Patent Ductus Arteriosus

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Abstract

Patent ductus arteriosus (PDA) is the continuous connection between the pulmonary artery and aortic after birth, resulting in an abnormal shunt through ductus. It is one of the most common congenital heart diseases, which can exist alone or can be combined with other congenital cardiac malformations. The diagnosis can be accomplished by noninvasive imaging examination. However, more details need to be evaluated before clinical decision-making. In this chapter, based on a typical case, we will make a systematic understanding of PDA and discuss the role of CT in the diagnosis and treatment of PDA.

19.1 Case of PDA

19.1.1 History

- A 52-year-old female patient was identified with a cardiac murmur detected by a routine physical examination in more than 20 years ago.
- Dyspnea on exertion and occasional precordial pain occurred without edema of lower limbs in the last 3 years.

Physical Examination

- Auscultation: a "machinery" murmur was heard at the second interspace to the left sternum through the entire cardiac cycle.

19.1.2 Imaging Examination

Echocardiogram

Echocardiogram revealed a patent ductus arteriosus extended between the left pulmonary artery and descending thoracic aortic isthmus. The inner diameter of the patent ductus was about 9 mm. And a left-to-right shunting through the ductus arteriosus was detected.

X-Ray (Fig. 19.1)

CT Images (Fig. 19.2)

Cardiac Angiography (Fig. 19.3)

19.1.3 Imaging Findings and Diagnosis

The CTA images, echocardiography, and aortic angiography manifested the patent ductus arteriosus connecting the proximal descending aorta

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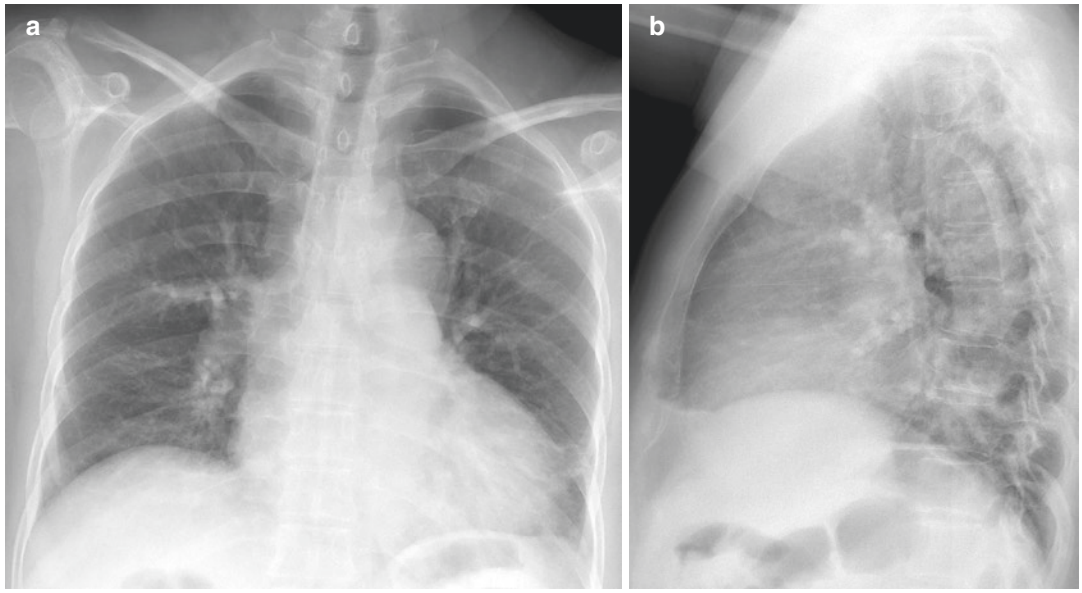

Fig. 19.1 The pulmonary artery was prominent. And pulmonary vessels in the lungs were enlarged, indicating the increased pulmonary blood flow. In the anteroposterior (**a**) and left lateral (**b**) projection, the apex was low and downward due to the left ventricular enlargement. The cardiothoracic ratio was 0.60

and main pulmonary artery. Left-to-right shunting through the ductus arteriosus could be detected by echocardiography and aortic angiography. The apex was low and downward due to the left ventricular enlargement (Fig. 19.1). PDA can be clearly diagnosed with a comprehensive analysis of the signs above (Figs. 19.2 and 19.3).

