

Case report of dependent venous contrast pooling and layering in a patient without acute cardiogenic shock

Willi L. Wagner, MD^{a,b,*}, Daniel Spira, MD^a, Florian André, MD^c, Ajith Kantharajah, MD^c, Hans-Ulrich Kauczor, MD^{a,b}, Theresa Mokry, MD^a

Abstract

Rationale: We present a case of incidental venous contrast pooling and layering in a patient without sudden cardiac arrest or cardiogenic shock.

Patient concerns: The patient presented with only discrete symptoms and did not suffer fatal cessation of the cardiac pump function during or shortly after the scan.

Diagnosis: The patient showed stigmata of venous gravity-dependent pooling and layering of contrast medium, which has frequently been described as a sign of imminent cardiogenic shock and cardiac arrest.

Interventions: A cardiologic consultation including echocardiography was initiated.

Outcomes: Echocardiography confirmed valvular heart disease and biventricular heart failure. A subsequent follow-up CT acquired 8 months after the incidental finding showed no signs of dependent contrast pooling.

Lessons: Pooling and layering of contrast medium can occur in patients not suffering acute fatal cessation of the cardiac pump function. Nonetheless, any signs of venous pooling observed in CT examinations, especially gravity-dependent layering of contrast medium, are indicative of severe heart dysfunction and should prompt immediate cardio-pulmonary monitoring and increased level of medical care.

Abbreviation: CT = computed tomography.

Keywords: computed tomography, contrast layering, contrast pooling, heart dysfunction, tricuspid insufficiency

1. Introduction

Contrast-enhanced computed tomography (CT) is a diagnostic radiologic tool applied in a vast variety of clinical settings. Numerous reports describe reflux of contrast medium and layering of the contrast agent in dependent areas of the venous system.^[1–6] In all reported cases, impending cardiogenic shock or sudden cardiac arrest were described. We present a case with the incidental finding of dependent contrast pooling and layering in a patient without any evidence of acute circulatory failure.

Editor: N/A.

The authors have no competing and no conflicts of interest to disclose.

^a Department of Diagnostic and Interventional Radiology, University of Heidelberg,

^b Translational Lung Research Center Heidelberg (TLRC), German Center for Lung Research (DZL), ^c Department of Cardiology, Angiology and Pneumology, University of Heidelberg, Heidelberg, Germany.

* Correspondence: Willi L. Wagner, Department of Diagnostic and Interventional Radiology, University Hospital, Im Neuenheimer Feld 110, 69120 Heidelberg, Germany (e-mail: willi.wagner@med.uni-heidelberg.de).

Copyright © 2018 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

Medicine (2018) 97:47(e13277)

Received: 30 July 2018 / Accepted: 23 October 2018

<http://dx.doi.org/10.1097/MD.00000000000013277>

2. Methods

2.1. Computed tomography

All examinations were performed on a helical CT scanner (Philips Brilliance iCT 256). Around 85 mL of contrast medium (Accu-Paque 350, GE Healthcare) were administered at a rate of 3.5 mL/sec via a 20 GA peripheral brachial venous catheter using a Stellant D (MEDRAD, Bayer, Leverkusen, Germany) injection system.

2.2. Echocardiography

Examination was performed using a M5Sc transducer (Vivid E9, GE Healthcare Vingmed, Trondheim, Norway).

2.3. Patient consent

The institutional review board “Ethikkommission der Medizinischen Fakultät Heidelberg” and “Datenschutzbeauftragter des Klinikums Heidelberg” have approved the case report and waived the requirement to obtain patient’s informed consent. Explicit written patient consent could not be obtained because the patient deceased ere to the next hospital visit. Therefore, the institutional medical data protection commission and the institutional ethics review board were contacted. Both commission and board approved the utilization of the clinical data and image data, providing that full individual patient data anonymization is warranted. The authors state that individual patient data are fully anonymized and no conclusions from the written and image content of this case report can be drawn to the identity of the patient.

