European Journal of Radiology Open 7 (2020) 100245

Contents lists available at ScienceDirect

European Journal of Radiology Open

journal homepage: www.elsevier.com/locate/ejro

Incidental, non-gated thoracic CT angiographic detection of proximal right coronary artery total occlusion associated with acute myocardial infarction

Rene Epunza Kanza[a,b,*], Samir Ayoub[b], Francis Bonenfant[c,b]

[a] Department of Radiology, Chicoutimi Hospital, Saguenay, QC, G7H5H6, Canada
[b] Faculty of Medicine, University of Sherbrooke, Sherbrooke, QC, J1H 5N4, Canada
[c] Department of Cardiology, Chicoutimi Hospital, Saguenay, QC, G7H5H6, Canada

ARTICLE INFO

Keywords:
CTA
Non-gated computed tomography angiography
RAG sign
RCA
Occlusion
Aorta

ABSTRACT

Herein, we present a case of a right coronary artery proximal occlusion and acute myocardial infarction with absence of the reverse attenuation gradient sign that was incidentally identified in the emergency room with non-gated computed tomography angiography of the aorta performed to rule out aortic dissection. This case highlights the importance of assessing the heart and coronary arteries even on non-gated computed tomography angiography.

1. Introduction

The use of chest computed tomography (CT) and aortic CT angiography (CTA) as imaging tests for the evaluation of thoracic pathology has significantly increased in recent decades [1]. Because the investigation of cardiac diseases is not the main purpose of these tests, radiologists tend to overlook the heart when interpreting non-gated thoracic CT [2,3]. Several studies have reported that recent advances in CT technology have led to a significant reduction in heart motion artifacts [1]. As a result, thoracic CT can now facilitate the identification of several cardiac findings, even without electrocardiogram (ECG) gating [2–4]. These observations range from benign to malignant, life-threatening discoveries.

Herein, we present the case of a complete, proximal right coronary artery (RCA) occlusion, associated with an acute myocardial infarction, in the absence of the reverse attenuation gradient (RAG) sign [5–8]. The occlusion and related infarction were incidentally identified on a non-gated CTA of the aorta performed in the emergency room to rule out an aortic dissection. The details of this case emphasize the importance of heart and coronary artery assessment by radiologists, cardiologists, and other referring physicians, even on non-gated CT.

2. Case presentation

A 57-year-old woman presented to the emergency department with epigastric pain that started 1 week prior to presentation and was constant at rest. The pain became more intense and radiated to her back the day before admission. She reported no associated chest pain, dyspnea, or signs of deep vein thrombosis. This was her first episode of such pain, but she had numerous cardiovascular risk factors including peripheral arterial disease, hypertension, dyslipidemia and a history of smoking. Her medical history also included a ruptured abdominal aortic aneurysm treated with aortoiliac bypass.

Her vital signs were normal, as were the results of physical cardiac and pulmonary examinations. Electrocardiography (ECG), routine laboratory tests, and aortic computed tomography angiography (CTA) were ordered upon admission to the emergency room to rule out myocardial infarction or aortic dissection. ECG revealed minor nonspecific changes without Q waves or ST elevations. The patient's heart rate during the ECG was 75 beats per minute. Laboratory tests revealed elevated troponin I (4.2 μg/L) and D-dimer (1548 μg/L) levels.

Aortic CTA was performed without ECG gating using a multi-slice computed tomography (MSCT) scanner (BrightSpeed 16, GE Healthcare, Milwaukee, WI, USA) after intravenous injection of 80 ml of iodinated contrast agent (Iopamidol 370 mgI/mL, Bracco Imaging, Montreal, Canada) at flow rate of 4 mL/s using the bolus tracking technique triggered on the ascending aorta. CT parameters included 2.5-mm slice thickness at a 1.25-mm interval, gantry rotation time 0.5 s, 120 kVp, average tube current 300 mA, and pitch 1.375:1. We used the single arterial phase acquisition technique. No venous or late phase

* Corresponding author at: Department of Radiology, Chicoutimi Hospital Affiliated with Sherbrooke University, 305 Rue Saint-Vallier, Saguenay, QC, G7H 5H6, Canada.

