



Pericardial Recess: Computed Tomography Findings of Varying Disorders

심낭오목: 다양한 질환에서의 CT 소견

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A pericardial recess is frequently seen in patients undergoing chest computed tomography (CT). It is important to be aware of the normal anatomy of the pericardium as it is often mistaken for normal variants and/or disease. Therefore, we will describe the anatomy and location of the pericardial recess and the specific findings in various diseases associated with the pericardial recess.

Index terms Pericardium; Anatomy; Computed Tomography, X-Ray

INTRODUCTION

The pericardium is a fibrous sac surrounding the heart. It consists of visceral and parietal pericardium. The pericardial space between the two layers contains 15–30 mL of fluid. The pericardial space is divided into the pericardial space proper and the pericardial sinuses, which are connected to the pericardial recesses (1). The pericardial recesses formed by the pericardial reflection include superior aortic recess, inferior aortic recess, right pulmonic recess, left pulmonic recess, postcaval recess, right pulmonic venous recess, left pulmonic venous recess and posterior pericardial recess (2). Because the pericardial sinuses and recesses contain a space reserved for liquids, they can be observed on computed tomography (CT). Based on the study, all patients show at least one of the sinuses and recesses on CT, and the left pulmonic recess and transverse sinuses are most commonly found (3). Fluid retention in the pericardial recess may mimic mediastinal lymph node or mass, and the variants such as superior pericardial recess or aortopulmonary window recess should be differentiated from the mediastinal cystic lesions (1). In addition, CT findings are specific for pericardial effusion, pericarditis, pericardial hematoma, metastasis, calcification and pericardial effusion developing in the pericardial sinus and recess. Therefore, in this study, we investigated the CT

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findings of the pericardial recess in various disease of the pericardium.

DEFINITION AND ANATOMY OF PERICARDIAL RECESS AND SINUS

Normal pericardium consists of visceral and parietal pericardium, and is less than 2 mm on CT. The pericardial space between the inner visceral and outer parietal pericardium is divided into the pericardial cavity proper and the pericardial sinus, which connect the pericardial recesses. These spaces are not distinct compartments but are extensions of the pericardial cavity.

The pericardial sinuses are divided into transverse and oblique sinuses. The ascending aorta and pulmonary artery together are ensheathed by the visceral pericardium. The pulmonary and the major veins are covered by visceral pericardium, separately. The pericardial cavity is divided into an upper compartment surrounding the aorta and the pulmonary artery, and a lower compartment surrounding the superior/inferior vena cava and pulmonary vein. The transverse sinus is located between the two compartments, posterior to the ascending aorta and pulmonary trunk and above the left atrium. The oblique sinus lies behind the left atrium and inferior to the transverse sinus (Figs. 1, 2).

The pericardial recesses are formed by pericardial reflection covering heart and great vessels. Several studies have defined the pericardial recesses. Vesely and Cahill (2) systematically described the pericardial recesses, and their nomenclature is widely used. The pericardial recesses include superior aortic recess, inferior aortic recess, right pulmonic recess, left pul-

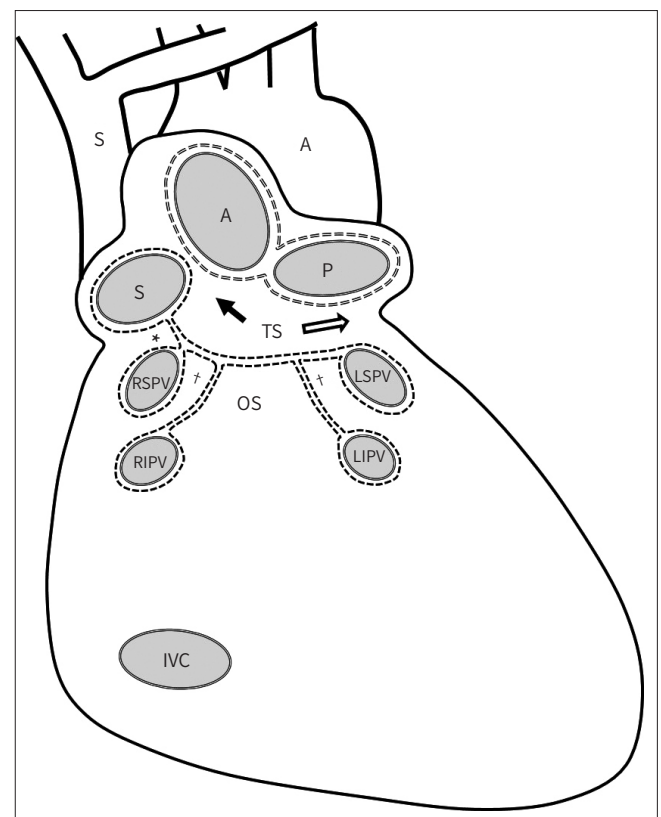


Fig. 1. Schematic representation of the interior of the serosal pericardial sac after segmentation of the large vessels.

