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Minimum-intensity projection of multidetector-row computed tomography for assessment of pulmonary hypertension in children with congenital heart disease

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ABSTRACT

Background: The present study aimed to assess the feasibility of minimum-intensity projection (minIP) images for the evaluation of pulmonary hypertension (PH) in children with congenital heart disease (CHD).
Methods: A total of 70 consecutive patients (mean age, 4.6 ± 4.4 years; range, 6 months–16 years) underwent multidetector-row computed tomography (MDCT) angiography of the thorax prior to cardiac catheterization and lung perfusion scintigraphy. Contiguous axial, coronal and sagittal minIP images of 5-mm thickness were reconstructed from the contrast-enhanced CT datasets. Two reviewers evaluated the images in consensus and qualitatively graded lung parenchyma attenuation as homogeneous (Class I), slightly heterogeneous lung attenuation that does not conform to the anatomic boundaries of the secondary pulmonary lobule (Class II), and mosaic pattern (Class III). MinIP attenuation grading results were then compared with those of perfusion scintigraphy. Furthermore, the relationships between the results of these modalities and mean pulmonary artery pressure (mPAP) and pulmonary vascular resistance (PVR) were evaluated.
Results: In 51 (73%) patients, concordant findings were observed between the modalities, although minIP showed a higher grade for heterogeneous images than did scintigraphy. mPAP and PVR showed significant difference among the minIP attenuation classes ($p < 0.0001$ for both). High-grade heterogeneous minIP images were associated with high mPAP, high PVR, presence of major aortopulmonary collateral artery, and chromosomal abnormality.
Conclusion: MinIP is a promising technique for depicting lung perfusion and can be used as superior alternative to scintigraphy in the evaluation of PH.

1. Introduction

Pulmonary hypertension (PH) is defined as mean pulmonary artery pressure (mPAP) greater than 25 mm Hg at rest, or as pulmonary vascular resistance (PVR) greater than 3 Wood units [1]. According to the current classification [1], PH is divided into 5 classes: (1) pulmonary arterial hypertension, (2) pulmonary hypertension associated with left heart diseases, (3) pulmonary hypertension associated with lung diseases and/or hypoxemia, (4) pulmonary hypertension due to chronic thrombotic and/or embolic disease, and (5) miscellaneous. According to the Venice classification, PH associated with congenital heart disease (CHD) is commonly assigned to the first category [2]. If the hypertension persists or increases further, right heart insufficiency may develop. This condition is associated with impaired exercise tolerance and reduced quality of life. In cases of preoperative CHD, PH results in difficulties in performing total correction and a poor postoperative prognosis.

Alterations in lung perfusion are a well-known feature of PH that are apparent on nuclear medicine studies [3]. Abnormal radiotracer distribution in patients with PH may be caused by arterial thromboembolic occlusion, as in chronic thromboembolic pulmonary hypertension; by parenchymal destruction, as in interstitial lung disease and pulmonary emphysema; or by distal arteriopathy, as in idiopathic pulmonary arterial hypertension and other nonembolic pathologies [4–6]. Cardiac catheterization remains the gold standard for PH assessment but is associated with several disadvantages, including significant radiation exposure, the need for general anesthesia and the potential for vascular injury.

Multidetector-row computed tomography (MDCT) is increasingly used for non-invasive assessment of congenital cardiovascular structural abnormalities, including pediatric pulmonary vasculature [7,8]; however, the utility of this technology for the assessment of the pulmonary vascular beds in children with CHD remains unknown. Previous studies have reported the characteristic MDCT features of PH

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of various causes to include inhomogeneous and mosaic patterns of lung attenuation in adults [9–11] but no studies to date have evaluated the diagnostic MDCT findings for PH in children with CHD. Furthermore, previous studies regarding adult CHD patients evaluated MDCT imaging in Eisenmenger syndrome [9–11]. In the present study, we investigated the feasibility of MDCT angiography in assessing mild to moderate PH in preoperative children in whom it is important to assess pulmonary vascular bed condition for operative indications and postoperative treatment. Bartalena et al. first demonstrated that minimum-intensity projection (minIP) reconstructions using MDCT pulmonary angiography could be an alternative to scintigraphy in the analysis of lung perfusion patterns in adult patients [12].

The objective of the present study was to evaluate minIP reconstructions as an alternative to scintigraphy in the analysis of lung perfusion patterns in children with CHD. Furthermore, we aimed to evaluate the feasibility of minIP reconstruction for assessing the presence and severity of PH.

