Beyond the graft: incidental cardiac and extracardiac findings in cardiac CT studies of heart transplant recipients.

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Learning objectives

To underline the importance of carefully evaluating cardiac and extracardiac structures in heart transplant patients to detect potentially life-threatening conditions that may affect this patient population.
Background

Nowadays, heart transplantation (HT) has evolved as the procedure of choice for end-stage heart disease.

Due to immunosuppressive therapy and to the natural condition of cardiac transplantation, heart transplant patients are at risk of developing complications, many of them being asymptomatic and potentially critical for patients' life. The most common early post-transplantation mortality causes include rejection and acute right heart failure, which occurs in patients with severe pulmonary hypertension.

In the first year after transplantation, infection due to immunosuppressive therapy is the major cause of mortality. After the first year, coronary allograft vasculopathy (CAV) followed by malignancy are considered the most important causes of death.

Due to rapid data acquisition and its high spatial resolution, coronary CT angiography (CCTA) is becoming the reference standard for the clinical assessment of HT patients. This non-invasive imaging test possesses an excellent sensitivity, specificity and negative predictive value for the evaluation of the coronary arteries, heart chambers and cardiac function.

Furthermore, cardiac CT yields information of the mediastinum, lungs, pleura, chest wall, spine, upper abdomen and also enables to visualize HT complications. Reduced field of view reconstructions (FoV) allow for detailed evaluation of the heart, but may hamper the evaluation of other thoracic structures and limit the ability to detect diseases that may influence patient outcomes. Thus, full field of view reconstructions become mandatory in HT patients. In our patient cohort, we found 38 of 109 HT patients undergoing CCTA presenting a clinically relevant incidental finding.
Findings and procedure details

Why CCTA with large FoV?

The size of the FoV directly affects the number of incidental and clinically important extracardiac findings. A FoV confined to the heart improves the spatial resolution to evaluate coronary vasculature. Large FoV reconstructions are required, however, to depict disease involving the chest cavity, mediastinum and lungs. In fact, there are several studies that have shown that the majority of clinically important non-cardiac findings are only depicted with large FoV reconstructions. As an example, the most common incidental finding at CCTA are indeterminate pulmonary nodules, many of them located in the peripheral portions of the lungs. Considering that some of these pulmonary nodules correspond to an early stage lung cancer, which is potentially curable, the importance of large FoV reconstructions is undeniable.

1-CARDIAC FINDINGS

1.1 Coronary findings

CCTA allows the detection and characterization of the coronary artery lumen and wall. **Coronary allograft vasculopathy** (CAV) is usually silent and it is considered the main cause of death after the first year post-transplantation. CAV is manifested as diffuse luminal narrowing produced by a concentric intimal thickening of the arterial wall. Early diagnosis of CAV and prompt treatment are mandatory so as to prevent catastrophic events. (Fig 1, 2)

1.2 Non coronary findings

1.2.1 Normal postoperative appearance of orthotopic HT.

In orthotopic cardiac transplantation, the recipient’s heart is removed through a median sternotomy, and cuffs of the ascending aorta and pulmonary artery are left in place. HT is then performed using the biatrial or bicaval technique.

1.2.2 Heart chambers

In the biatrial technique, the enlargement of the left atrium is a normal post-transplantation finding because the posterior halves of the recipient’s left and right atria are preserved and anastomosed with the anterior parts of the donor’s atria (Fig.3). With the bicaval technique, the recipient’s right and left atria are excised, while inferior and superior caval
cuffs, the posterior wall of the left atrium and the pulmonary vein openings are left intact. (Fig. 3, 4)

The normal enlargement of the left atrium in orthotopic transplanted heart may favor the presence of atrial thrombus. (Fig.5)

In the evaluation of the myocardium, the presence of chronic cardiac infarcts can be detected as hypodense scars with myocardial thinning. (Fig.6)

1.2.3 Pericardial effusion

Postoperative pericardial effusions are frequently detected after orthotopic cardiac transplantation. They develop in approximately 20% of the patients and tend to occur within the first 3 months after transplantation. Late development of pericardial effusion is uncommon. (Fig.7, 8)

2-EXTRACARDIAC FINDINGS

2.1 Pulmonary findings

Due to the immunosuppressive therapy, infection is considered the first cause of death in heart-transplanted patients in the first year after transplantation. In particular, nosocomial and opportunistic pneumonia account for about 40% of the deaths in this patient population. (Fig.9)

Malignancy, presumably also related to immunosuppression, is the second most common long-term cause of mortality after the first year. Pulmonary tumors may appear as a new pulmonary nodule, solid mass or suspicious enlarged lymph node. The most common pulmonary tumors in these patients are adenocarcinomas and lymphoproliferative disorders. The latter can often present like a solitary mass, multiple non-cavitated nodules or mediastinal/hilar adenopathy. (Fig. 10, 11)

Pulmonary embolism following heart transplantation remains an important cause of morbidity and mortality despite using a correct thromboprophylactic regimen. As described in the literature, HT patients with pulmonary embolism are more likely to be on cyclosporine/mycophenolate mofetil regimen. The development of pulmonary embolism is associated with a higher mortality over the #ve-year follow-up period. (Fig 12, 13, 14)

2.2 Pleura

Pleural effusions are frequent after cardiac transplantation. Complications may occur in a small portion of patients, with most effusions being nonspecific and having a benign course with spontaneous resolution.
Pleural calcifications may also be observed, that could indicate prior asbestos exposure. (Fig. 15)

2.3 Chest wall and thoracic spine

Osteoporosis and the development of bone fractures are well-known complications in patients following organ transplantation and affect their quality of life.