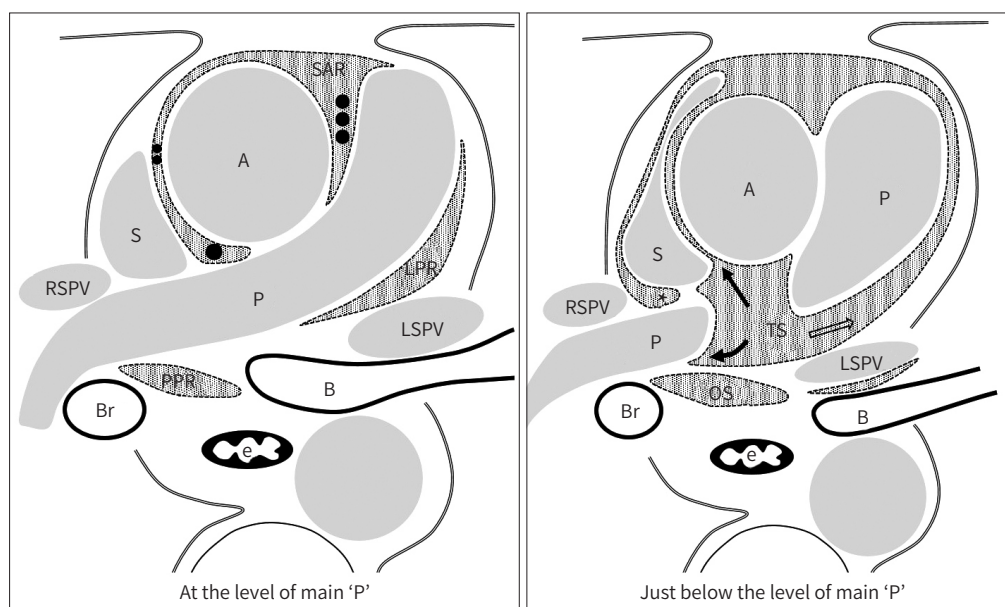
Line diagram illustrating the posterior pericardial reflection, which forms the transverse and OS and their associated recesses. Line diagram of the pericardial sinuses and recesses after segmentation of the large vessels and removal of the heart. Pericardial sinuses are composed of a TS and an OS. The pericardial space is divided into two compartments: one surrounding the 'A' and the 'P' (double dashed lines), and another surrounding the vena cava and the pulmonary veins (single dashed lines). The TS is located between the two compartments. The TS is connected to the superior aortic recess (black arrow) and the left pulmonic recess (white arrow). The right and left pulmonary venous recesses (+) are located between the superior and the inferior pulmonary veins. The postcaval recess (*) is located behind the 'S'.

A = aorta, IVC = inferior vena cava, LIPV = left inferior pulmonary vein, LSPV = left superior pulmonary vein, OS = oblique sinus, P = pulmonary artery, RIPV = right inferior pulmonary vein, RSPV = right superior pulmonary vein, S = superior vena cava, TS = transverse sinus

Fig. 2. Cross-section of the pericardial sinuses and recesses.

The pericardial sinuses are composed of the TS and the OS. The TS is connected to the aortic recess (straight arrow), the right pulmonic recess (curved arrow), and the LPR (open arrow). The aortic recess is divided into the superior and the inferior aortic recesses. The SAR is the uppermost portion of the TS and extends upward along the right side of the 'A' usually to the level of the sternal angle. The SAR is subdivided into the anterior (single dot), the right lateral (two dots) and the posterior (three dots) sections. The LPR is located between the proximal portion of the right main 'P' and the LSPV, below the left main 'P'. The OS lies behind the left atrium anterior to the 'e'. The PPR of the OS is located posterior to the right 'P' and medial to the Br. The postcaval recess (*) behind the 'S' is a diverticulum of the pericardial cavity proper. The left pulmonic venous recess is located posterior to the LSPV.

A = aorta, B = left main bronchus, Br = bronchus intermedius, e = esophagus, LPR = left pulmonic recess, LSPV = left superior pulmonary vein, OS = oblique sinus, P = pulmonary artery, PPR = posterior pericardial recess, RSPV = right superior pulmonary vein, S = superior vena cava, SAR = superior aortic recess, TS = transverse sinus



monic recess, postcaval recess, right pulmonic venous recess, left pulmonic venous recess and posterior pericardial recess.

FLUID IN PERICARDIAL RECESS AND SINUS

Normally, fluid is stored in the pericardium and the pericardial recess, and is easily visible on CT. Budoff et al. (4) reported that at least 97.2% of all cases carry at least one of the sinuses or recesses visible on precontrast electron beam tomography. The sinuses or recesses were seen at the following frequency: transverse sinus (93.9%), oblique sinus (71.8%), and superior aortic recess (51.2%).

Liquid retention of the pericardium varies in size depending on the scan time or the respiration state. In addition, pericardial effusion may increase or change in size depending on the size of the heart (Fig. 3). Pericardial effusion, pericarditis, constrictive pericarditis, and pericardial tumors can be seen in pericardial sinuses and recesses (5).