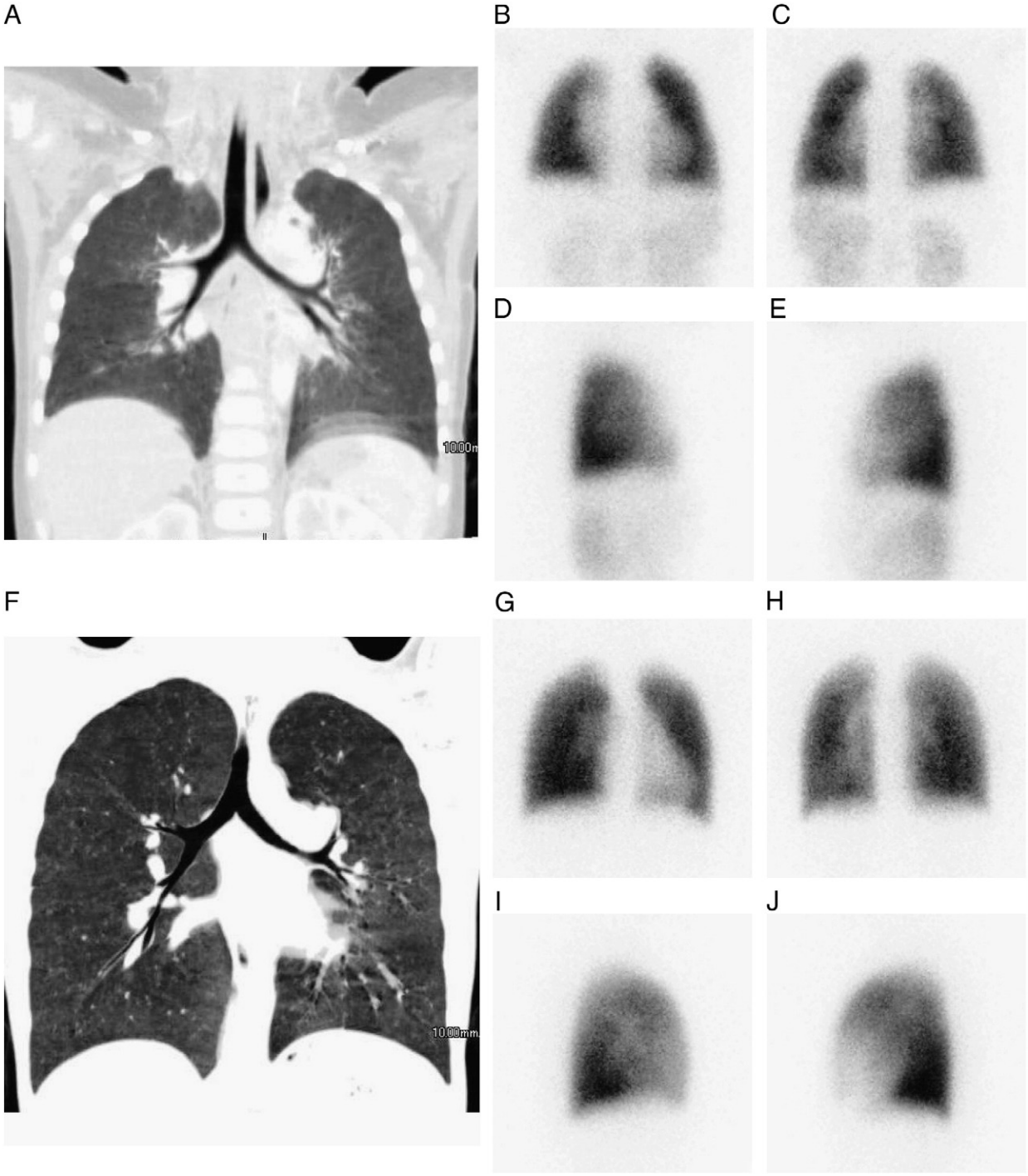

Fig. 1. A–E: Minimun-intensity projection image (MinIP) following modified Blalock–Taussig shunt in a 9-month old girl suffering from pulmonary atresia with ventricular septal defect. Coronal minIP imaging (A) shows homogeneous lung parenchyma attenuation (Class I). Anterior (B), posterior (C), right lateral (D), and left lateral (E) views of lung perfusion scans show homogeneous perfusion (Class I). Renal accumulation is also shown because of right-to-left shunt. F–J: A 5-year-old boy with atrial septal defect. Coronal minimum-intensity projection imaging (F) shows homogeneous lung parenchyma attenuation (Class I). Anterior (G), posterior (H), right lateral (I), and left lateral (J) views of lung perfusion scans show homogeneous perfusion (Class I).