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Computed tomography of acute heart failure: A novel case and literature review

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Computed tomography (CT) is used in patients whose conditions span the gamut from healthy to critically ill. In the specific subset of patients with cardiac arrest or imminent cardiac failure who receive contrast-enhanced CT, extant literature illustrates a set of imaging findings that include inferior vena cava and hepatic parenchymal contrast reflux, pooling, and layering in a dependent fashion. We review the literature and present a case in which these findings are demonstrated along with renal venointerstitial reflux, a finding that has not been previously described.

Introduction

Computed tomography is widely used in inpatient, outpatient, and emergency settings. Patients who undergo CT span the gamut of conditions, with asymptomatic, healthy individuals who may be scanned for candidacy as living kidney or partial liver donors at one extreme. At the other extreme are critically ill patients who either sustain cardiac arrest during the imaging procedure or shortly thereafter. In the subset of patients with either cardiac arrest or imminent cardiac failure who undergo a CT study with intravenous contrast, a number of specific imaging findings have been described by previous authors, including inferior vena cava and hepatic parenchymal contrast reflux, pooling, and layering in a dependent fashion. In this paper, we review the literature of CT imaging in the setting of cardiac arrest or imminent cardiac failure. We also present a case that demonstrates both these previously described imaging findings as well as a novel finding of venointerstitial reflux: that is, forced reflux of contrast from the renal veins into the renal interstitium in a manner analogous to pyelointerstitial reflux (described in the voiding cystourethrography literature).

Literature review

We performed searches on PubMed and Google Scholar for the query terms "cardiac arrest" and "computed tomography." These general search terms produced a surplus of results, as there has been much scholarly activity regarding the imaging appearance of the heart itself and the brain in the setting of cardiac arrest. Manual parsing of the results to those relevant to our intended query revealed five groups that have described imaging findings of contrast-enhanced CT performed in patients with imminent or actual cardiac arrest.

We summarize the findings of previous authors in order of publication. Ko, et al. initially described imaging findings of "strikingly dense abdominal veins, variable degrees of arterial enhancement, and poor abdominal visceral enhancement."(1) Singh, et al. in a nearly contemporaneous publication, described "reflux of contrast into the abdomen as indicated by opacification of renal veins, hepatic veins, inferior vena cava, and hepatic and renal parenchyma," and additionally described a case of reflux into the portal vein (2). Roth, et al. refined the description in their later work, noting dependent pooling and layering of contrast within the superior vena cava and right atrium as well as "a contrast-blood interface and pooling in [...] the IVC, dependent hepatic veins, right renal vein, lumbar veins, and iliac veins." Jana, et al. echoed these findings in their own small case series (3, 4). Most recently, Sami, et al. have described a case of complete cardiac arrest in which no opacification of the left heart was seen, and in which

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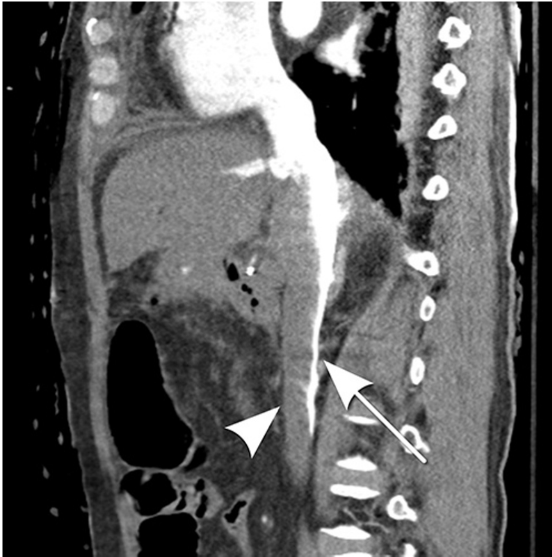

Fig. 1. Right parasagittal reformatted image from a contrast-enhanced CT of the abdomen and pelvis obtained 75 seconds after contrast injection shows reflux of contrast from the right atrium into the dependent portion of the IVC (arrow), without opacification of blood pool within the non-dependent portion of the IVC lumen (arrowhead).

there was "regurgitation of contrast medium from the right atrium into the inferior vena cava and hepatic veins"(5).