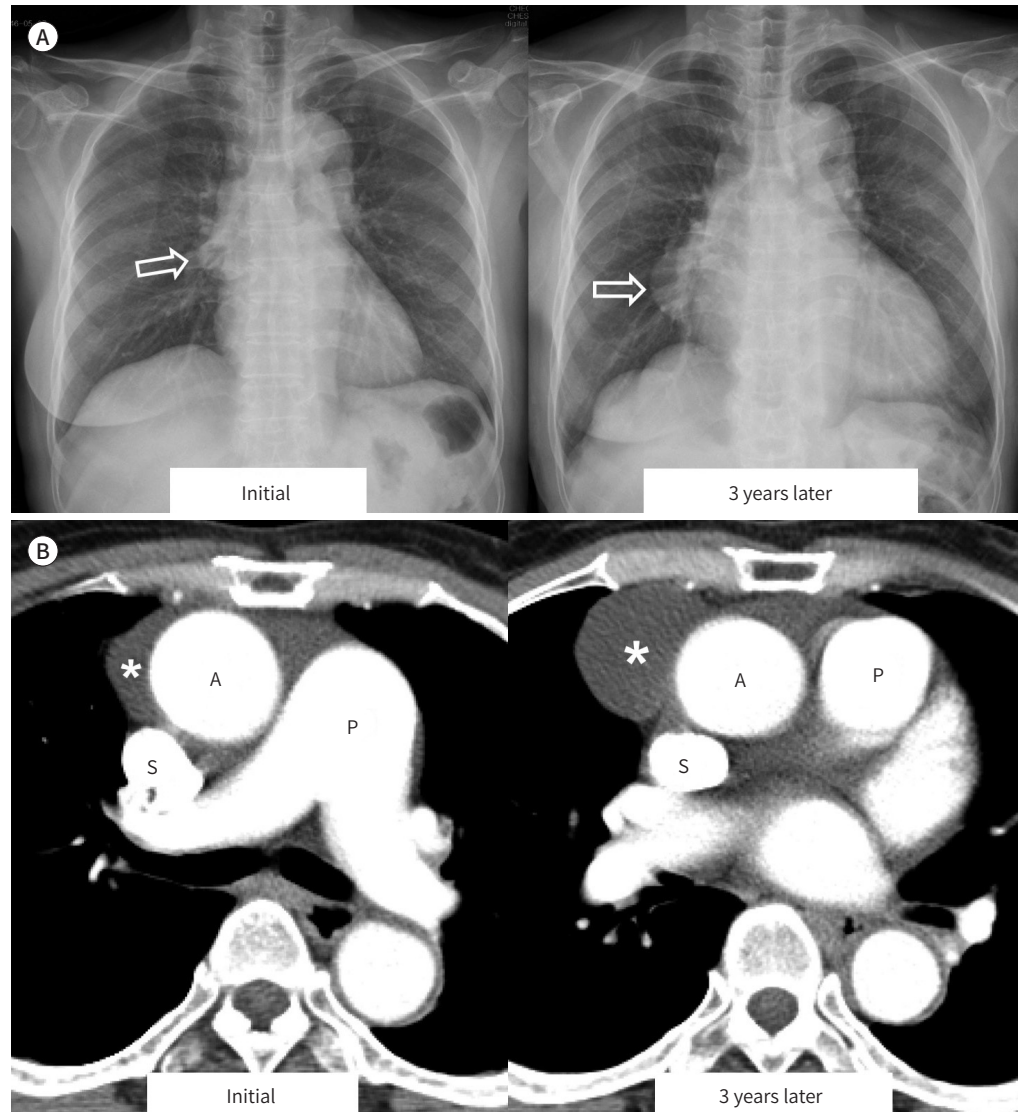
In the following sections, the location of each pericardial recess will be described and the

Fig. 3. Change in size of the pericardial recess in a 65-year-old woman.

A. Initial chest radiograph shows a small right mediastinal bulge (arrows), and an increased right mediastinal bulge and an enlarged cardiac size are seen on chest radiograph obtained 3 years later.

B. Axial CT image shows fluid collection (*) at the right lateral portion of the superior aortic recess, extending to the right cardiac border. Fluid collection at the cardiac border (*) is increased on CT obtained three years later. The size variation of the pericardial recess may be related to the amount of pericardial effusion rather than the cardiac size per se.

A = aorta, P = pulmonary artery, S = superior vena cava



clinical significance of the pericardial recess based on the related variants is discussed.

SUPERIOR AORTIC RECESS

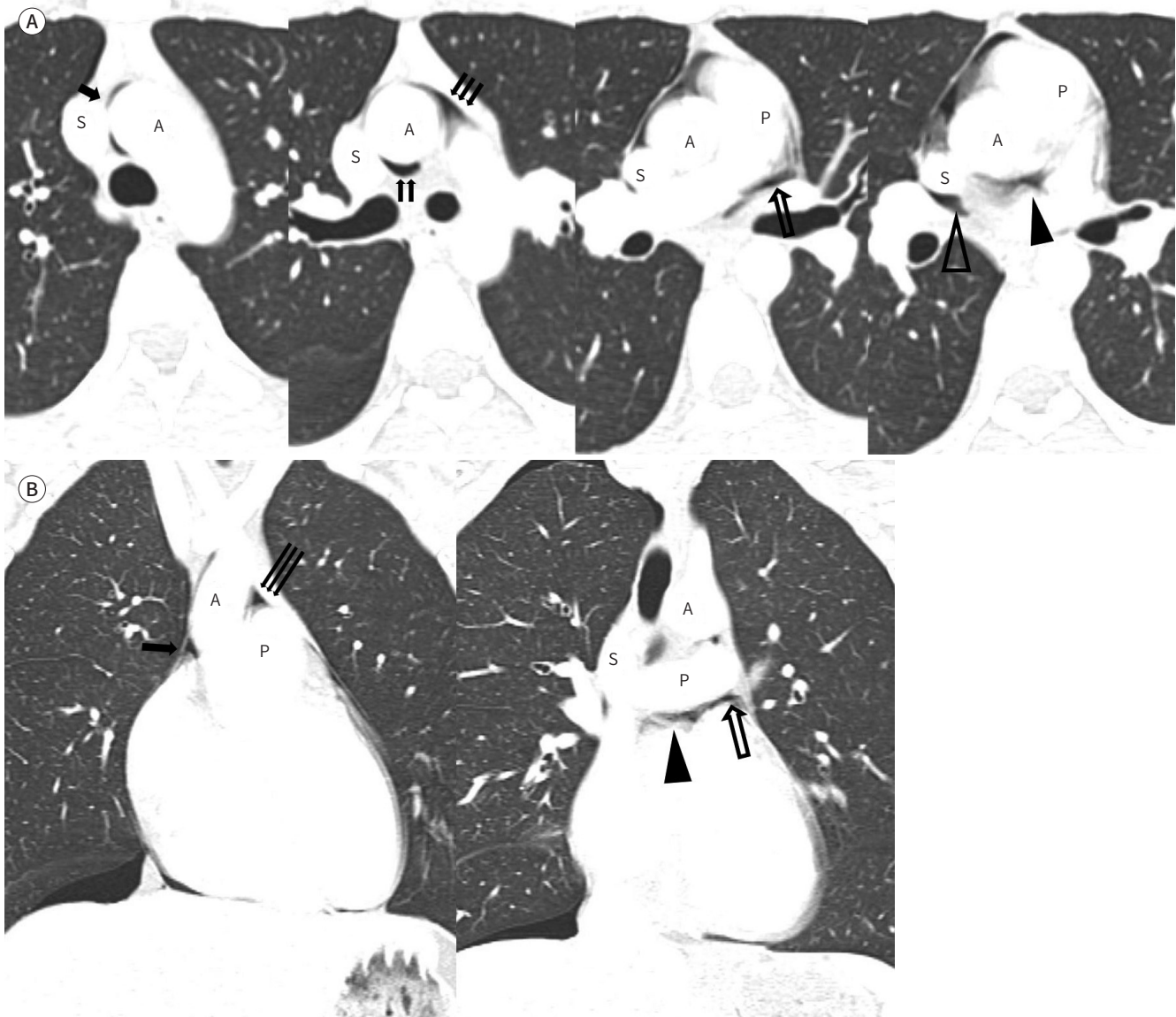
The superior aortic recess, located between the aorta and the superior vena cava, represents the superior extent of the transverse sinus. Kubota et al. (6) divided the superior aortic recess into anterior, posterior, and right lateral portions (Fig. 4). The anterior and posterior portions do not completely enclose the ascending aorta (Fig. 5). The superior aortic recess