E-mail addresses: rn.kn.01@gmail.com, rene.kanza.epunza@usherbrooke.ca (R.E. Kanza).

https://doi.org/10.1016/j.ejro.2020.100245
Received 29 May 2020; Received in revised form 23 June 2020; Accepted 1 July 2020

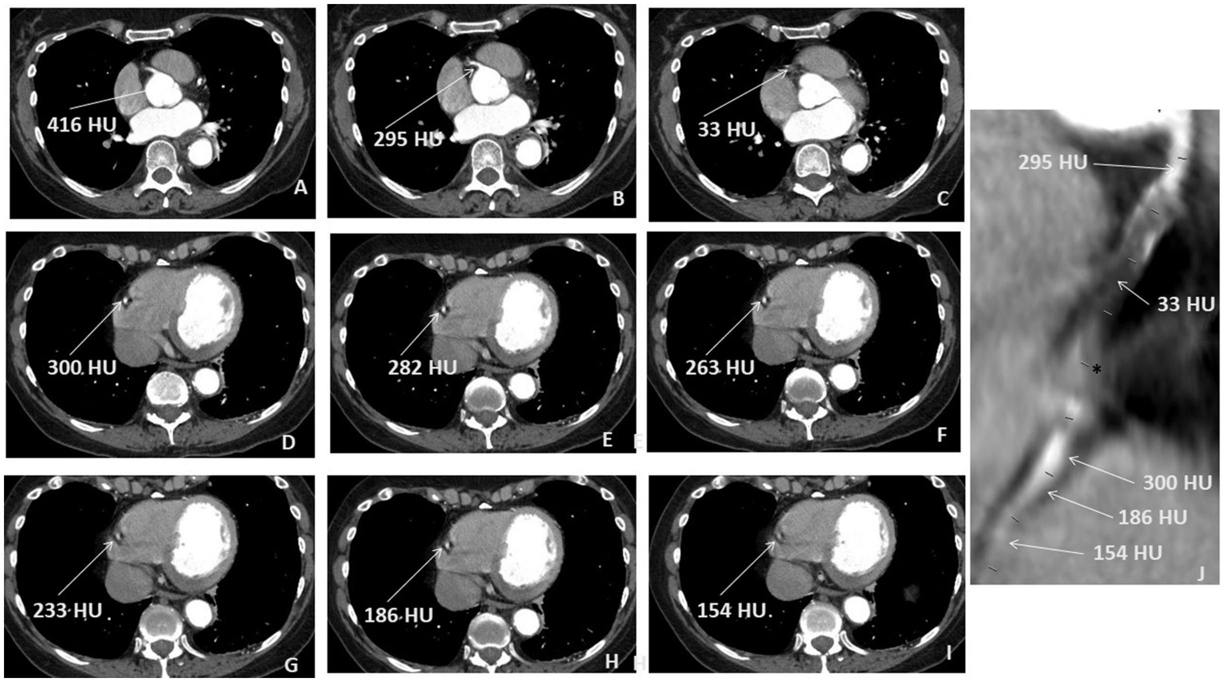

Fig. 1. A–J. A–I, Axial non-gated chest computed tomography angiography depicting different levels of endoluminal contrast attenuation from the aorta to the distal right coronary artery (RCA). Note the endoluminal hypodensity (32 Hounsfield units) on the proximal RCA (C) corresponding to the occlusive lesion due to thrombus. There is also evidence of linear decrease per slice of contrast attenuation distal to the occlusive lesion, consistent with the absence of RAG sign in the context of total RCA occlusion. The mean distal gradient attenuation was approximatively -35 Hounsfield units.
*Note that some of the slices at the mid-RCA have been excluded from the analysis because they were of nondiagnostic quality owing to artifacts.
J, Corresponding curved planar reformation (CPR) of the RCA image shows a nonopacified occlusive lesion. *Note a segment with inaccurate HU measurement due to motion artifact as well as the absence of RAG sign.

images were acquired.

Multi-planar reformation (MPR) as well as curved planar reformation (CPR) were obtained using a separate workstation (Agfa IMPAX 6.7, Agfa HealthCare, Mortsel, Belgium).

