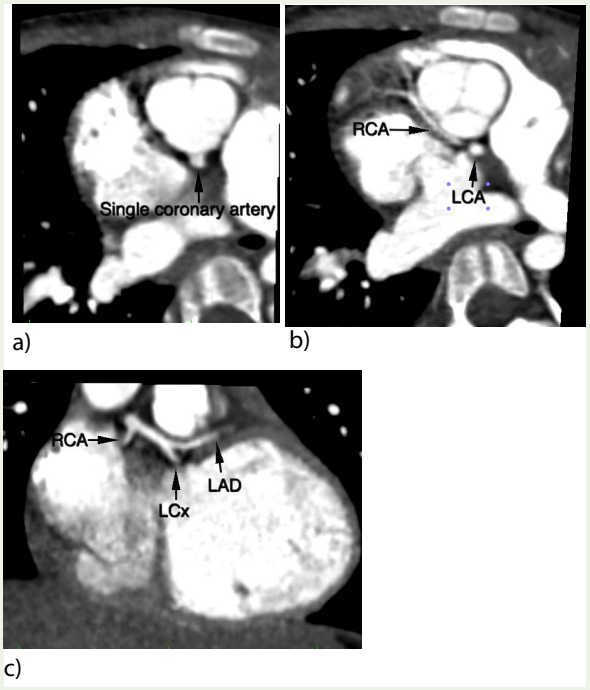

Figure 2: Cardiac CT angiography showing single coronary artery. a) Single coronary artery arising from posterior coronary sinus. b) It is bifurcating into right coronary artery and left coronary artery. c) Left coronary artery further divides into anterior descending artery and circumflex artery. RCA- right coronary artery, LCA- left coronary artery, LAD- left anterior descending artery, LCx- left circumflex artery.

effective radiation dose of 0.2 milliSieverts was given to the patient. A volume of 2 ml/kg bodyweight of non-ionic iodinated contrast agent was administered through IV cannula at a rate of 2 ml/sec via power injector. Care bolus tracking technique was employed with the region of interest placed within the descending thoracic aorta, at the level of the carina and scan threshold set at 100 Hounsefield Units (HU). Contrast saline solution of 50% dilution was utilized in bolus chasing technique to improve contrast within the cardiac chambers. ECG synchronized retrospective gating technique was employed for coronary artery evaluation.

Results

Anomalous coronary arteries in 3 cases in cardiac CT are described below.

Case 1

Anomalous origin of left anterior descending artery from right sinus of Valsalva was noted (Figure 1a). Its proximal segment traversed anteriorly for a short length and then angulated towards left

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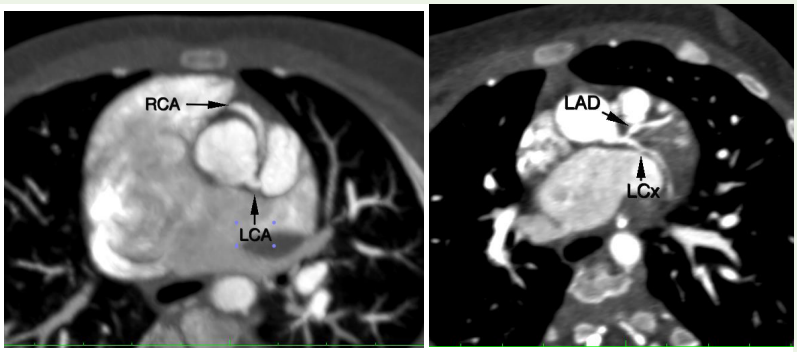

Figure 3: a) Cardiac CT angiography showing anomalous origin of right coronary artery. Right coronary artery arising from left coronary sinus. **b)** Normal origin of left coronary artery dividing into anterior descending artery and circumflex artery. RCA- right coronary artery, LCA- left coronary artery, LAD- left anterior descending artery, LCx- left circumflex artery.

coursing anterior to right ventricle and further along interventricular sulcus (Figure 1b). Left circumflex artery had normal origin from left sinus of Valsalva and traversed posteriorly along left atrioventricular groove. Right coronary artery had normal separate origin from right sinus of Valsalva and traversed along anterior atrioventricular groove.