has also been referred to as the recess aorticus, aorticocaval recess, superior pericardial recess, and superior sinus (7, 8). The superior sinus referred to by Aronberg et al. (9) was defined by a crescent-shaped fluid retention behind the ascending aorta, and corresponded to the posterior portion of the superior aortic recess. The anterior portion of the superior aortic recess was seen as a triangle between the ascending aorta and the pulmonary trunk, and as a beak-shaped structure in front of the aorta and pulmonary artery (Fig. 4). The right lateral extension of the superior aortic recess was detected between the ascending aorta and the superior vena cava, but its incidence on CT scan was lower than that of the anterior and poste-

Fig. 4. Pneumopericardium in a 17-year-old boy.

A, B. Serial axial (**A**) and coronal (**B**) images show air in anterior (triple arrows), posterior (paired arrows) and right lateral (arrows) portions of the superior aortic recess. A pneumopericardium is seen at the transverse sinus (arrowheads) posterior to the ascending thoracic 'A' in the axial view and below the main 'P' in the coronal view. Air was also detected at the postcaval recess (open arrowhead) and the left pulmonic recess (open arrows).

A = aorta, P = pulmonary artery, S = superior vena cava



rior portions (6). The fluid collection in the right lateral portion of the superior aortic recess may manifest as a right mediastinal contour bulge or cardiomegaly on chest radiograph, and appear as a cystic mass along the right anterior mediastinum on CT (Fig. 6) (10).

Normally, the pericardium extends upward along the ascending aorta to the level of the

Fig. 5. The anterior and posterior portions of the superior aortic recess in a 55-year-old man. Axial and coronal images show anterior (†) and posterior (*) portions of the superior aortic recess with a gap (arrows). This finding suggests that the superior aortic recess incompletely surrounds the ascending thoracic aorta.

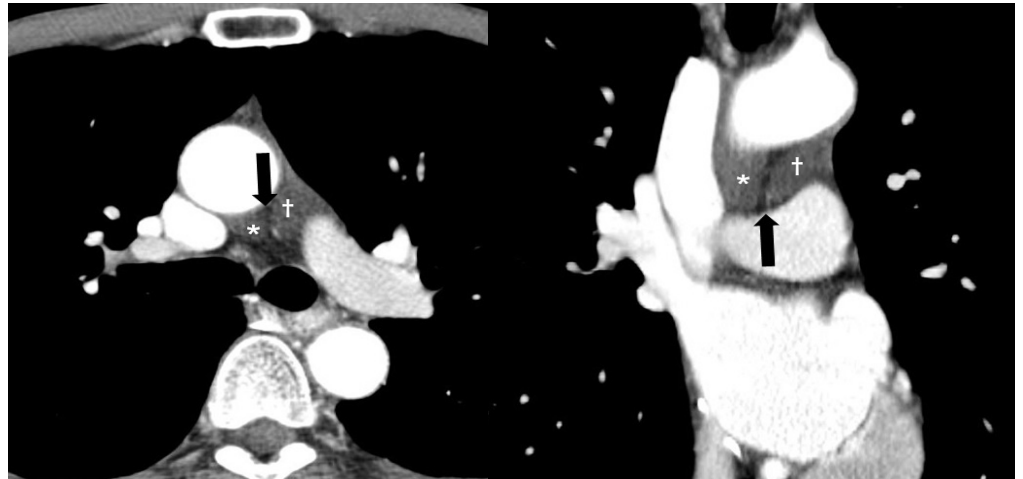


Fig. 6. The right lateral portion of the superior aortic recess in an 86-year-old woman. Serial axial and reformatted oblique sagittal images show a cystic mass (*) at the right anterior mediastinum, with contiguity (arrows) to the right lateral portion of the superior aortic recess. A = aorta, P = pulmonary artery, S = superior vena cava



sternal angle or 6 cm above the aortic root. However, the posterior portion of the superior aortic recess may extend cephalad into the upper right paratracheal region as a triangular, crescent-shaped, or elliptical water attenuation structure (Fig. 7). It was designated as a high-riding superior pericardial recess by Choi et al. (11). The anterior portion of the superior aortic recess may extend cephalad along the left lateral margin of aortopulmonary window and the aortic arch, forming the aortopulmonary window recess (Fig. 8). Fluid collection in the variants of pericardial recesses should be distinguished from mediastinal lymphadenopathy or cystic mass (Fig. 9). The variants can be differentiated by their typical location and contiguity with other pericardial spaces on multiplanar reformation.