From these extant works, a number of common imaging features are readily evident, including reflux of contrast into the inferior vena cava, hepatic, and occasionally renal veins; layering of contrast in a dependent manner; and parenchymal enhancement in the dependent portion of the liver. Some authors describe reflux even more distally, to the level of the pelvis, while others do not, likely reflecting heterogeneity in the cardiac output of the patients being examined, as these series include patients in both frank present and imminent cardiac arrest.

Building on this published literature, we present the case of a patient who received a CT scan during a brief period of marginal cardiac function, flanked by periods of cardiac arrest. This case both illustrates the previously described imaging findings, including that of pooling and layering as described by Roth, et al. and additionally depicts a novel, previously undescribed finding of renal interstitial contrast reflux via the renal vein.

Case report

A 65-year-old man with a distant history of coronary artery disease requiring angioplasty and stenting (as well as pancreatic adenocarcinoma resected several weeks earlier) presented in ventricular fibrillation that progressed rapidly to pulseless electrical activity. Emergency medical services performed cardiopulmonary resuscitation en route to the emergency department, with return of spontaneous circulation after four rounds of intravenous epinephrine and defibrillation shocks. Upon arrival in the emergency room, a new right bundle branch block was diagnosed with electrocardiography and, given this finding, CT, pulmonary angiography, and nonangiographic imaging of the abdomen and pelvis were emergently performed. Almost immediately after performance of these CT studies, the patient sustained another cardiac arrest, with 30 minutes of cardiopulmonary resuscitation performed during pulseless electrical activity. The patient was pronounced deceased after cardiac activity could not be revived.

Findings and diagnosis

CT and pulmonary angiography revealed no pulmonary embolus, but did demonstrate rib and chondral fractures consistent with prolonged cardiopulmonary resuscitation. Imaging of the abdomen and pelvis performed at a 75-second delay from initial contrast bolus injection revealed dense opacification of the aorta as well as retrograde opacification, layering, and pooling of contrast within the dependent aspects of the inferior vena cava, hepatic veins, and right renal vein (Fig. 1). Contrast opacified the dependent aspect of the right hepatic lobe parenchyma (Fig. 2). Furthermore, contrast also was seen exclusively within the right renal parenchymal interstitium, contiguous with the opacified renal veins, without contrast within either the left or right renal collecting system to suggest excretion (Fig. 3).

The imaging findings indicative of right heart failure, along with the clinical scenario of known coronary artery disease, new right bundle branch block, and pulseless electrical activity immediately before and after (but not during)

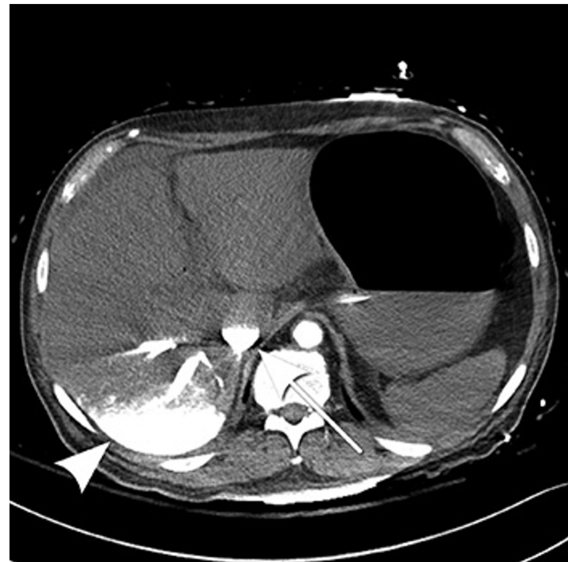

Fig. 2. Axial image from a contrast-enhanced CT of the abdomen and pelvis obtained 75 seconds after contrast injection shows reflux of contrast into the dependent portion of the IVC (arrow) as well as reflux of and pooling of contrast within the dependent hepatic veins and parenchyma (arrowhead).

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