Case 2

Single coronary artery was noted arising from left sinus of Valsalva (Figure 2a). After a short course, the single artery bifurcated into right coronary artery and left coronary artery (Figure 2b). Right coronary artery traversed anteriorly between aortic root and right atrium to reach anterior atrioventricular groove. Left coronary artery divided into left anterior descending and left circumflex arteries (Figure 2c). Left anterior descending artery traversed posterior to right ventricular outflow tract for a short length and then coursed along interventricular sulcus. Left circumflex artery traversed posteriorly along left atrioventricular groove.

Case 3

Anomalous origin of right coronary artery from left sinus of Valsalva was noted. Its ostioproximal segment was coursing between ascending aorta and main pulmonary artery suggestive of malignant course (Figure 3a). The mid and distal segments of right coronary artery traversed along the usual anterior atrioventricular groove. Left coronary artery had normal origin from left sinus of Valsalva and divided into left anterior descending and left circumflex arteries (Figure 3b). Left anterior descending artery traversed along its normal course in interventricular sulcus and left circumflex artery traversed in posterior atrioventricular groove.

Discussion

Previous studies have shown that the incidence of coronary artery anomalies in patients with tetralogy of Fallot is in the range of 2-14% [1,2]. Meyer et al reported 23 cases in a study group of 926 patients with tetralogy of Fallot having coronary artery anomalies [8]. Hurwitz et al found 25 out of 250 patients undergoing complete repair of tetralogy of Fallot with abnormal coronary artery [9]. Shrivastava et al studied 32 cases of coronary artery anomalies in 296 patients with tetralogy of Fallot [10]. The incidence of total coronary artery anomalies in our study was 6.5% which was within the range of the previous reports.

Origin of the left anterior descending artery from the right coronary artery or from a separate ostium in the right sinus of Valsalva is the most common coronary artery anomaly associated with tetralogy of Fallot. After its anomalous origin, the left anterior descending artery crosses over the anterior surface of the right ventricular outflow tract and continues in its normal course and distribution in the interventricular sulcus. Case 1 described above corresponds to this anomaly. Single coronary artery is the second most common coronary anomaly in patients with tetralogy of Fallot. The single coronary originates with equal frequency from the right or left sinus of Valsalva. Smith reviewed three major anatomic varieties of single coronary artery [11]: 1) a single coronary artery following the course of either the normal right or left coronary artery and supplying blood to the entire myocardium by its branches; 2) a single coronary artery dividing into two major branches shortly after its origin, each of these branches following the distribution of the normal right and left coronary arteries; and 3) a single coronary artery with abnormal distribution that it cannot be compared with either the right or left coronary artery. Most of the cases reported with tetralogy of Fallot are of the second type in which the single coronary artery divides early in its course into the right coronary artery and left coronary artery [12,13]. The single coronary artery described in Case 2 also corresponds to the second type as reviewed by Smith. A rare anomaly is the origin of left circumflex artery from the right coronary artery and crossing directly over the outflow tract, the left anterior descending artery normally distributed and arising as the total left coronary artery [9]. No such anomaly was seen in our patients with tetralogy of Fallot. However, an anomalous origin of right coronary artery from left sinus of Valsalva with malignant course was noted as described in Case 3.

