Case Report

J Korean Soc Radiol 2021;82(2):435-439
https://doi.org/10.3348/jksr.2020.0070
eISSN 2288-2928

대한영상의학회지

CT Diagnosis of Paradoxical Embolism via a Patent Foramen Ovale in a Patient with a Pulmonary Embolism and Prominent Eustachian Valve

난원공개존증과 거대 유스타기오밸브를 가진 환자에서 기이색전증의 CT 진단

Min Ji Son, MD[1], Seung Min Yoo, MD[1]*, Charles S White, MD[2]

[1]Department of Radiology, CHA University Bundang Medical Center, Seongnam, Korea
[2]Department of Radiology, University of Maryland, Baltimore, MD, USA

While there is a high prevalence of patent foramen ovale in adults, paradoxical embolism via a patent foramen ovale is rare. Previous echocardiographic studies indicated that paradoxical embolism might only occur in patients with high-risk features of patent foramen ovale (i.e., large defect size, presence of a Eustachian valve, and high right atrial pressure). Here, we present a case of patent foramen ovale with high-risk CT features for paradoxical embolism.

Index terms Paradoxical Embolism; Patent Foramen Ovale; Computed Tomography, X-Ray

Received January 11, 2020
Revised April 22, 2020
Accepted May 13, 2020

***Corresponding author**
Seung Min Yoo, MD
Department of Radiology,
CHA University
Bundang Medical Center,
59 Yatap-ro, Bundang-gu,
Seongnam 13496, Korea.

Tel 82-31-780-5423
Fax 82-31-748-5000
E-mail smyoo@cha.ac.kr

ORCID iDs
Min Ji Son
https://orcid.org/0000-0002-5602-8315
Seung Min Yoo
https://orcid.org/0000-0002-1990-8145
Charles S White
https://orcid.org/0000-0002-9789-7648

INTRODUCTION

Prevalence of patent foramen ovale (PFO) is about 20–30% in the general population (1). Although most of PFOs are innocent bystander without clinical consequence, rare paradoxical embolism via PFO is associated with serious clinical conditions such as cryptogenic brain embolism, embolic myocardial or renal infarction, and even migraine (1, 2). According to the echocardiographic study (2), this discrepancy of the prevalence between silent PFO and paradoxical embolism may be caused by presence or absence of high risk features of PFO. However, high risk CT findings of PFO regarding paradoxical embolism is scarce in the literatures. The authors report a case of PFO dem-

onstrating the high risk CT features for paradoxical embolism with accompanying clinical findings.

CASE REPORT

A 70 year-old-male presented with acute chest pain and dyspnea to the emergency department. His blood pressure was low (systolic and diastolic pressure, 90 and 50 mm Hg, respectively), indicating hypotension. Serum level of D-dimer (10000 ng/mL, normal range = 0–500 ng/mL) and pro-brain natriuretic peptide (9140 pg/mL, normal range = 0–263 pg/mL) was increased suggesting presence of pulmonary embolism. Pulmonary CT angiography (CTA) was performed by using 64-slice multidetector-row CT (MDCT) (Light-speed VCT, GE Healthcare, Waukesha, WI, USA). CT scanning parameters were as follows: 120 kV and 650 mA, 0.625 mm collimation. Sixty mL of intravenous Ioversol (Optiray 320 mg/mL, Tyco Healthcare, Montreal, Canada) injected at a flow rate of 5 mL/s. CT scanning was initiated for CT attenuation valve of the main pulmonary artery > 100 Household units (HU) after contrast administration. On pulmonary CTA, multiple pulmonary emboli, embolus captured within the PFO, and multiple renal infarcts in the both kidneys (Fig. 1A-D) are demonstrated. Subsequent transthoracic echocardiography confirmed MDCT findings (i.e., mobile echogenic mass within the inter-atrial septum, marked dilation of right ventricle and atrium, and elevated right ventricular pressure (77 mm Hg) with tricuspid regurgitation). Electrocardiogram (ECG)-gated cardiac CTA (Light-speed VCT, GE Healthcare) was performed on 7 days later. CT scanning parameters were as follows: 120 kV and 750 mA, 0.625 mm collimation. Eighty mL of intravenous Ioversol (Optiray 320 mg/mL, Tyco Healthcare, Montreal, Canada) injected at a flow rate of 5 mL/s. CT scanning was initiated for CT attenuation valve of the ascending aorta > 100 HU after contrast administration. On ECG-gated cardiac CTA (Fig. 1E, F), PFO with a wide gap at the bottom and prominent Eustachian valve of inferior vena cava (IVC) are demonstrated.