Fig. 7. Pneumopericardium in a 62-year-old man, who was admitted due to a motorcycle accident.

Serial axial images show an air shadow in the high-riding superior pericardial recess (*) and the pericardial space proper (†).

A = aorta, S = superior vena cava, T = trachea

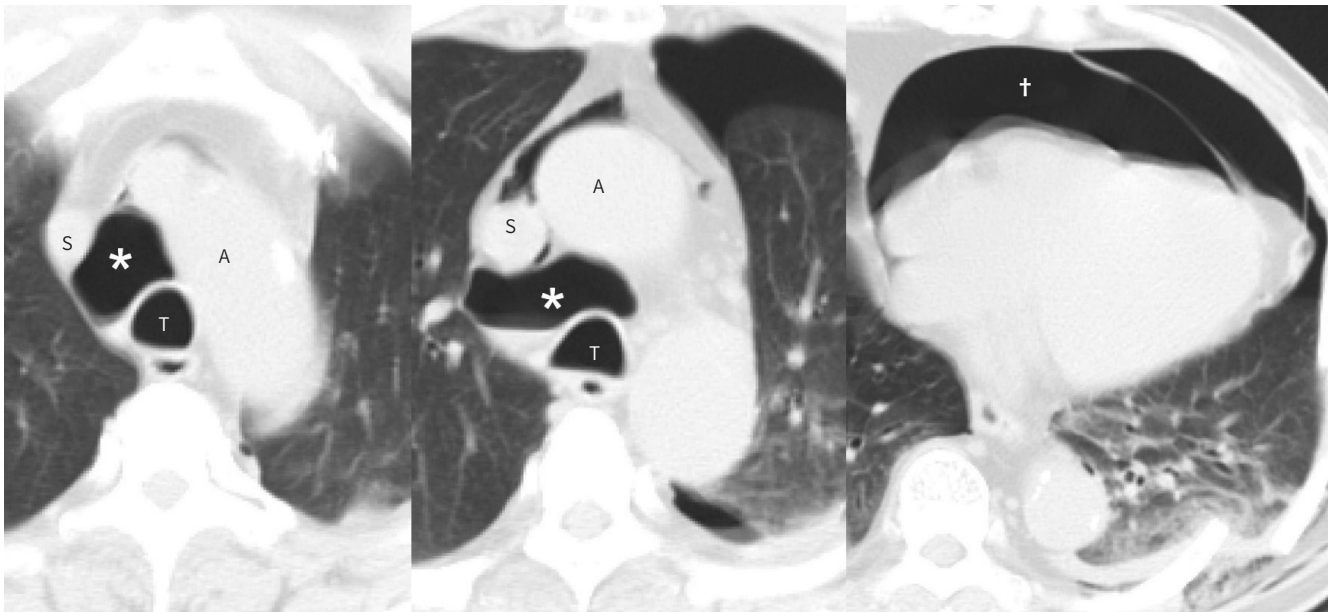
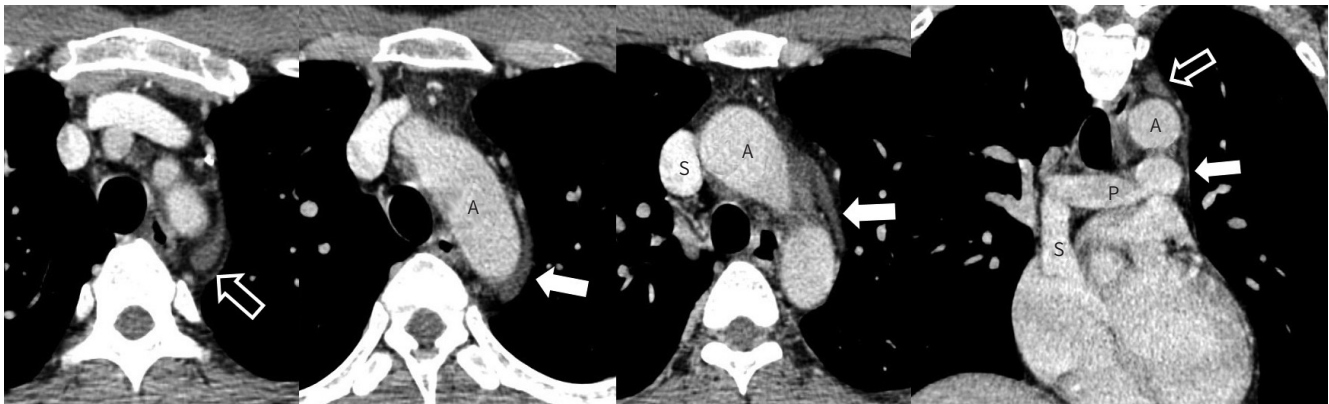


Fig. 8. Aortopulmonary window recess in a 37-year-old woman.

Serial axial and coronal images show fluid collection (arrows) along the aortic arch extending superior and posterior above the aortic arch (open arrows).