3. Case report

3.1. Clinical findings and diagnostic assessment

A 61-year old outpatient received a routine CT to follow an underlying carcinoma of the gastroesophageal junction. The patient was known to have ischemic cardiomyopathy with severely impaired left ventricular function, pulmonary arterial hypertension, paroxysmal atrial fibrillation, arterial hypertension and type II diabetes. During the late arterial contrast enhanced upper abdomen phase and also during the late portal phase the patient showed signs of contrast agent pooling in the dependent areas of the venous system (Fig. 1A–D). Namely the inferior vena cava, the right hepatic vein, the right renal vein, the right testicular vein and right-sided lumbar veins were involved in the pooling phenomenon. During the late arterial phase a two-phase layering of dense contrast medium and nonenhanced venous blood was evident. During the late portal phase a three-phase layering of dense contrast medium, slightly enhanced venous blood and nonenhanced venous blood were identified in the inferior vena cava. The rich enhancement of arterial blood in the abdominal aorta indicated forward motion of blood in the

circulatory system. No evidence was found for pulmonary embolism or aortic dissection. The patient was checked immediately following the CT scan and denied loss of consciousness or palpitations during the examination. The patient showed no signs of allergic reaction to contrast medium. No echocardiogram was acquired during the CT examination. The patient reported a general increasing shortness of breath and limited ability to exercise within the last year. The patient's primary physicians were informed immediately, and a cardiac workup was initiated. Echocardiography, which was performed after the first CT study, showed a dilated, mildly concentric hypertrophied left ventricle with severely impaired systolic function (biplane ejection fraction 12%). The inferoseptal segments were thinned and akinetic. The anteroseptal and anterior segments were also akinetic and the Apex was dyskinetic. Both atria were dilated. The right ventricle was dilated and showed an impaired systolic function. The inferior vena cava was dilated with poor inspiration collapse consistent with elevated right atrial pressure (Fig. 4D). The aortic valve was calcified and showed a good separation and a moderate regurgitation (Fig. 4A). The mitral valve was also calcified and