Tissue plasmigen activator [Actilyse (Alteplase 60 mg, Boehringer Ingelheim Korea, Seoul, Korea)] was intravenously administered for 2 hours, and conservative treatment including oxygen supply were performed. And then, after loading dose (3600 IU) of intravenous heparin (Heparin sodium, Greencross, Yongin, Korea), 25000 IU of heparin per day was infused for 7 days while monitoring the level of serum aPTT. After discontinuation of intravenous heparin, 15 mg Xarelto (Rivaroxaban, Bayer Korea, Seoul, Korea) was administered for anticoagulation twice per day.

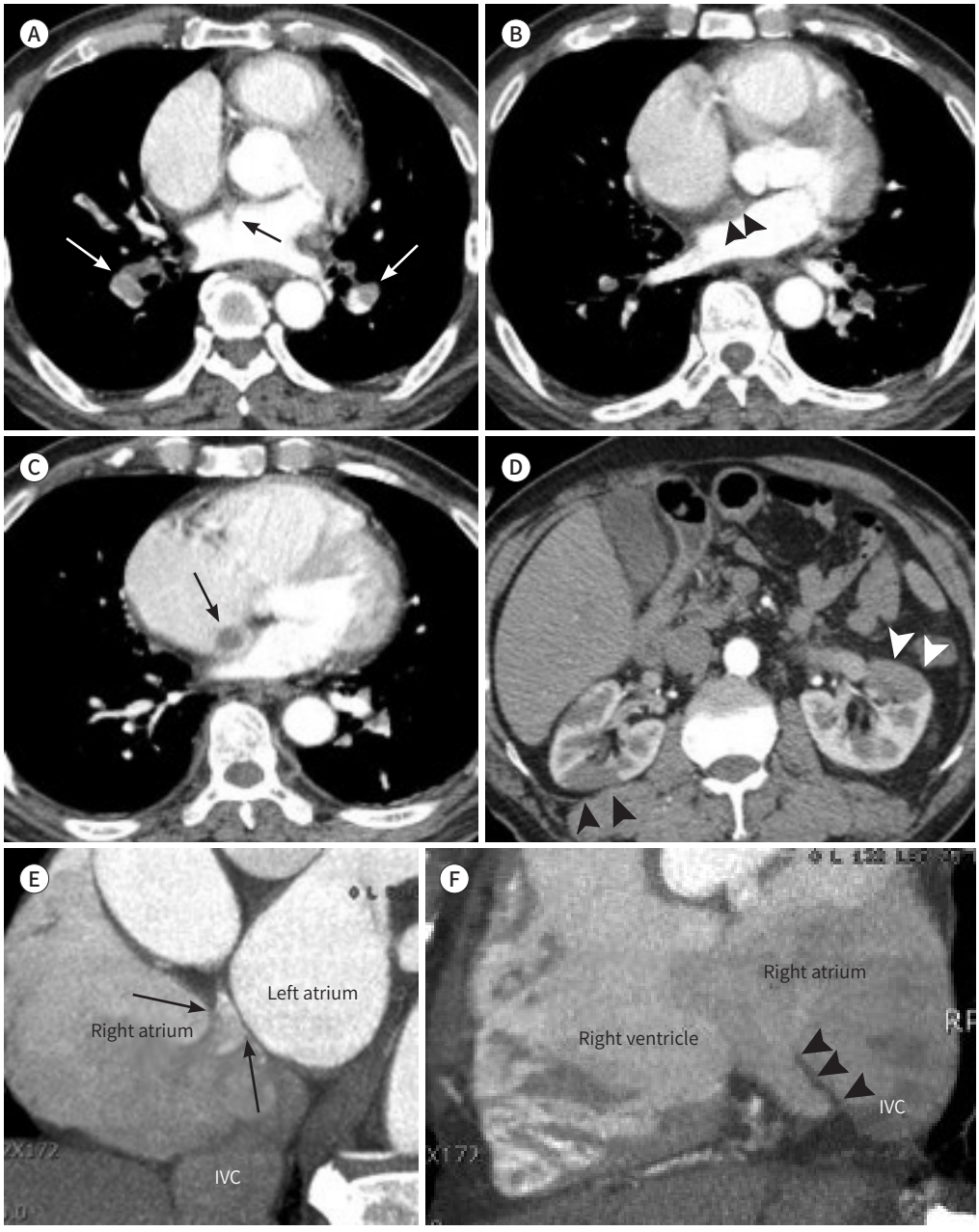
Decrease in the extent of pulmonary embolism was noted on follow-up pulmonary CTA performed on 13 days later. After 2 weeks later, the patient denied residual dyspnea, and has been discharged without any consequence.

DISCUSSION

This case report represented a patient who has PFO with typical high risk CT features for paradoxical embolism.