A = aorta, P = pulmonary artery, S = superior vena cava



INFERIOR AORTIC RECESS

The inferior aortic recess extends inferiorly from the transverse sinus posterior to the aorta and anterior to the left atrium (Figs. 9, 10). Extension into the lower portion of the aortic valve may be confused with aortic dissection.

RIGHT AND LEFT PULMONIC RECESS

The pulmonic recess is connected to both sides of the transverse sinus. The right pulmonic recess is located beneath the proximal portion of the right pulmonary artery (Fig. 4). The left pulmonic recess is located between the left superior pulmonary vein and the right pulmonary artery, and inferior to the left pulmonary artery.

POSTERIOR PERICARDIAL RECESS

The oblique sinus is located posterior to the left atrium, anterior to the esophagus (Fig. 1), and connected to the upper right to form a posterior pericardial recess (Fig. 2). The posterior pericardial recess is located posterior to the distal segment of the right pulmonary artery and on the medial side of the right bronchus.

POSTCAVAL RECESS

The postcaval recess is located behind and on the right lateral aspect of superior vena cava (Fig. 4A).

Fig. 9. Loculated pericardial effusion at the inferior aortic recess in a 46-year-old woman. Serial axial and coronal images show loculated pleural effusion at the inferior aortic recess (*). It can mimic a cystic mass. A = aorta, P = pulmonary artery, S = superior vena cava

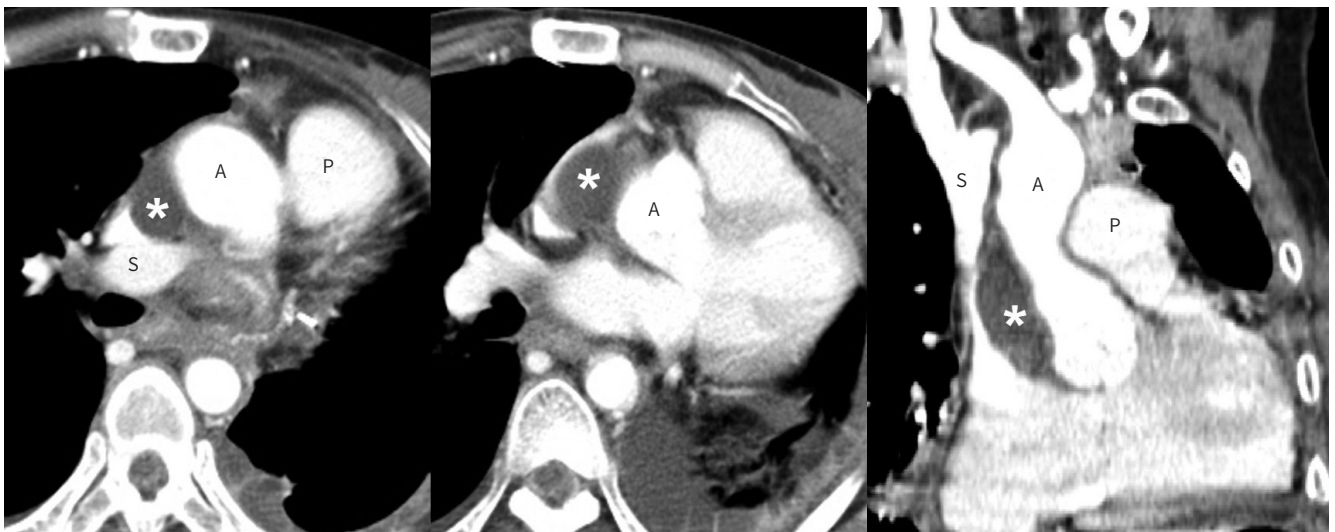
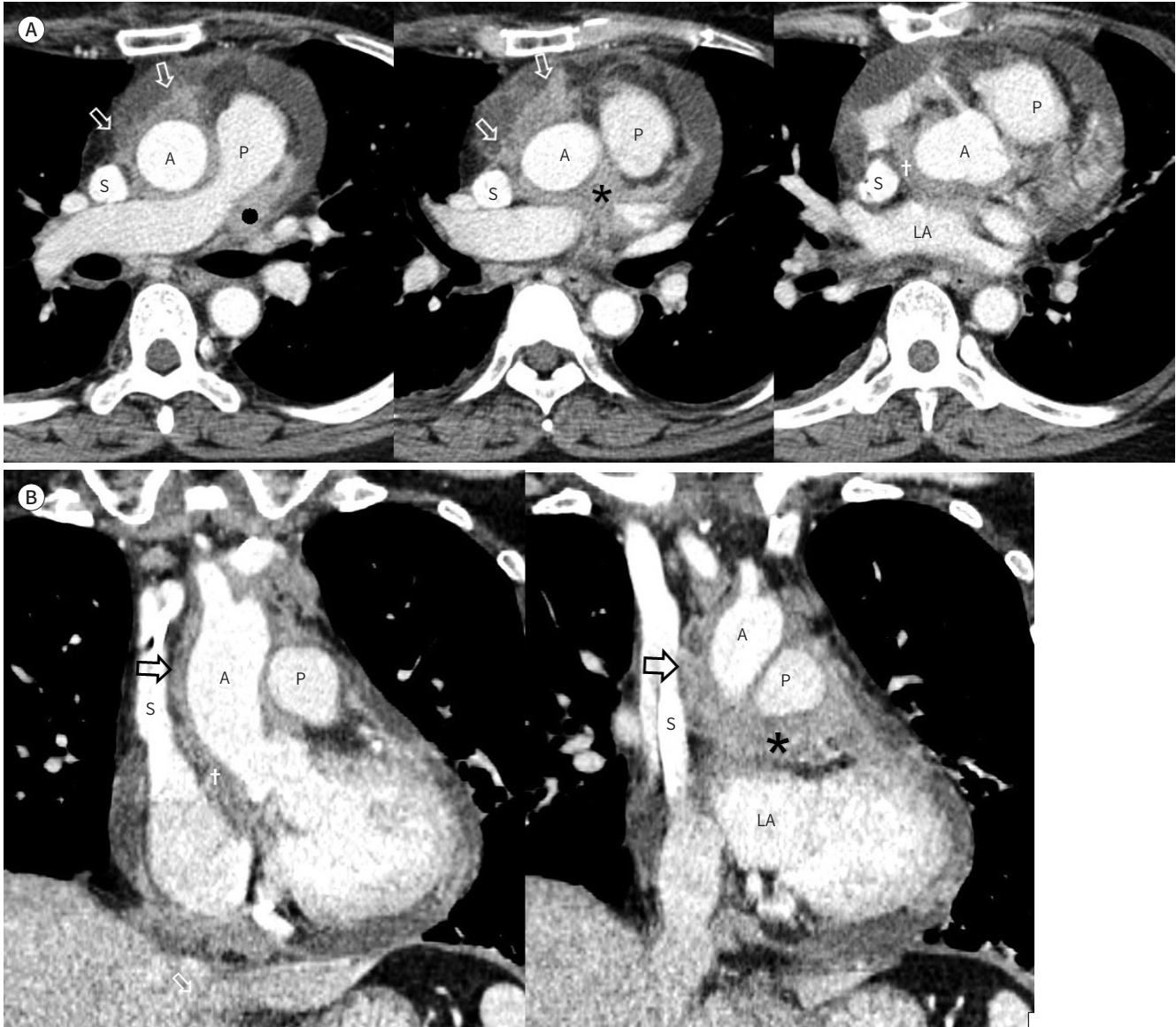