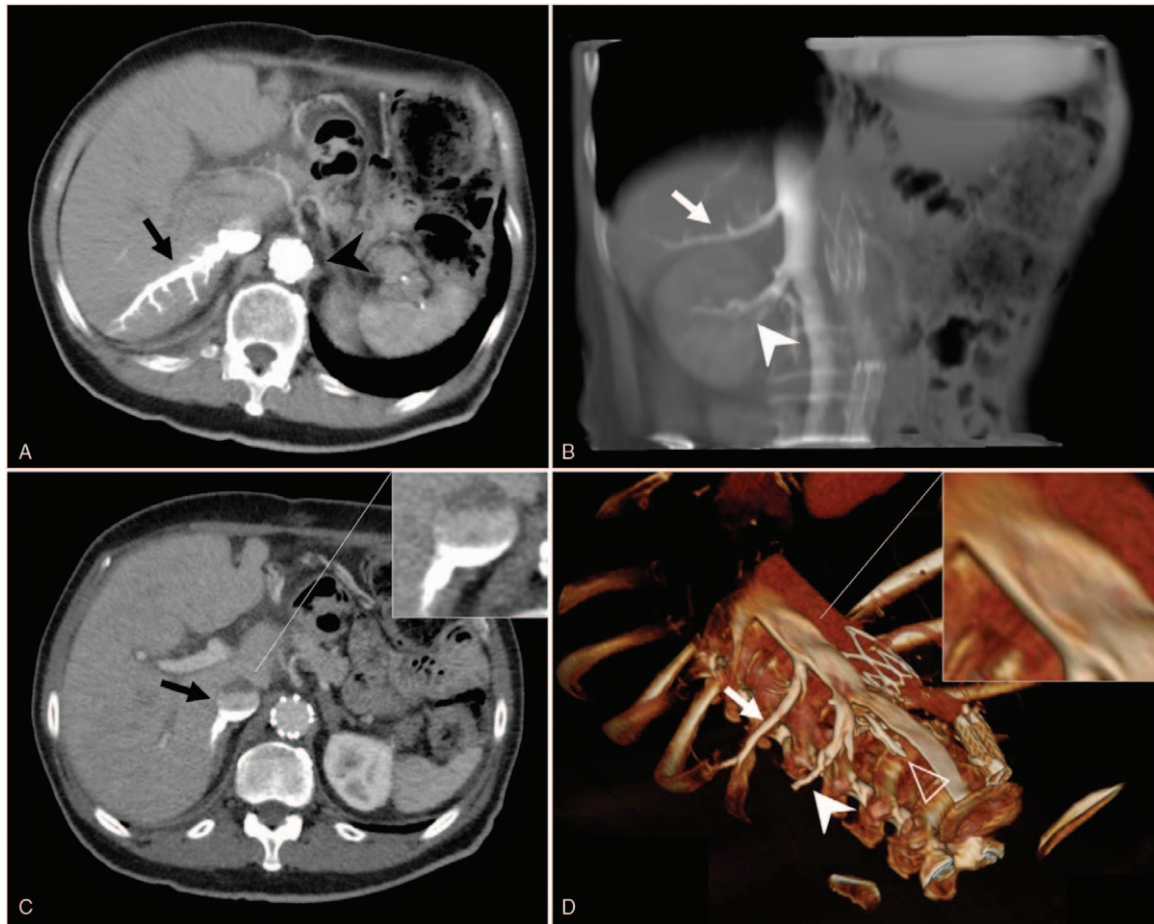


Figure 1. Dependent venous contrast pooling and layering. Strong enhancement of the right hepatic vein (black arrow) and side branches during the late arterial contrast phase (A), note the rich enhancement of the abdominal aorta (black arrowhead), indicating forward motion of blood without the formation of a blood-contrast level. (B) Multi-intensity projection image of the upper abdomen shows dependent contrast into the right hepatic vein (white arrow) and the right renal vein (white arrowhead) during the late portal contrast phase. A decrease in dense contrast medium layer thickness accompanied by the appearance of a three-phase layering in the inferior vena cava indicates a partial mobilization of the pooled contrast agent during the late portal contrast phase (C). Volume rendering of upper abdomen illustrates the distinct long-stretched pool of the dense layer of contrast medium in the inferior vena cava with dependent filling of the right hepatic vein (white arrow) and the right renal vein (white arrowhead) with partial filling of the right testicular vein (open arrow head) (D).