Although contrast transthoracic and/or trans-esophageal echocardiography is primary tool

Fig. 1. A 70 year-old-male with paradoxical embolism via the PFO with a large Eustachian valve in the IVC.
A. On pulmonary CT angiography, multiple pulmonary emboli (white arrows) are demonstrated in both lungs on an axial image at the level of the left atrium. A low attenuation filling defect near the septum of the left atrium can be seen (black arrow).
B, C. The filling defect seen in (A) passes into the PFO (arrowheads on B) and continues into the right atrium (arrow, C), indicating that the embolus is captured within the PFO.
D. Multiple renal infarcts in both kidneys are seen (arrowheads).
E. On follow-up cardiac CT angiography performed 7 days later, a PFO, with a wide gap at the bottom, is observed (between the arrows).
F. A prominent Eustachian valve of the IVC (arrowheads) can be seen on the two-chamber view of the cardiac CT angiography.
IVC = inferior vena cava, PFO = patent foramen ovale



to diagnose PFO, Kim et al. (3) reported that cardiac CTA can identify the presence of PFO (i.e., channel-like appearance of the interatrial septum accompanied by left-to-right contrast agent jet) with moderate sensitivity (73.1%) and high specificity (98.4%) (2, 3). The chance of paradoxical embolism via PFO may increase at a situation with simultaneous presence of 1) marked increase of the right atrial pressure (e.g., massive pulmonary embolism); 2) large PFO; 3) prominent Eustachian valve (2, 4). Thus, variable combinations, and presence or absence of the high risk features may determine probability complicated by paradoxical embolism.

In the present case, presence of massive pulmonary embolism may further increase the size of PFO. In this case, there was marked dilatation of the right atrium and ventricle with tricuspid regurgitation (i.e., severe pulmonary hypertension) secondary to massive pulmonary embolism. Increase in the right atrial pressure compared to the contralateral side may displace septum primum into the left atrium leading to increase in size of PFO. This situation is similar to increase in the right atrial pressure during Valsalva maneuver. Thus, severity of the right-to-left shunt via PFO is determined just after the release of the Valsalva maneuver, not resting state (2). Eustachian valve of IVC has an important role in fetal circulation. That is, blood flow from the IVC preferentially directs PFO rather than tricuspid valve at the presence of prominent Eustachian valve (2). In a similar way, embolus originated from deep vein thrombosis in the lower extremity may preferentially direct PFO in the presence of large Eustachian valve, not right ventricle (2). All of these combinations may increase the chance of paradoxical embolism via PFO in the present case.

In conclusion, simultaneous presence of marked increase of the right atrial pressure, large PFO, prominent Eustachian valve of IVC may increase the chance of paradoxical embolism via PFO.

Author Contributions

Conceptualization, S.M.J., Y.S.M.; data curation, all authors; formal analysis, all authors; investigation, all authors; methodology, all authors; project administration, Y.S.M.; resources, S.M.J., Y.S.M.; software, S.M.J., Y.S.M.; supervision, Y.S.M.; validation, all authors; visualization, S.M.J., Y.S.M.; writing—original draft, all authors; and writing—review & editing, all authors.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Funding

None

REFERENCES

1. Meissner I, Whisnant JP, Khandheria BK, Spittell PC, O'Fallon WM, Pascoe RD, et al. Prevalence of potential risk factors for stroke assessed by transesophageal echocardiography and carotid ultrasonography: the SPARC study. Stroke prevention: assessment of risk in a community. *Mayo Clin Proc* 1999;74:862-869
2. Aggeli C, Verveniotis A, Andrikopoulou E, Vavuranakis E, Toutouzas K, Tousoulis D. Echocardiographic features of PFOs and paradoxical embolism: a complicated puzzle. *Int J Cardiovasc Imaging* 2018;34:1849-1861
3. Kim YJ, Hur J, Shim CY, Lee HJ, Ha JW, Choe KO, et al. Patent foramen ovale: diagnosis with multidetector CT--comparison with transesophageal echocardiography. *Radiology* 2009;250:61-67
4. Kato Y, Dembo T, Takeda H, Fukuoka T, Tanahashi N. Prominent persisting Eustachian valve initiates spontaneous right-to-left shunt and paradoxical embolism in a patient with patent foramen ovale. *Neurol Sci* 2011;32:925-926

J Korean Soc Radiol 2021;82(2):435-439

대한영상의학회지

난원공개존증과 거대 유스타기오밸브를 가진 환자에서 기이색전증의 CT 진단

손민지[1] · 유승민[1*] · Charles S White[2]

난원공개존증은 정상 성인에서 흔히 발견된다. 그러나, 임상에서 난원공개존증에 의한 기이색전증은 드물다. 심장 초음파를 이용한 이전 연구에 따르면, 기이색전증은 큰 직경이며, 유스타키오관이 동반되고, 좌우 심방의 압력차가 큰 난원공개존증에서 주로 발생하였다. 저자들은 기이색전증이 발생한 난원공개존증 환자 1예의 특징적인 CT 소견을 제시한다.

[1]차의과학대학교 분당차병원 영상의학과,
[2]매릴랜드대학 영상의학과

https://doi.org/10.3348/jksr.2020.0070