Fig. 10. Pericardial metastasis from breast cancer in a 49-year-old woman.

A, B. Serial axial (**A**) and coronal (**B**) images show irregular enhanced masses in the superior aortic recess (arrows), the left pulmonic recess (black dot), the transverse sinus (*) and the inferior aortic recess (†).

A = aorta, LA = left atrium, P = pulmonary artery, S = superior vena cava



RIGHT AND LEFT PULMONARY VENOUS RECESSES

The right and left pulmonary venous recesses are located between superior and inferior pulmonary veins. The pulmonary veins penetrate the fibrous pericardium as they enter the left atrium, and the serosal pericardium surrounds the veins in a sleeve (Fig. 11). The size of pulmonary venous recess is determined by the degree of fluid accumulation. Fluid in the sleeve can be misinterpreted as adenopathy. Fluid in pulmonary venous recess can be seen anterior and posterior to the vein; however, adenopathy is typically observed in a single segment of the vein.

Fig. 11. Right pulmonary venous recess in a 4-year-old boy.

Serial axial, coronal and sagittal images show fluid collection in the posterior (open arrows) and inferior (arrows) sleeves of the right inferior 'V'. Coronal image shows fluid collection in the inferior sleeve (arrows) of the right inferior 'V'. As the pulmonary veins penetrate the fibrous pericardium to enter the LA, a serosal sleeve of the pericardium surrounds the veins. At the level of the inferior 'V', pericardial fluid in the sleeve can be misinterpreted as adenopathy.

LA = left atrium, V = pulmonary vein



VARIOUS DISEASES ASSOCIATED WITH PERICARDIAL RECESS

Various diseases involving the pericardial recess reflect the distinct anatomical structure of the recesses and their respective connections (Fig. 4). Pneumopericardium, metastatic seeding nodules, calcification, and hemopericardium occur in the pericardial recess (Figs. 10, 12). In the case of pneumopericardium in a patient sustaining motorcycle accident, the air cavity along with the high-riding superior pericardial recess is a very rare finding (Fig. 7). Aggregated pericardial calcification in a 56-year-old man is characterized by the anatomical relationship between the posterior portions of superior aortic recess on coronal images (Fig. 13). Leaked contrast media or air into pericardial space reveals the anatomy of each pericardial sinus and recess (Figs. 4, 14).

We clearly identified the anatomy of the pericardial recesses and established the relationship between each other. Accurate localization of the pericardial recess in various diseases can facilitate understanding of the imaging findings.

CONCLUSION

The CT findings and anatomy of various recesses were discussed. Because of the location and characteristics of the pericardial recess, differential diagnosis of diseases is essential. For example, in case of fluid retention in the pericardial recess, it is necessary to distinguish between lymphadenopathy and mediastinal cystic mass. The definitive diagnosis of high-riding superior pericardial recess, aortopulmonary recess, and fluid collection in the right lateral portion of the superior aortic recess often requires differentiation from a cystic mass of the mediastinum. The diagnosis is facilitated by the location of recess, lack of mass effect on adjacent structure, and contiguity with other pericardial spaces on multiplanar reformation.

In conclusion, accurate diagnosis of diseases involving the pericardial sinuses and recesses can be established based on the location, shape and variants of pericardial recess.

Fig. 12. Hemopericardium by aortic dissection in a 70-year-old man.

Serial axial images show a high-attenuation hematoma at the inferior aortic recess (*), the transverse sinus (+) and the left pulmonic recess (‡).

A = aorta, P = pulmonary artery, S = superior vena cava



Fig. 13. Pericardial calcification in the superior aortic recess of a 56-year-old man.