With large FoV reconstructions, the presence of rib and vertebral fractures can easily be evaluated. Moreover, bone quality, the presence of vertebral hemangiomas and other focal bone lesions can also be assessed. (Fig. 16)

2.4 Abdominal findings

Hiatal hernia is considered the most common benign incidental finding.

Due to the vulnerability of heart transplant patients to develop tumors, solid abdominal organs should be reviewed in large FoV reconstructions. Pancreatic cysts, focal hepatic lesions and renal cysts are examples of benign pathology that may be found, yet malignant incidental tumors could also be identified. (Fig. 17, 18)
Fig. 1: Curved planar reformatted CT image for detection of coronary allograft vasculopathy. A. Example of diffuse concentric thickening of the left coronary artery (arrowheads). B. Left anterior descending artery showing a significant stenosis in the proximal segment (50-69% of luminal diameter). Diffuse concentric narrowing of the middle and distal segments of the coronary artery was also observed (arrowheads).

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**Fig. 2:** 69 year old HT patient with a significant stenosis of the proximal segment of the left anterior descending artery (Arrows in A, stenosis 50-69%) that progresses in two years (arrow in B, stenosis of 99%). In addition, this patient developed a new significant stenosis in the mid LAD (arrowhead in B)

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**Fig. 3:** A- Axial CT image showing the normal enlargement of the left atrium in biatrial technique. B- Axial CT image shows the normal appearance of a transplanted heart with the bicaval technique (the recipient’s right and left atria are excised, while inferior and superior caval cuffs, the posterior wall of the left atrium and the pulmonary vein openings are left intact)

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**Fig. 4:** Normal appearance of a Transplanted heart. (A) Axial cardiac CT image shows normal left atrial anastomosis that simulates abnormal dilatation of the left atrium. The donor left atrium was incised and sutured to the recipient’s posterior atrial wall (arrow). Axial (B) and coronal (C) cardiac CT images showing the surgical clips of the pulmonary artery and aortic anastomoses. Note that size discrepancies of the donor’s and recipient’s vessels may simulated abnormal dilatation.

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**Fig. 5:** A-Axial CT image demonstrating a giant left atrial thrombus. B-Reformatted 2-chamber view in the same patient showing the giant left atrial thrombus.

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**Fig. 6:** 65-year-old heart transplanted man with known coronary allograft vasculopathy. A. Axial CT image showing inferior and lateral myocardial thinning with a hypodense
subendocardial area representing fatty metaplasia in infarcted segments. B. Short axis image of the same patient.

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**Fig. 7:** Non-complicated pericardial effusion (*) in different heart transplant recipients.

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**Fig. 8:** Axial cardiac CT image early after HT showing a high density pericardial effusion (>35 HU) (arrowhead) and a hyperdense anterior mediastinal collection (arrow) compatible with mediastinal haematoma.

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**Fig. 9:** 70-year-old HT recipient with pulmonary infection. Axial cardiac CT images show multiple opacities (A, B) and a nodular RLL consolidation (C).

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**Fig. 10:** 63-year-old man with heart transplantation 7 years earlier. Axial cardiac CT images show a right hilar mass that infiltrates bronchial and vascular structures, including the RUL bronchus, right pulmonary artery and right superior pulmonary vein (Arrows).

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Fig. 11: 70 year old male transplanted 12 years earlier. Axial CT slices show a RLL subpleural nodule that represented lung cancer at biopsy.

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Fig. 12: 68 year old male with HT 6 years earlier. After a traumatic vertebral fracture the patient underwent vertebroplasty. As a complication of this procedure, cement embolism
in subsegmental branches in the right middle lobe (arrow in A) and left lower lobe (arrow in B) can be observed.

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**Fig. 13:** 66-year-old HT recipient. A tiny pulmonary embolism in subsegmental left upper lobe branches was incidentally found.

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**Fig. 14:** 66-year-old male. Pulmonary embolism in subsegmentary branches of the left lower lobe.

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**Fig. 15:** 72 year-old heart transplant recipient with history of prior asbestos exposure. Axial CT image showing calcified and non-calcified pleural plaques.
Fig. 16: A. Left rib fractures. B. Degenerative changes in the thoracic spine. C. Previously unknown vertebral hemangioma in the thoracic spine.
**Fig. 17:** Axial cardiac CT images show a hiatal hernia containing the gastric fundus

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**Fig. 18:** A-Incidentally found marked dilatation of a pancreatic branch duct compatible with intraductal papillary mucinous neoplasm (branch duct type) in a 54 year old male with HT years earlier. B-In another 77 year old male with HT 6 years earlier, CCTA revealed circumferential wall thickening of the esophagus. A biopsy confirmed an esophageal carcinoma.

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Conclusion

Considering that incidentally found extra-cardiac findings are frequent in heart transplant patients, and that many of them are serious and potentially fatal, a systematic review of cardiac CT examinations in this patient population is crucial.
References