While CT angiography did not reveal any signs of dissection, despite the presence of some artifacts due to heart motion and possible misregistration of data, it incidentally revealed an abrupt interruption of opacification in the right coronary artery (RCA) approximately 1 cm from the ostium with endoluminal hypodensity that was suggestive of a total occlusion by a probable thrombus. The endoluminal hypodensity, representative of a non-opacified occlusive lesion, was relatively long (approximately 30 mm) and extended from the proximal to mid-RCA. (Fig. 1A–I). Distal to that area of non-opacification, the RCA was again opacified. Careful visual assessment of the RCA determined that the endoluminal attenuation directly beyond the occlusive lesion was higher and decreased linearly in a manner indicative of retrograde flow, but with absence of the reverse attenuation gradient (RAG) sign. Measurement of endoluminal contrast attenuation showed a negative mean value of attenuation gradient in the RCA distal to the occlusive lesion (Fig. 1D–I). The mean attenuation gradient of distal segments was approximately −35 Hounsfield units (HU)/slice, indicating an absence of the RAG sign. CPR of the RCA (Fig. 1J) also demonstrated the proximal, total occlusive lesion with contrast medium filling in the distal segment and an absent RAG sign.

Moreover, non-gated CTA depicted myocardial hypoattenuation in the RCA territory, suggestive of severe ischemia or infarction (Fig. 2A, B).

The patient was immediately given appropriate doses of acetyl salicylic acid, ticagrelor, morphine, and heparin. She was then taken to the cardiac catheterization laboratory and conventional coronary angiography was performed, revealing three-vessels disease (Fig. 3A, B), which was also visible on the corresponding CTA (Fig. 3D–F). Though the RCA was dominant and occluded from the proximal to middle portions, a good distal downstream bed was maintained due to well-developed collateral vessels from the left coronary artery (3 C). A small thrombus was present in the RCA just before the beginning of the occlusion, confirming the CTA findings. Retrograde flow into the distal RCA beyond the occlusive lesion was also observed on late frames of the right coronary angiogram (Video 1 in Data Supplement). These findings were consistent with the aortic CTA results (Fig. 4A–D). Left ventriculography revealed severe hypokinesis of the inferior wall in the territory of an RCA myocardial infarction (Video 2 in Data Supplement), as previously depicted via CTA as an area of myocardial hypoenhancement. The patient subsequently underwent successful coronary artery bypass surgery.

3. Discussion

With increased improvements in CT technology, newer CT machines are expected to provide more precise and interpretable heart and coronary images during thoracic CTA, even when using non-gated methods. The heart and coronary artery should be assessed during the interpretation of non-gated thoracic CTA because such assessments can reveal the first evidence of occlusive coronary artery lesions and acute myocardial infarction, as in the present case.

Although the case presented here was scanned using an earlier-generation multi-slice scanner, a sixteen-slice CT scanner that uses smaller longitudinal coverage, the findings were still recognizable despite somewhat poor image quality at the mid-RCA due to motion artifact. Indeed, the mid-RCA region will often show artifact, even on ECG gated CT. We believe that state-of-the-art MSCT scanners, which use wide-array or isophasic technology, would provide even better non-gated image quality. This might increase the rate of detection of such discoveries, if readers do not overlook the heart and coronary vessel components when interpreting routine, non-gated chest CTA imaging.