Serial axial and coronal images show coarse calcification at the posterior portion of the superior aortic recess (arrows).

A = aorta, P = pulmonary artery

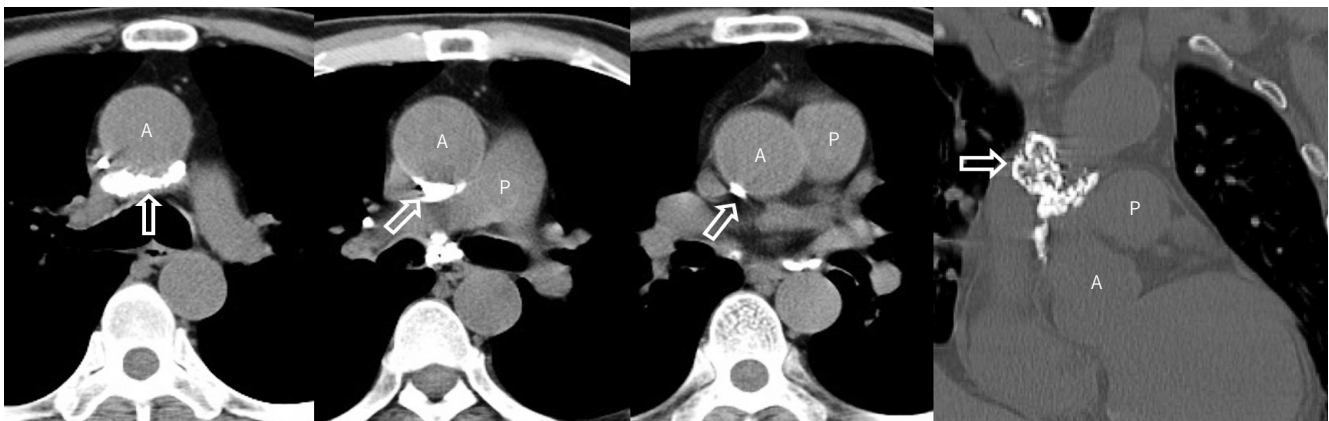
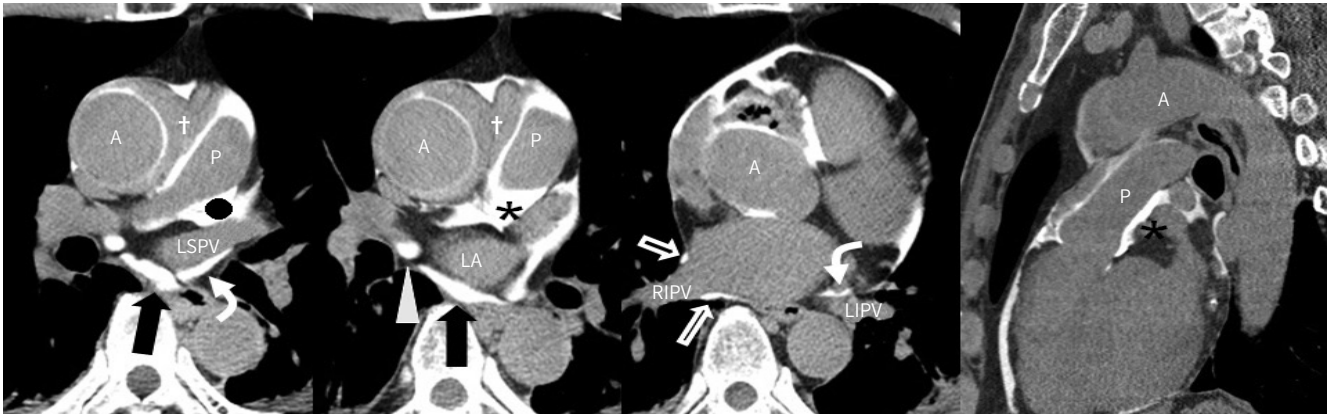


Fig. 14. Leakage of contrast media into the pericardial space due to iatrogenic coronary artery dissection in a 49-year-old man. The patient developed iatrogenic coronary artery dissection during coronary angiography. Serial axial and sagittal images show leaked contrast media and a hematoma in the pericardial cavity including the recesses and sinuses. Leaked contrast media and a hematoma are apparent at the anterior portion of the superior aortic recess (†). Also, note the leaked contrast media at the transverse sinus (*), the oblique sinus (black arrows), the left pulmonic recess (black dot), the posterior pericardial recess (white arrowhead), the right pulmonic venous recess (open white arrows), and the left pulmonic venous recess (curved white arrows). The oblique sinus is located anterior to the esophagus and cephalad to the LA.

A = aorta, LA = left atrium, LIPV = left inferior pulmonary vein, LSPV = left superior pulmonary vein, P = pulmonary artery, RIPV = right inferior pulmonary vein



Author Contributions

Conceptualization, all authors; data curation, S.J., K.Y.; investigation, S.J., K.Y.; supervision, K.Y., J.S., P.C.; visualization, S.J., K.Y.; writing—original draft, all authors; and writing—review & editing, all authors.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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심낭오목: 다양한 질환에서의 CT 소견

서진호 · 김영통* · 조성식 · 박찬호

심낭오목은 흉부 컴퓨터단층촬영을 받는 환자에서 종종 확인이 된다. 심낭은 종종 정상 변이나 질환과 오인될 수 있어 심낭의 정상 해부학 구조를 알고 있는 것이 중요하다. 그러므로 이 논문에서는 심낭오목의 해부학 및 위치 그리고 심낭오목과 관련된 다양한 질환에서 보일 수 있는 특징적인 소견에 대해 기술할 것이다.

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