Echocardiographic analysis remains the first step in the evaluation of patients with tetralogy of Fallot, however it may have limitations in depicting anomalous coronary arteries. A study showed missed coronary artery anomaly in 3 of 7 cases by echocardiography [14]. Similarly, 1 case of missed coronary artery anomaly by echocardiography was noted in our study. Review of literature shows that CT is a highly accurate noninvasive modality for demonstrating

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coronary artery origins, their course and spatial relationships to adjoining structures. Goo conducted a study to evaluate incidence and diagnostic accuracy of preoperative cardiac CT for identifying detailed coronary artery anatomy in 318 patients with tetralogy of Fallot. Coronary artery anatomy on preoperative cardiac CT was compared with surgical findings. Incidences of total and surgically critical coronary artery anomalies, concordance rate between cardiac CT and surgical findings and diagnostic accuracy of cardiac CT were assessed. The incidences of total and surgically critical coronary artery anomalies were 8.5% and 5.0% respectively. The concordance rate between cardiac CT and surgical findings was 95.0% and the diagnostic accuracy of cardiac CT was 96.9% [15]. Another study by Vastel-Amzallag et al assessed the accuracy of preoperative dual source CT in detecting coronary artery anomalies by using surgical findings as the reference standard. Their study revealed 100% sensitivity and 100% specificity for detecting coronary artery abnormalities. Major coronary artery abnormalities were found in 7% patients [14]. In addition to non invasive coronary evaluation, cardiac CT allows accurate depiction of pulmonary artery anatomy, major aortopulmonary collateral arteries and the aorta at the level of diaphragm.

Chronic cyanosis with its associated rheologic changes is a known risk factor for glomerular nephropathy. Contrast induced nephrotoxicity thus should be an important consideration in patients with tetralogy of Fallot. A study investigated 23 cyanotic patients for blood viscosity and renal damage before and after administration of non ionic contrast medium. Only one of the 23 patients showed renal damage after contrast administration. Elevated blood viscosity in cyanotic patients was slightly reduced by the contrast [16]. In our study, none of the patients showed renal damage after contrast administration.

Surgical correction of tetralogy of Fallot includes closure of the ventricular septal defect, resection of infundibular stenosis and pulmonary valvotomy through an incision in the right ventricular outflow tract [17]. The standard vertical incision is given as it can be continued through hypoplastic pulmonary annulus into the main pulmonary artery for enlargement of these structures with a Dacron patch. With this incision, a major coronary artery crossing the right ventricular outflow tract can be injured easily. In most instances, the left anterior descending artery arising from the right coronary artery is prone to injury [18]. In such cases, a transverse or oblique incision is given parallel to the unusual coronary artery during total correction of tetralogy of Fallot [19]. The latter approach was followed during total correction in Case 1, however there was no surgical concern in Case 2 and Case 3.

The mortality rate reported in the literature is 9-30% for the repair of patients with tetralogy of Fallot and anomalous coronary artery [4,8,9,20,21]. The majority of the deaths occurred due to inadvertent division of the anomalous left anterior descending artery [4,10,20]. Other factors included inadequate resolution of the right ventricular outflow tract obstruction and acute right ventricular aneurysmal dilatation causing attenuation or occlusion of the overlying left anterior descending artery. Post operative period was uneventful in our 3 cases of tetralogy of Fallot with coronary artery anomalies.

Conclusion

Anomalous coronary arteries in patients with tetralogy of Fallot may produce disastrous consequences during surgical correction. Cardiac CT is an accurate and noninvasive modality for delineating coronary artery anatomy. Echocardiography and cardiac CT have the advantage of obviating the need for cardiac catheterization in patients with tetralogy of Fallot.