Assessment of the presence of the RAG sign has been proposed as a

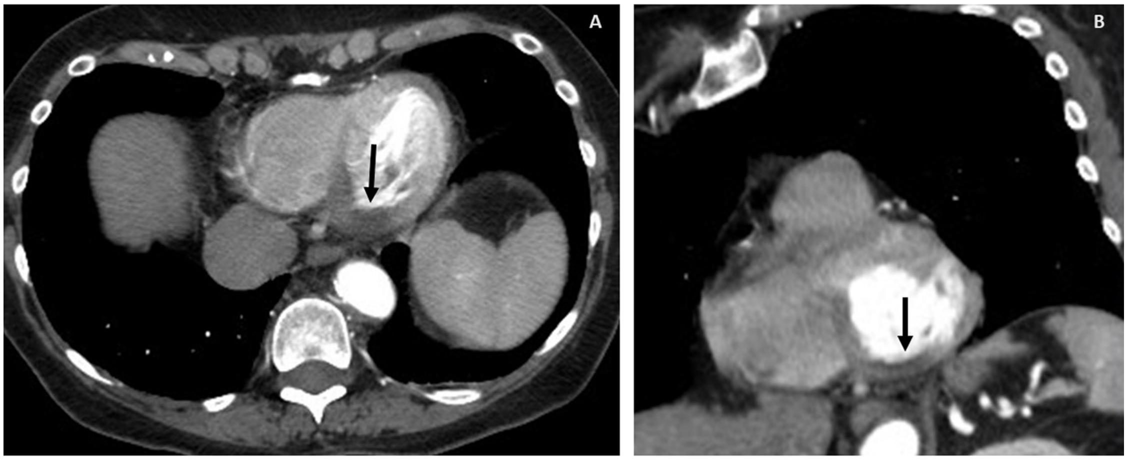

Fig. 2. A, B. Non-gated chest axial computed tomography angiography and reconstruction in the short axis depicting hypoenhancement/hypodensity of the inferior wall of the left ventricle (black arrow) suggestive of severe ischemia or infarction in the right coronary artery territory.

potential, non-invasive tool for differentiating between total and subtotal coronary artery occlusion via ECG-gated coronary CTA [5–8]. Although the presence of the RAG sign has been described as more indicative of total occlusion than of subtotal occlusion, it is frequently absent in cases of total occlusion. As reported in a study by Li et al. [5], the RAG sign was absent in 17/49 (35 %) cases – as it was in the present case. Absence of the RAG sign, in the current case, may have been due to the relatively late acquisition as well as a relatively lower longitudinal coverage of the CT scanner that we used taking in consideration that the examination was originally targeting the aorta, not the coronary artery. Delayed acquisition might also have resulted in contrast medium filling of the segment beyond the lesion to the lumen region just below the occlusive lesion rather than in the distal portion, altering depiction of the presence of the RAG sign in the setting of total or complete occlusion. Additionally, the patient's bridging collateral vessels were also a probable source of some antegrade and retrograde filling distal to the occlusion. The extent of antegrade flow may also affect the assessment of the presence of the RAG sign. Notably, however, the presence of a long occlusive lesion and the presence of bridging collateral vessels favor a diagnosis of total occlusion rather than subtotal occlusion [5].

To the best of our knowledge, there have been no previously reported attempts to assess the RAG sign or demonstrate total coronary artery occlusion with absence of the RAG sign using non-ECG gated thoracic CTA.