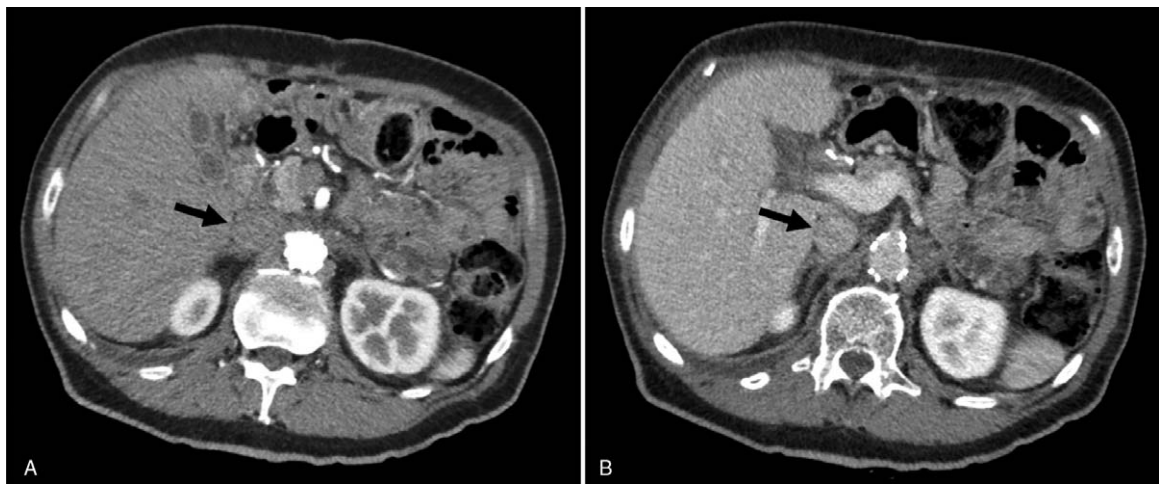


Figure 2. Subsequent CT examination of the same patient 8 months later. No signs of dense abdominal veins or dependent contrast pooling was evident during a subsequent follow-up examination, 8 months after the first CT examination. Black arrow indicates inferior vena cava during the late arterial phase (A) and during the late portal phase (B). CT=computed tomography.