References

1. Mawson JB (2002) Congenital heart defects and coronary anatomy. Tex Heart Inst J 29: 279-289.
2. Kervancioglu M, Tokel K, Varan B, Yildirim SV (2011) Frequency, origins and courses of anomalous coronary arteries in 607 Turkish children with tetralogy of Fallot. Cardiol J 18: 546-551.
3. White RI, Frech RS, Castaneda A, Amplatz K (1972) The nature and significance of anomalous coronary arteries in tetralogy of Fallot. Am J Roentgenol Rad Ther Nucl Med 114: 350-354.
4. Berry BE, McGoon DC (1973) Total correction for tetralogy of Fallot with anomalies coronary artery. Surgery 74: 894-898.
5. Goo HW, Seo DM, Yun TJ, Park JJ, Park IS, et al. (2009) Coronary artery anomalies and clinically important anatomy in patients with congenital heart disease: multislice CT findings. Pediatr Radiol 39: 265-273.
6. Ben Saad M, Rohnean A, Sigal-Cinqualbre A, Adler G, Paul JF (2009) Evaluation of image quality and radiation dose of thoracic and coronary dual-source CT in 110 infants with congenital heart disease. Pediatr Radiol 39: 668-676.
7. Goo HW, Yang DH (2010) Coronary artery visibility in freebreathing young children with congenital heart disease on cardiac 64-slice CT: dual-source ECG-triggered sequential scan *vs.* single-source non-ECG-synchronized spiral scan. Pediatr Radiol 40: 1670-1680.
8. Meyer J, Chiariello L, Hallman GL, Cooley DA (1975) Coronary artery anomalies in patients with tetralogy of Fallot. J Thorac Cardiovasc Surg 69: 373-376.
9. Hurwitz RA, Smith W, King H, Girod DA, Caldwell RL (1980) Tetralogy of Fallot with abnormal coronary artery: 1967 to 1977. J Thorac Cardiovasc Surg 80: 129-134.
10. Shrivastava S, Mohan JC, Mukhopadhyay S, Rajani M, Tandon R (1987) Coronary artery anomalies in tetralogy of Fallot. Cardiovasc Intervent Radiol 10: 215-218.
11. Smith JC (1950) Review of single coronary artery, with report of 2 cases. Circulation 1: 1168-1175.
12. Friedman S, Ash R, Klein D, Johnson J (1960) Anomalous single coronary artery complicating ventriculotomy in child with cyanotic congenital heart disease. Am Heart J 59: 140-147.
13. Kirklin JW, Ellis Jr FH, McGoon DC, DuShane JW, Swan HJ (1959) Surgical treatment for tetralogy of Fallot by open intracardiac repair. J Thoracic & Cardiovasc Surg 37: 22-51.
14. Vastel-Amzallag C, Le Bret E, Paul JF, Lambert V, Rohnean A, et al. (2011) Diagnostic accuracy of dualsource multislice computed tomographic analysis for the preoperative detection of coronary artery anomalies in 100 patients with tetralogy of Fallot. J Thorac Cardiovasc Surg 142: 120-126.
15. Goo HW (2018) Coronary artery anomalies on preoperative cardiac CT in children with tetralogy of Fallot or Fallot type of double outlet right ventricle: Comparison with surgical findings. Int J Cardiovasc Imaging 34: 1997-2009.
16. Dittrich S, Kurschat K, Dahnert I, Vogel M, Muller C, et al. (2000) Cyanotic nephropathy and use of non-ionic contrast agents during cardiac catheterization in patients with cyanotic congenital heart disease. Cardiol Young 10: 8-14.

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17. Hallman GL, Cooley DA (1963) Surgical treatment of tetralogy of fallot: experience with indirect techniques. J Thorac Cardiovasc Surg 46: 419-435.

18. Longnecker CP, Reemtsma K, Creech O Jr (1961) Anomalous coronary artery distribution associated with tetralogy of Fallot: a hazard in open cardiac repair. J Thorac Cardiovasc Surg 42: 258-262.

19. Gerbode F, Ross JK, March HW, Osborn JJ, Kerth WJ (1962) Transverse Ventriculotomy. Bull Soc Int Chir 21: 345-353.

20. Humes RA, Driscoll DJ, Danielson GK, Puga FJ (1987) Tetralogy of Fallot with anomalous origin of left anterior descending coronary artery. J Thorac Cardiovasc Surg 94: 784-787.

21. Landolt CC, Anderson JE, Zorn-Chelton S, Guyton RA, Hatcher Jr CR, et al. (1986) Importance of coronary artery anomalies in operations for congenital heart disease. Ann Thorac Surg 41: 351-355.

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