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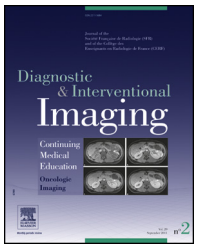

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Detection of pulmonary and coronary artery anomalies in tetralogy of Fallot using non-ECG-gated CT angiography

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KEYWORDS
Tetralogy of Fallot;
Computed tomography;
Pulmonary artery;
Coronary artery

Abstract
Objectives: To evaluate the use of non-ECG-gated computed tomography (CT) angiography to describe pulmonary and coronary defects in patients with tetralogy of Fallot (TOF).
Patients and methods: This retrospective study was carried out on TOF patients having undergone pre-operative non-ECG-gated CT angiography between February 2007 and September 2012. The following clinical parameters were recorded: mean age at CT angiography, sex, the existence of genetic disease and the need to sedate the patient prior to CT angiography. CT data were analyzed retrospectively to determine the site(s) of pulmonary stenosis (infundibular, valvular or arterial), the size of pulmonary arteries and the presence of anomalous coronary artery courses. CT findings were then compared to the anatomy observed during surgery.
Results: Thirty-five patients were included in the study. The mean age was 4.30 ± 1.91 months (boys/girls = 17/18). Two patients had associated chromosome disorders (one 22q11 microdeletion and one CHARGE syndrome). Sixteen patients (45.71%) were sedated prior to CT. Pulmonary artery assessment revealed 24 patients (68.57%) with infundibular stenosis, 5 (17.5%) with infundibular and/or valvular stenosis, and 6 (21%) with anomalous pulmonary arteries. CT angiography also evidenced anomalous coronary arteries in 8 patients (22.85%).

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Conclusion: Due to its reduced scanning time and high spatial resolution, non-ECG-gated CT angiography is a non-invasive imaging modality that provides accurate information on pulmonary and coronary artery anatomy in patients with TOF.

Congenital heart disease (CHD) affects between 6 and 8 per 1000 live births. Half of these babies only have minor anomalies that do not affect cardiac function, rarely alter their well-being and only exceptionally require surgical management [1]. Tetralogy of Fallot (TOF) is the most common cyanotic congenital heart defect; the prevalence of TOF is 3.5-9% [2]. Surgical management of TOF, as well as the age at which it is carried out, depends on the severity and type of pulmonary obstruction. Early, complete and single-stage surgical repair is currently the recommended procedure. It is advised to perform surgery before the age of 3 to 6 months, or even earlier in symptomatic cases. A small portion of infants with more complex defects require multiple surgical procedures, intensive care and careful monitoring [3]. Appropriate surgical management is largely dependent on detailed characterization of the anatomy of the pulmonary and coronary arteries. Classically, cardiac catheterization (CC) was performed to describe morphological defects in TOF patients [4]. However, due to its reduced scanning time and very high spatial resolution, computed tomography (CT) can provide accurate information on the intra- and extra-cardiac anatomy of patients with TOF [5]. The disadvantage of CT is that patients are exposed to ionizing radiation. Therefore, the need to perform multiple CT scans should be carefully assessed [6]. In the present study, the use of non-ECG-gated CT angiography to describe pulmonary and coronary artery anomalies in children with TOF was evaluated and compared with intraoperative findings, the gold standard for this disease.

Patients and methods

Patients

This retrospective study was carried out on all of the children with TOF in our database having undergone non-ECG-gated CT angiography between February 2007 and September 2012, prior to surgical repair. Signed consent was obtained from all the parents of patients included in this study. The evaluation criteria for these patients were the mean age at CT, the child's sex, the existence of an associated genetic disease and the need to sedate the patient prior to CT.

Computed tomography

During the period covered by the study, all patients with TOF were scanned using same CT scanner (Definition 64, SIEMENS, Erlangen, Germany) and the following protocol: acquisition 64×0.6 mm, 80 kV, 100 mAs, rotation time 0.33 s, manual intravenous injection in the arm of iodinated contrast agent (iobitridol 300 mg/L; Xenetix, Guerbet, Villepinte, France) at a dose of 2 ml/kg. Owing to the ventricular septal defect, multi-phase injection protocols were not possible. The following CT data were assessed:

- the site(s) of pulmonary stenosis (infundibular, valvular or arterial);
- the size of the pulmonary arteries in mm (infundibulum and valve measured in the sagittal plane on a multiplanar reconstruction [MPR] slice, pulmonary arteries measured at the hila on axial slices);
- the presence of anomalous coronary artery courses.

Pulmonary stenosis sites and coronary artery courses were analyzed qualitatively under blind conditions and then compared to the anatomy observed during surgery.

Statistical analysis

Results were expressed as means $\pm$ standard deviations. Pulmonary and coronary artery defects, as determined by CT angiography, were compared and evaluated against reference surgical findings. Data were analyzed using the Statistical Package for Social Sciences® (SPSS) 21.0 software for Windows®.

Results

During the study period, pre-operative non-ECG-gated CT angiography was performed for 35 children with TOF. The mean age at CT was 4.30 ± 1.91 months; the ratio of boys/girls was 17:18. Two patients had associated chromosome disorders: a 6.6-month-old girl with a 22q11 microdeletion and a 8.7-month-old girl with CHARGE syndrome. For 16 patients (45.71%), sedation was necessary prior to performing CT angiography.

Table 1 provides the CT findings for pulmonary artery anatomy in our patients. Twenty-four patients (68.57%) were determined as having infundibular stenosis, 5 patients (17.5%) were determined as having infundibular and/or valvular stenosis and 6 patients (21%) showed anomalous pulmonary arteries. Table 2 shows the diameters measured for the pulmonary trunk (PT), right pulmonary artery (RPA) and left pulmonary artery (LPA). Compared with the gold standard, i.e. surgical findings, the overall precision of CT angiography for characterizing pulmonary artery anatomy was 92,1%. The following anomalies were ''missed'' using CT angiography: 1 valvular stenosis and 2 LPA stenoses.