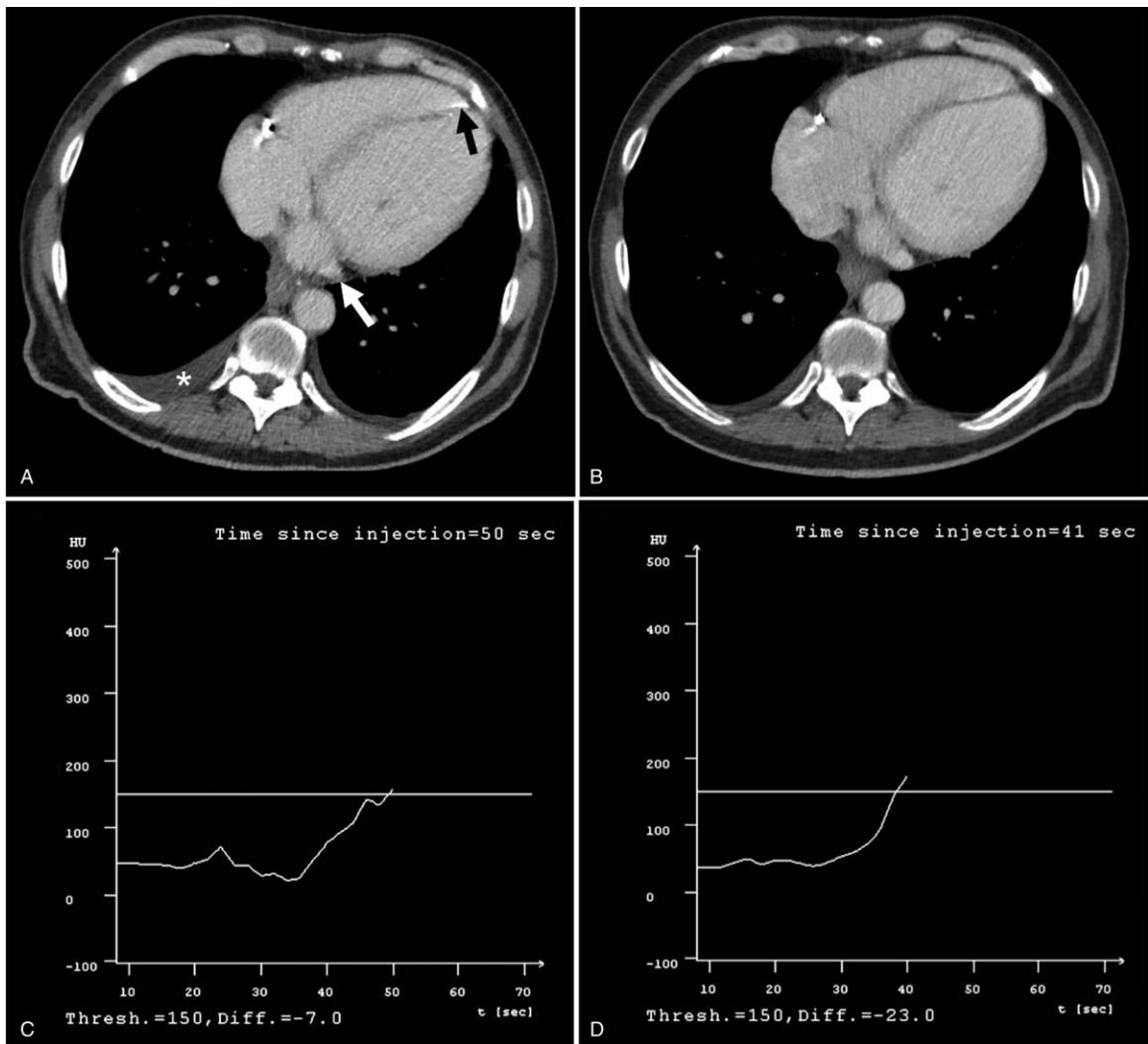


Figure 3. Volume of cardiac chambers and contrast bolus tracking. There was no obvious difference in volume of the cardiac chambers between the CT scans. Minimal contrast pooling was visible in the apical portion of the right ventricle (black arrow) in the first CT examination (A). No contrast pooling was observed in the coronary sinus (white arrow). The patient showed slightly more pleural effusion during the first CT examination (asterisk). During the acquisition of contrast medium bolus tracking in the first CT scan, a slight delay was evident during the first CT scan (C), indicative of a decrease in cardiac output as compared to the second examination (D). CT=computed tomography.

showed a sufficient separation and a mild regurgitation. The tricuspid valve showed a moderate-to-severe regurgitation (Fig. 4B). The estimated pulmonary artery systolic pressure was increased (approx. 55–60 mm Hg).

3.2. Follow-up and outcomes

A subsequent CT follow-up, performed 8 months after the first CT examination, showed no signs of contrast pooling or layering (Fig. 2A and B). No difference was observed in right ventricular morphology compared to the first CT examination. The patient did not receive invasive cardiologic interventions or a change in medication between the CT examinations. The patient joined a chronic heart failure program and made behavioral modifications, including dietary changes. Contrast bolus tracking was recorded during both CT examinations (Fig. 3B and C). The first CT examination, where the pooling phenomenon was observed (Fig. 3A and C), showed an 11 second delay in bolus tracking (50 seconds vs 41 seconds) compared to the second examination where no pooling was observed (Fig. 3B and D). In both CT studies, the bolus trigger was set in the descending aorta at approximately the same anatomic level at a threshold of 150 Hounsfield units.

4. Discussion

In this report, we present a case of incidental finding of pooling and layering of contrast medium in gravity-dependent areas of

the venous system in a patient who was not in acute cardiogenic shock or sudden cardiac arrest. To our knowledge, this is the first case of dependent layering without subsequent fatal outcome for the patient and later follow-up CT examination. Ko et al. reported 3 cases of venous pooling where patients fully recovered after the finding, however, no layering of contrast medium was described. A high injection rate of the contrast medium, tricuspid regurgitation, pulmonary hypertension and right ventricular dysfunction were identified as independent predictors for retrograde filling of the inferior vena cava and right hepatic vein.^[7] However, gravity-dependent layering, is generally considered to be an indicator of circulatory failure and death.^[1–6,8]

Several case reports describe pooling and layering as a characteristic imaging feature in patients suffering abrupt cessation of the cardiac pump function.^[2–6,8,9] However, in some cases layering in the right ventricle^[7,9] and pooling the pulmonary vasculature were noted.^[9] In our case only minimal signs of right ventricular pooling were evident (Fig. 4A) and no pooling was seen in the pulmonary vasculature. Contrary to previous reports,^[2–7,9] no contrast pooling was evident in the hepatic parenchyma or in the renal interstitium.^[4] Contrast bolus tracking showed a delayed scan trigger during the first CT examination, where the pooling phenomenon was observed. This may be indicative of a decrease in cardiac output. This finding is in line with the report of Clark et al,^[4] who described contrast layering in the inferior vena cava in an abdominal contrast phase CT triggered 75 seconds after initial contrast bolus injection.