In the present case, the well-developed coronary collateral vessels

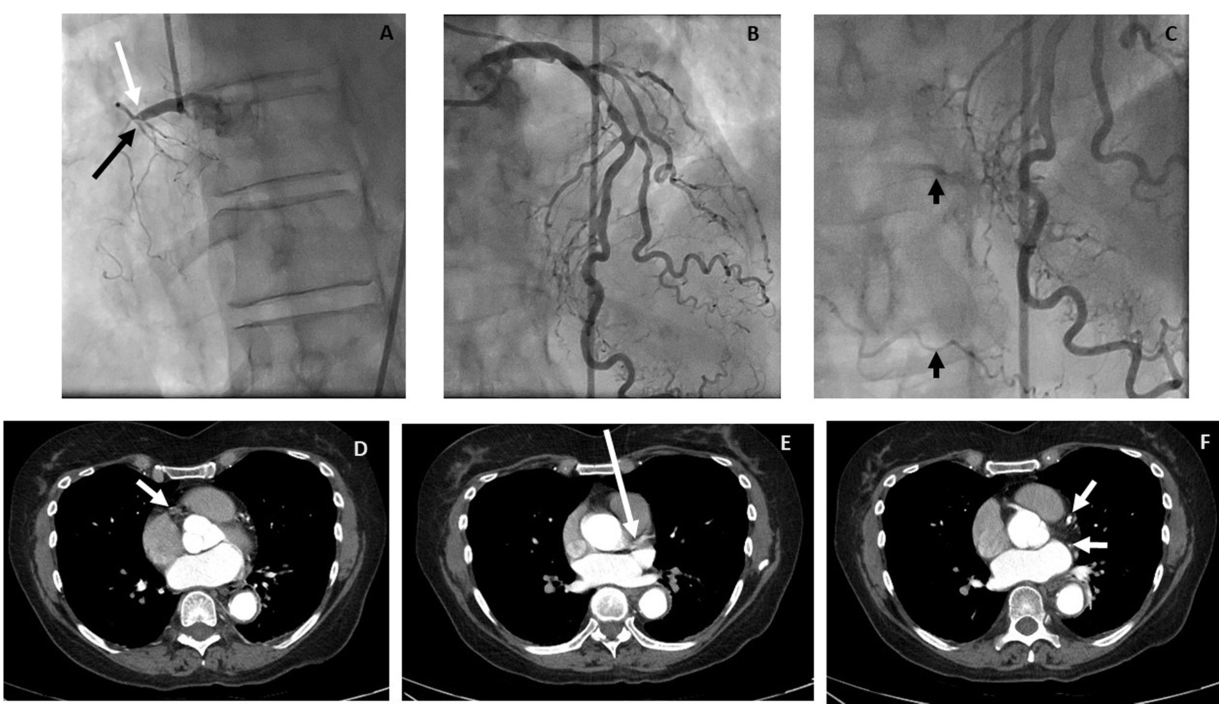

Fig. 3. A-F. A, B. Right and left coronary angiograms depicting three-vessels disease with total occlusion of the proximal right coronary artery (white arrow). Note a subtle small area of endoluminal contrast defect suggestive of acute thrombus (black arrow).

C, Contralateral left angiogram showing collateral vessels (short black arrows) from septal branches of left descending artery.

D-F, Computed tomography angiography images demonstrating three-vessel disease, with evidence of some calcific atheromatous changes (short white arrows) in the right coronary artery, proximal left descending and left circumflex arteries; as well as findings suspicious of atheromatous changes in the left main artery (long white arrow), which could be visualized despite the presence of some artifacts.

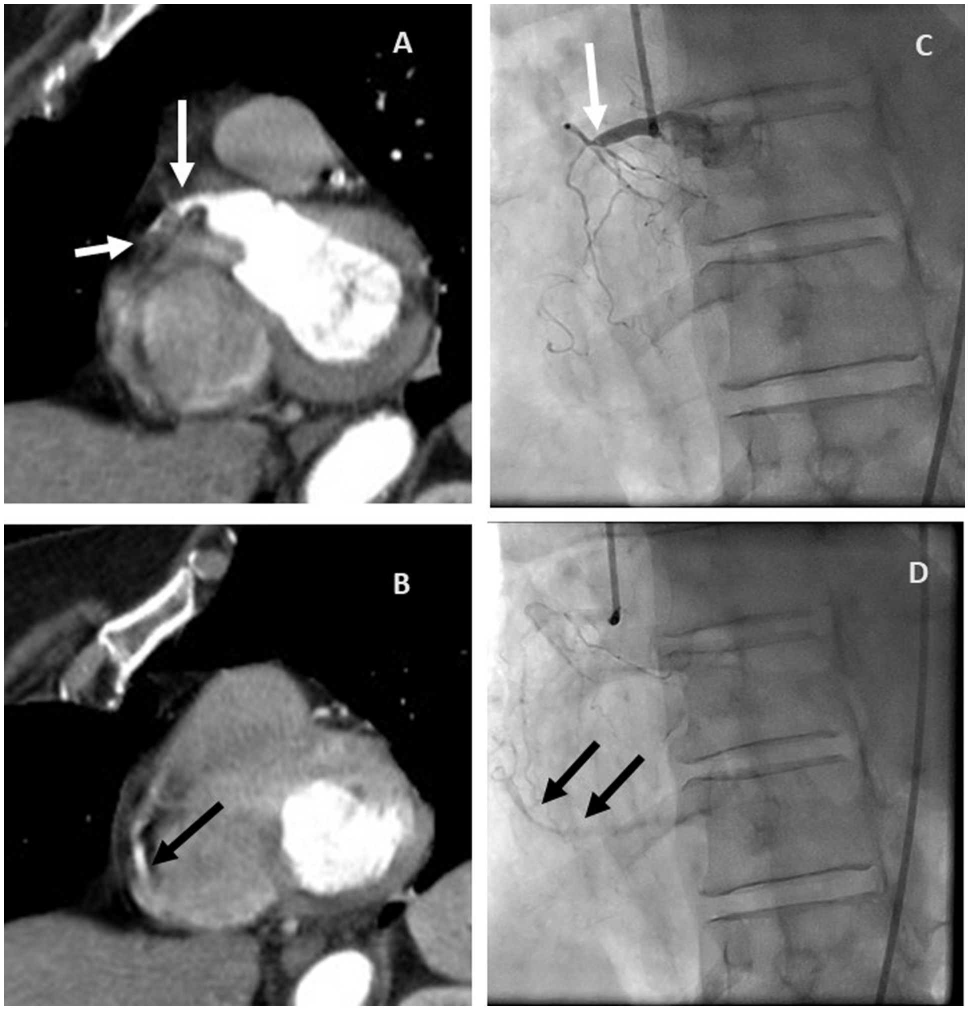

Fig. 4. A-D. A, B. Reconstruction of non-gated thoracic computed tomography angiography in a short axis view depicting abrupt cessation of opacification of the proximal right coronary artery (A, white arrow) and distal retrograde flow (B, black arrow). **C, D.** Corresponding conventional coronary angiography images showing similar findings, where D is an image from a late frame of the right coronary artery angiogram.