19.1.4 Management

The patient underwent patent ductus arteriosus occlusive operation. A 16/14 mm ductal occlusive device was implanted. When the left-to-right shunt through ductus disappeared during the procedure, the occlusive device was successfully released.

19.2 Discussion

The ductus arteriosus is a fetal vascular structure between the proximal descending aorta and the main pulmonary artery, which normally closes spontaneously after birth. The patent ductus arteriosus (PDA) is the neonatal persistence of the essential conduit. It has been reported that the incidence of PDA is 1 in 2000 term newborns and the female-to-male ratio is about 2:1 [1, 2]. This accounts for 5–10% of all congenital heart disease.

The lungs of the fetus have no ventilation functions and pulmonary circulation resistance is high. The blood from right ventricle mainly flows into the descending aorta through the ductus arteriosus in fetal period. Then the pulmonary circula-

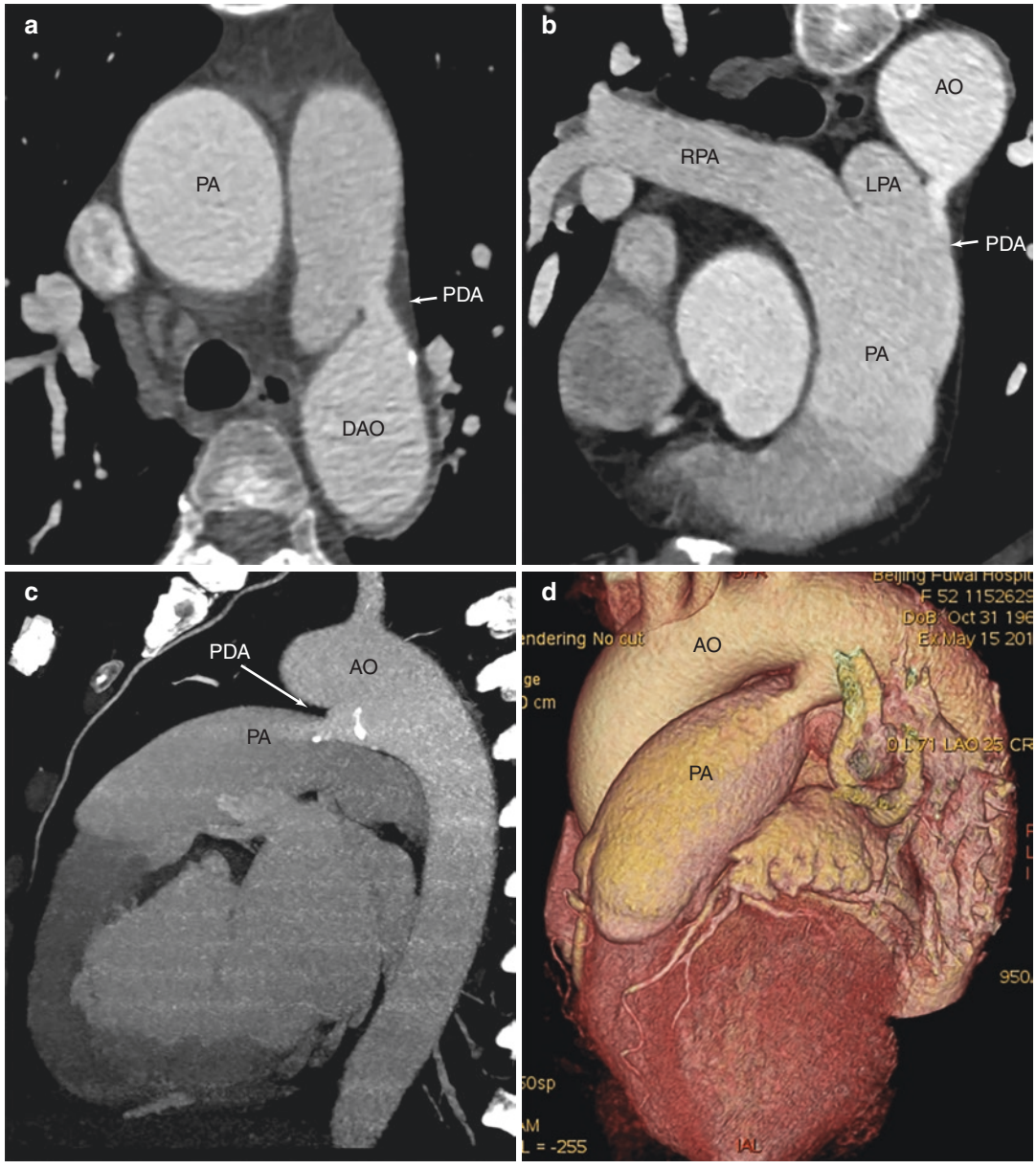

Fig. 19.2 (**a**, **e**, axial view; **b**, **c**, MPR; **d**, VR; **f**, **g**, **h**, CPR) The axial view (**a**), multi-planar reformation (**b**, **c**) and volume rendering (**d**) showed the patent ductus arteriosus extended between proximal descending aorta and pulmonary artery. (**e**) Axial view also manifested the enlargement of the left atrium and ventricular. Curved planar reconstruction (**f**, **g**, **h**) showed unobstructed lumens of LAD, RCA, and LCX