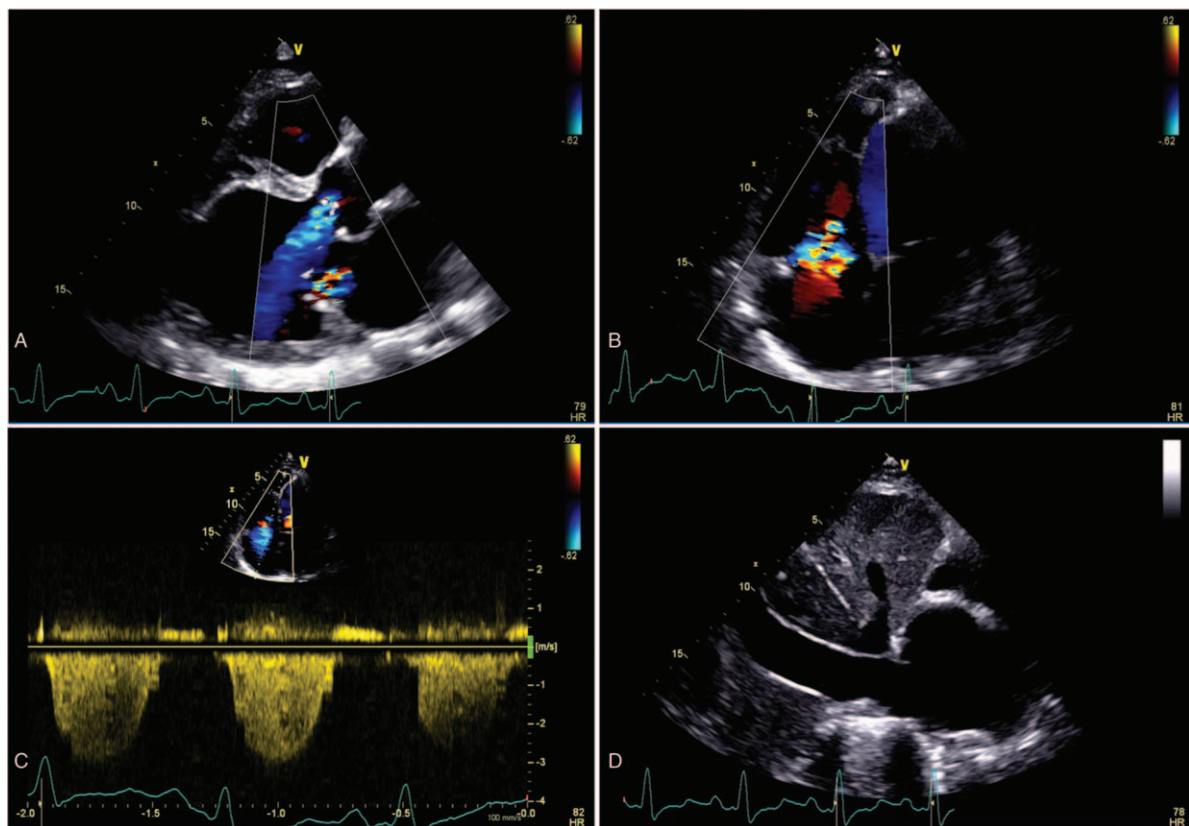


Figure 4. Echocardiography confirmed valvular heart disease and biventricular heart failure. Parasternal long axis of the dilated left ventricle with color Doppler showing a moderate aortic regurgitation and a mild mitral regurgitation (A). Color Doppler of the tricuspid valve showing a moderate-to-severe regurgitation with an increased velocity as result of the elevated systolic pulmonary artery pressure, shown by Doppler (B and C). Subcostal view displaying the dilated inferior vena cava (D).