indicate that the patient probably had chronic severe stenosis of the RCA, which became completely occluded by a superimposed new clot (culprit lesion), as demonstrated first by the non-gated CTA and then by conventional coronary artery angiography. Furthermore, despite the complete occlusion, no Q wave or ST elevation was evident on ECG. We believe that the absence of signs of infarct on ECG may be explained by the presence of well-developed collateral vessels, which are somewhat protective of the myocardium for the prevention of a transmural infraction, and by the well-known fact that ECG has a low sensitivity in detecting infarctions [9].

The current case illustrates the potential value of examining coronary arteries and myocardial perfusion on non-gated thoracic CTA, which may be particularly useful in situations in which clinical and other diagnostic tests are inconclusive.

4. Conclusion

Above, we have described a case of incidental detection of RCA proximal total occlusion associated and acute myocardial infarction with an absent RAG sign via non-gated chest CTA. When using modern CT scanners, the coronary arteries and heart should be assessed, even on non-gated thoracic CTA images, because such assessments can provide the first evidence of occlusive coronary artery lesions and acute myocardial infarction.

Declaration of Competing Interest

None of the authors has any relevant conflict of interest or industry support related to this report.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ejro.2020.100245.

References

[1] G.S. Hurlock, H. Higashino, T. Mochizuki, History of cardiac computed tomography: single to 320-detector row multislice computed tomography, Int. J. Cardiovasc. Imaging 25 (Suppl. 1) (2009) 31–42, https://doi.org/10.1007/s10554-008-9408-z.

[2] R.E. Kanza, C. Allard, M. Berube, Cardiac findings on non-gated chest computed tomography: a clinical and pictorial review, Eur. J. Radiol. 85 (2016) 435–451, https://doi.org/10.1016/j.ejrad.2015.11.042.

[3] F. Secchi, G. Di leo, M. Zanardo, M. Ali, P.M. Cannao, F. Sardanelli, Detection of incidental cardiac findings in noncardiac chest computed tomography, Medicine 96 (29) (2017) e7531.

[4] R. Arai, D. Fukamachi, Y. Ebuchi, N. Akutsu, Y. Okumura, Potential utility of non-gated enhanced computed tomography for an early diagnosis of myocardial infarctions, Intern. Med. 59 (2) (2020) 215–219, https://doi.org/10.2169/internalmedicine.3496-19.

[5] M. Li, J. Zhang, J. Pan, Z. Lu, Obstructive coronary artery disease: reverse attenuation gradient sign at CT indicates distal retrograde flow—A useful sign for differentiating chronic total occlusion from subtotal occlusion, Radiology 266 (2013) 766–772, https://doi.org/10.1148/radiol.12121294.

[6] H. Goerne, S.S. Saboo, P. Rajiah, Reverse gradient sign, J. Thorac. Imaging 32 (2017) W4 doi: 10.1097/RTI0000000000000266.

[7] M. Li, J. Zhang, Q. Zhang, J. Pan, Z. Lu, M. Wei, Coronary stent occlusion: reverse attenuation gradient sign observed at computed tomography angiography improves diagnosis performance, Eur. Radiol. 25 (2015) 568–574, https://doi.org/10.1007/s00330-014-3429-x.

[8] Y.H. Choe, J.H. Choi, S.M. Kim, Transluminal attenuation gradient and other CT techniques for gauging lesion significance, in: U. Schoepf (Ed.), CT of the Heart, Contemporary Medical Imaging, Humana, Totowa, NJ, 2019.

[9] O.J. Mechanic, S.A. Grossman, Acute Myocardial Infarction. StatPearls [Internet], Available from: StatPearls Publishing, Treasure Island (FL), 2020https://www.ncbi.nlm.nih.gov/books/NBK459269/.