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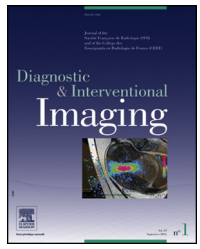

PICTORIAL REVIEW / *Cardiovascular imaging*

MDCT of interatrial septum

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Abstract ECG-gated cardiac multidetector row computed tomography (MDCT) allows precise analysis of the interatrial septum (IAS). This pictorial review provides a detailed description of the normal anatomy, variants and abnormalities of the IAS such as patent foramen ovale, congenital abnormalities such as atrial septal defects as well as tumors and tumoral-like processes that develop on the IAS.

Introduction

Major technical advances in computed tomography (CT) in recent years have made it possible to use multidetector row CT (MDCT) in the field of cardiac imaging. Besides coronary arteries, ECG-gated cardiac MDCT provides high-resolution images of all cardiac structures. It is therefore important for radiologists to understand and be able to analyze the normal anatomical structures, variants and diseases of these different structures.

This article provides an analysis of the interatrial septum (IAS) based on a pictorial review. After a short embryological and anatomical description, we will illustrate the normal anatomy and variants of the IAS, anomalies such as patent foramen ovale (PFO), congenital diseases such as atrial septal defects (ASD) as well as tumors and tumoral-like processes that develop on the IAS.

Abbreviations: ASA, atrial septal aneurysm; ASD, atrial septal defect; ECG, electrocardiogram; IAS, interatrial septum; IVC, inferior vena cava; IVS, interventricular septum; LV, left ventricle; M, myxoma; PFO, patent foramen ovale; RSPV, right superior pulmonary vein; RV, right ventricle; SVC, superior vena cava; MIP, maximal intensity projection; TEE, transesophageal echocardiography; TV, tricuspid valve.

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Embryological and anatomical description

The IAS is composed of two septa: the septum primum and the septum secundum.

The septum primum, which is the thin wall of the IAS, develops first. Then, the septum secundum, which is composed of muscular tissue, develops to the right of the septum primum, by forming a tunnel between the two atria, called the fossa ovalis. The fossa ovalis includes the area that is delimited by the septum secundum and covered by the septum primum.

During intrauterine life, these two walls are separate and fetal circulation occurs through this tunnel. This physiological interatrial communication short circuits pulmonary circulation and allows the flow of highly oxygenated blood from the umbilical vein via the inferior vena cava towards the left atrium.

In the first months of life, the septa primum and secundum fuse in response to increased left atrial pressure, thus creating a hermetically sealed wall between the two atria in 70 to 75% of patients. However, in 25 to 30% of the general population fusion of the septa does not occur or is incomplete, resulting in patent foramen ovale (PFO) (Fig. 1) [1].

Interatrial septum: anatomy and variants (channel-like, PFO, ASA)

The development of ECG-gated cardiac MDCT has made it possible to identify several morphological variants of the IAS on imaging:

- a completely closed IAS with no residual flap. Only the location of the fossa ovalis can be identified. This corresponds to complete fusion of the septa primum and secundum;
- a so-called ''channel-like'' variant, which is seen as a channel in the IAS. This ''channel-like'' feature in the IAS is a sign of incomplete fusion of the septa primum and secundum, so that the septum primum is visible on the left side of the IAS. On MDCT this ''channel-like'' element appears tubular shaped in the IAS. This channel-like IAS is a frequent anatomical variant in adults, which is usually asymptomatic, and only associated with confirmed PFO in certain cases (cf. infra). The frequency of this ''channel-like'' variant ranges in the literature from 15 to 38% [2,3].

Patent foramen ovale

PFO is a short permeable interatrial tunnel that is caused by incomplete fusion of the septum primum and the septum secundum, creating a double wall.

PFO needs to be distinguished from fossa ovalis defect (secundum ASD) by the completeness of the septum primum that is able to overlap the muscular rim of the septum secundum under normal circumstances.

PFO can result in an intermittent bidirectional shunt between the two atria based on the respiratory cycle. A left-to-right shunt is the most frequent. However, any temporary increase in right atrial pressure, such as a valsalva maneuver, coughing, or a physical effort can create a right-to-left shunt: a paradoxical embolism may occur in this situation.

The prevalence of PFO varies depending on the imaging modality and the population studied. In an autopsy-based series, the estimated prevalence was between 25% and 30% in the general population [1]. It is observed in approximately 15% of patients with bubble saline contrast transthoracic echocardiography and in 25% with transesophageal echocardiography (TEE) [2]. The presence of PFO is strongly associated with neurological events such as cryptogenic ischemia stroke in young patients. In this population, the presence of a PFO is identified in approximately 40% of patients by TEE. In migraine patients in the MIST 1 study, nearly 38% of the patients were shown to have a PFO on contrast-enhanced echocardiography.

Although TEE is the gold standard for the assessment of PFO, it is an invasive technique that is not always well tolerated, requiring sedation that can make it difficult to perform a valsalva maneuver. ECG-gated cardiac MDCT, with its excellent spatial and temporal resolution, provides a precise anatomical analysis of the IAS. In different studies, evaluating the IAS by MDCT, the following anatomic variants of IAS were described (Fig. 2) [2—5]:

- type 1: an IAS with no visible channel: no visible septal flap;
- type 2: a closed channel;
- type 3: an open channel with no visible jet flow of contrast material between the two atria;
- type 4: an open channel with a visible jet flow of contrast material between the atria.

The three latter types correspond to the classification ''channel-like''.

In a study of 152 patients comparing cardiac MDCT to TEE (the gold standard for the detection of PFO), Kim et al. concluded that the diagnosis of PFO by cardiac MDCT is strongly suggested in the presence of type 4 IAS (open channel with a jet flow of contrast material towards the right atrium, confirming the presence of a left-to-right shunt) [5]. On the other hand, a closed or opened channel with no visible jet flow (types 2 and 3) does not reliably confirm the presence of PFO. According to Saremi et al., a short channel and the presence of an atrial septal aneurysm (ASA) are frequently associated with the presence of a shunt (Fig. 3) [3].

Compared to TEE, cardiac MDCT only provides anatomical information obtained during a single breathhold, with no provocative test possible. This explains the mediocre sensitivity of cardiac MDCT for the diagnosis of PFO. While a left-to-right shunt through a ''channel-like'' IAS is specific for PFO on cardiac MDCT, a channel-like IAS alone can be observed in patients without PFO. The presence of a shunt associated with PFO depends not only on interatrial pressure but also on the anatomical characteristics of the PFO, such as the size of the entry zone into the right atrium and the length of the channel. A left-to-right shunt is more frequent when the free flap of the PFO (corresponding to the free rim of the septum primum) is short [3]. Moreover, a short channel and an ASA are frequently associated in patients presenting with a PFO with a left-to-right shunt.

Despite the insufficient diagnostic sensitivity for PFO, cardiac MDCT can nevertheless provide precise anatomical