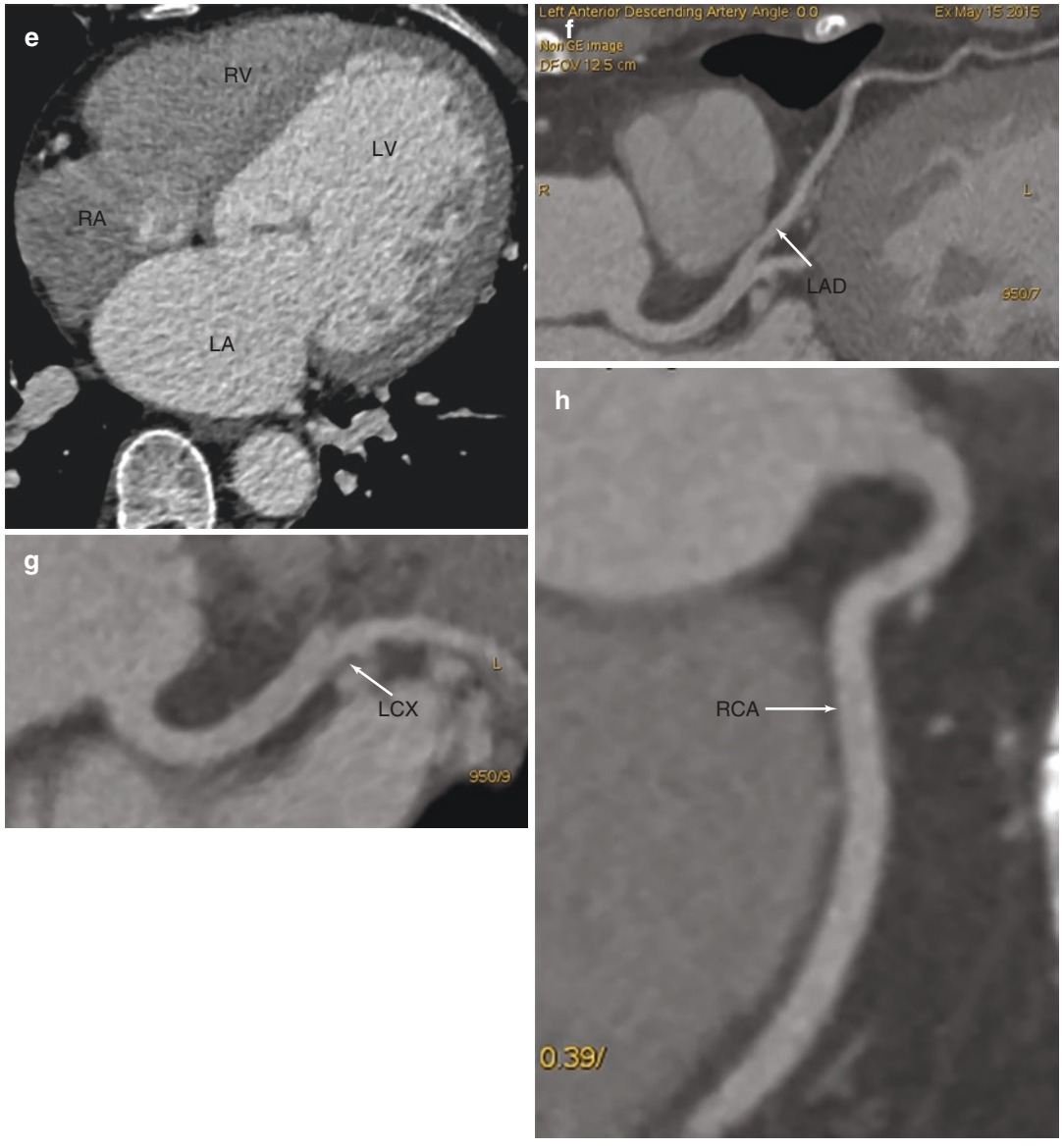

Fig. 19.2 (continued)

tion resistance decreased being lower than aortic pressure as the lungs inflate after birth, and the blood flows directly into pulmonary arteries from right ventricle. When the ductus persists, the shunting from the aorta to the pulmonary artery (the left-to-right shunt) can lead to a series of hemodynamic and pathophysiological changes such as pulmonary over-circulation, a progressive increase in pulmonary vascular resistance and systemic hypoperfusion. When pulmonary vascular resistance exceeds the systemic vascular resistance, ductal shunting reverses causing cyanosis.

The symptoms of PDA patients vary a lot, depending on the shunt, pulmonary vascular resistance, age, and complicated with other malformations. There may be no obvious clinical

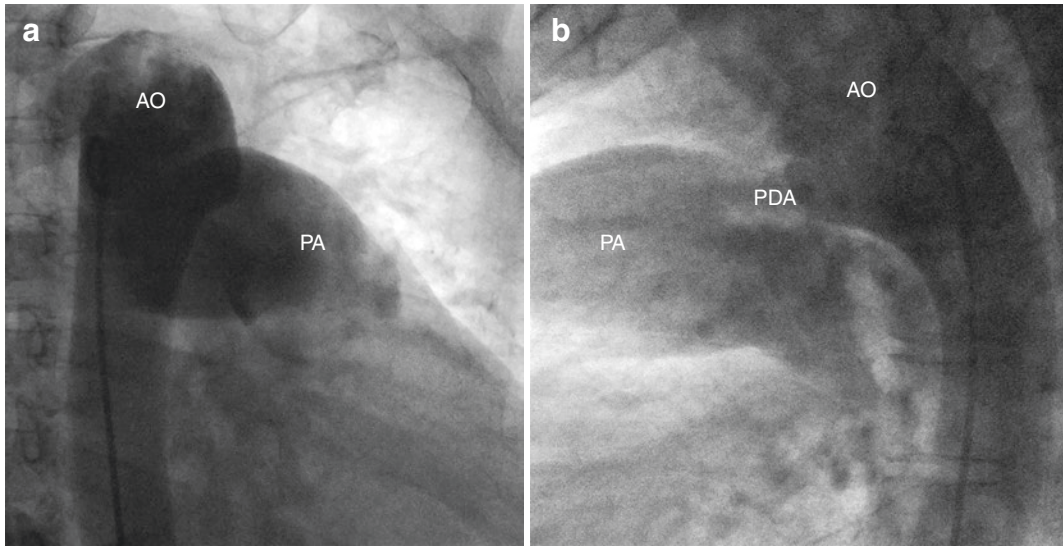

Fig. 19.3 Aortic angiogram showed the pulmonary arteries imaging could be immediately obtained after aortic imaging indicating the left-to-right shunting (**a**). In lateral projection (**b**), the ductus arteriosus was showed which connected the proximal descending aorta and the main pulmonary artery

symptoms in patients with small shunts. However, most patients may have complaints of palpitations, shortness of breath, fatigue, chest pain, recurrent respiratory tract infection, and stunting of growth in infancy. In the physical examination, the hallmark indicator is a continuous "machinery" murmur, located at the left margin of the sternum between the second and third interspaces. In the patient with a large ductus arteriosus, ECG may demonstrate sinus tachycardia or atrial fibrillation, left ventricular hypertrophy, and left atrial enlargement [3].