Roth et al. described dependent contrast layering as “a sign of imminent cardiogenic shock” [2] Some authors describe the pooling of contrast agent in the inferior vena cava as “pathognomonic of the absence of blood flow during the procedure” [10] or the spectrum of the findings as “pathognomonic of impending cardiac arrest” [11] Others recommend an immediate termination of the CT examination upon detection of venous pooling to perform cardiopulmonary resuscitation.[5] These assumptions become more relevant in light of our case findings. Our report indicates that it is rather the total spectrum of pooling and layering signs, which in their entirety are quite specific for cardiogenic shock and sudden cardiac arrest. Pooling and even layering of contrast medium occurred in a patient who presented with only discrete symptoms and did not suffer fatal cessation of the cardiac pump function during or shortly after the scan. Nonetheless, any signs of venous pooling observed in CT examinations, especially gravity-dependent layering of contrast medium, are indicative of severe heart dysfunction and should prompt immediate cardio-pulmonary monitoring and increased level of medical care.

Author contributions

Conceptualization: Willi L. Wagner, Theresa Mokry.

Data curation: Willi L. Wagner, Theresa Mokry.

Formal analysis: Willi L. Wagner, Daniel Spira, Florian André, Ajith Kantharajah, Hans-Ulrich Kauczor, Theresa Mokry.

Investigation: Willi L. Wagner, Florian André, Ajith Kantharajah, Theresa Mokry.

Methodology: Hans-Ulrich Kauczor.

Project administration: Hans-Ulrich Kauczor, Theresa Mokry.

Supervision: Hans-Ulrich Kauczor, Theresa Mokry.

Validation: Daniel Spira, Florian André, Hans-Ulrich Kauczor.

Visualization: Willi L. Wagner, Florian André, Ajith Kantharajah.

Writing – original draft: Willi L. Wagner.

Writing – review & editing: Willi L. Wagner, Daniel Spira, Florian André, Ajith Kantharajah, Hans-Ulrich Kauczor, Theresa Mokry.

References

- [1] Lin T-C, Lin C-S, Hsu H-H, et al. Contrast pooling and layering in a patient with left main coronary artery occlusion and cardiogenic shock. *Acta Cardiol Sin* 2015;31:461–3.
- [2] Roth C, Sneider M, Bogot N, et al. Dependent venous contrast pooling and layering: a sign of imminent cardiogenic shock. *Am J Roentgenol* 2006;186:1116–9.
- [3] Bagheri SM, Taheri MS, Pourghorban R, et al. Computed tomographic imaging features of sudden cardiac arrest and impending cardiogenic shock. *J Comput Assist Tomogr* 2012;36:291–4.
- [4] Clark TJ, Suby-Long T. Computed tomography of acute heart failure: a novel case and literature review. *Radiol Case Rep* 2016;10:1–4.
- [5] Tsai P-P, Chen J-H, Huang J-L, et al. Dependent pooling: a contrast-enhanced sign of cardiac arrest during CT. *Am J Roentgenol* 2002;178:1095–9.
- [6] Singh K, Gervais D, Mueller P, et al. Cardiac arrest: abdominal CT imaging features. *Abdom Imaging* 2004;29:177–9.
- [7] Ko SF, Ng SH, Chen MC, et al. Sudden cardiac arrest during computed tomography examination: clinical findings and “dense abdominal veins” on computed tomography. *J Comput Assist Tomogr* 2003;27:93–7.
- [8] Ozbek S. Cardiac arrest during computed tomography scanning: imaging findings. *J Radiol Radiat Ther* 2013;1:1018.
- [9] Yeh BM, Kurzman P, Foster E, et al. Clinical relevance of retrograde inferior vena cava or hepatic vein opacification during contrast-enhanced CT. *Am Roentgen Ray Soc* 2004;183:1227–32.
- [10] Millán S, Gallardo X, Martín-Loeches I. Contrast-enhanced signs of cardiac arrest during CT. *Medicina Intensiva (English Edition)* 2015;39:261.
- [11] Meiner EM, Rosioreanu A, Katz DS. CT findings of impending cardiac arrest. *Am J Emerg Med* 2004;22:504–5.