The typical imaging feature is the patent arteriosus extending between descending aorta and the main pulmonary artery closely to the root of left pulmonary vessel. And the echocardiogram is still the procedure of choice to make a diagnosis of PDA and then do many evaluations. The M-mode echocardiography can be used to measure the cardiac chamber sizes and evaluate left ventricular systolic function. And the degree of ductal shunting can be estimated sensitively and effectively by color Doppler. Depending on the amount of shunting, the chest film may be normal or demonstrate cardiomegaly with an enlarged pulmonary artery. Enhanced CT examination could show the vascular connectivity between the proximal descending aortic and the distal main pulmonary artery. The axial view, volume reconstruction, and sagittal MPR reconstruction can clearly manifest the position of aortic and pulmonary artery, as well as the position, shape, and size of ductus arteriosus. In addition, CT can be used to identify and evaluate the development status of aorta and pulmonary artery, calcification of ductus arteriosus and other cardiac defects.

19.3 Current Technical Status and Applications of CT

The diagnosis and management decisions of PDA can be accomplished by echocardiography alone. However, the abnormalities beyond the sonographic window, complex three-dimensional lesions, and detailed functional information require additional imaging [4]. CT can be used to provide the information above and identify and evaluate other associated cardiac malformations. Nowadays, 3D imaging derived from CT is

widely used to improve understanding of complex anatomy [5, 6]. Besides, for patients over 50 years old, it is necessary to rule out the possibility of coronary heart disease before operation. ECG-gated CT scan can make a definite diagnosis of coronary artery lesions and reduce unnecessary invasive coronary angiography. It not only saves the economic cost but also avoids the injury.

19.4 Key Points

- The patent ductus arteriosus (PDA) is a vascular structure that connects the proximal descending aorta to the roof of the main pulmonary artery near the origin of the left branch pulmonary artery.
- The diagnosis and management decisions of PDA can be simply accomplished by noninvasive imaging examination.
- CT provides the information beyond intracardiac structure for a comprehensive evaluation before treatment.

References

1. Carlgren LE. The incidence of congenital heart disease in children born in Gothenburg 1941–1950. Br Heart J. 1959;21:40–50.
2. Mitchell SC, Korones SB, Berendes HW. Congenital heart disease in 56,109 births: incidence and natural history. Circulation. 1971;43:323–32.
3. Schneider DJ, Moore JW. Patent ductus arteriosus. Circulation. 2006;114(17):1873–82. https://doi.org/10.1161/circulationaha.105.592063.PMID:17060397.
4. Chan FP, Hanneman K. Computed tomography and magnetic resonance imaging in neonates with congenital cardiovascular disease. Semin Ultrasound CT MR. 2015;36(2):146–60. https://doi.org/10.1053/j.sult.2015.01.006.PMID:26001944.
5. Kasprzak JD, Witowski J, Pawlowski J, et al. Percutaneous patent ductus arteriosus closure using intraprocedural mixed reality visualization of 3D computed tomography angiography data: first-in-man experience. Eur Heart J Cardiovasc Imaging. 2019;20(7):839. https://doi.org/10.1093/ehjci/jez008.PMID:31220228.
6. Saunders AB, Doocy KR, Birch SA. A pictorial view of the three-dimensional representation and comparative two-dimensional image orientation derived from computed tomography angiography in a dog with a patent ductus arteriosus. J Vet Cardiol. 2019;2019(21):34–40. https://doi.org/10.1016/j.jvc.2018.09.004.PMID:30797443.