Single-phase bilateral low dose contrast medium injection for diagnosing occlusions of the thoracic venous system: a case report

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Abstract
Occlusion of the thoracic venous system and/or occlusion of central venous catheters (CVC) of unknown cause can, in selected cases, require advanced imaging. Here, we describe a case study of a patient with a failing central dialysis catheter (CDC) which was diagnosed by computed tomography (CT) in connection with a single-phase bilateral low-dose contrast medium (CM) injection using only 3.6 g of iodine. By injecting a low CM dose, the risk of streak artifacts from first-pass of high intravascular concentrations of CM can be avoided. Therefore, the technique described here should be beneficial also to patients with normal renal function.

Keywords
CT, contrast agents – intravenous, thorax, vena cava

Date received: 15 December 2017; accepted: 30 April 2018

Introduction
Obstruction of the thoracic venous system can be due to numerous reasons, for example thoracic malignancies, especially lung cancer (1,2). Expansive tumor growth leads to a narrowing and eventually total occlusion of the superior vena cava (SVC). Failure of a central line may also occur or exacerbate due to thrombus formation in patients with central venous catheters (CVC) (3,4). Hence, an occlusion of a central dialysis catheter (CDC) constitutes a potential medical emergency. Diagnostic imaging for occlusions in the thoracic venous system SVC syndrome include contrast-enhanced computed tomography (CT), ultrasound/echo-cardiography, magnetic resonance imaging (MRI), or conventional venograms (4).

However, imaging in some patient groups, e.g. in the intensive care unit, may prove challenging. MRI may be inaccessible and ultrasound inconclusive. Furthermore, reduced kidney functions may be of concern in case of CT, as those may need relatively high iodine contrast media application for a complete chest CT (4).

We present an imaging option for a CT venogram with bilateral injection of low dose, diluted contrast medium in a patient with unclear occlusion of a CDC and failure to advance a new central catheter.

Case report
A 77-year-old male patient with biological aortic valve and pronounced cardiovascular disease (atrial fibrillation, pulmonary hypertension, dilated atriums, and...
mitral and tricuspid valve insufficiency) was referred to the radiology department after inconclusive ultrasonographic (US) Doppler of the thoracic venous system after the patient’s current CDC had failed and a new CDC was considered. Due to complete kidney failure without any expected rest function, a protocol with heavily reduced iodine content was developed. Here, we present our thoracic CT venography protocol with diluted contrast medium and bilateral intravenous injection.

The CT scan was performed using a dual source multidetector (MDCT) Somatom Definition Flash® (Siemens Healthcare, Forchheim, Germany). Scan parameters included helical scanning using 128 × 0.6 mm detector collimation at a pitch of 0.9, 100 kVp, and automatic tube current modulation. A simultaneous intravenous bolus injection consisting of sodium chloride (NaCl) and contrast media (CM) solution (Iomeprol 400 mg iodine per mL, Bracco Imaging, Milan, Italy) was performed using a dual head auto injector (Medrad Stellant®, Bayer, PA, USA). To obtain an attenuation of 400 Hounsfield units (HU) in the central veins, it was assumed that the given CM would be further diluted from blood at a ratio of 1:2 after the injection. The injected CM should therefore have an attenuation of approximately 3 × 400 = 1200 HU. After analyzing the attenuation of a set of CM dilutions in vitro (ranging from 200 mg/mL to 20 mg/mL, data not shown), it was concluded that a concentration of 40 mg/I mL results in roughly 1200 HU and should be optimal. Thus, each syringe was filled with a solution consisting of 90 mL NaCl and 10 mL CM, resulting in the desired concentration of 40 mg/I mL. Of that solution, 45 mL was injected from each syringe through an 18-gauge percutaneous venous catheter (PVC) applied in both left and right medial cubital vein giving a total dosage of 3.6 g iodine. Scan delay was set to 12 s.

Images were reconstructed with 0.75-mm slice thickness and 0.7-mm reconstruction increment. All reconstructed images series were sent to a dedicated workstation (Advantage Work Station® 4.6, GE Healthcare, Milwaukee, WI, USA) for 3D volume rendering (VR) post-processing.

The CT scan showed occlusion of the right subclavian vein along with collateral vessels ending in the SVC. On the left side, there was an elongated stenosis of the brachiocephalic vein along with abundant collateral vessels (Fig. 1–5).

Discussion

To visualize the central veins, we used 3.6 g iodine, which is approximately a 90% reduction from the clinical CM individualized standard CT protocol (up to 500 mg iodine per kg body weight) (6).

Contrast-induced acute kidney injury (CI-AKI) is considered a complication to the use of CM. The widely used definition of CI-AKI is an increase in serum creatinine of 25%, or 44 μmol/L, from baseline within 72 h after the administration of intravascular CM. The complication predominantly affects patients with reduced renal function. In clinical practice, it is considered that the risk of kidney damage increases with the dose of injected CM (7). Therefore, in dialysis patients with residual renal function, it is important to
minimize the use of CM to preserve kidney residual function. Although we injected a 10% CM solution, which in total contained only 3.6 g iodine, the dilution effect in the vessels was smaller than expected and an attenuation of approximately 900 HU was obtained in the central veins. This indicates that the CM could be further diluted, reducing the total CM dosage even more. In theory, to achieve 400 HU the dose could be halved, but there will be individual variations due to regional blood flow. Further studies refining the concentration of the injected CM should be performed in those patients where a repeated CM injection would be of less risk of CI-AKI. By injecting a low CM dose, the risk of streak artifacts from first-pass of high intravascular concentrations of CM (8) can be avoided. The technique described in this case report should therefore be beneficial also to patients with normal renal function.

There are several non-invasive techniques to evaluate the SVC. The simplest to the patient is US Doppler. However, US Doppler is user-dependent, and the lack of images is easy to interpret as the clinician makes alternative imaging and diagnostic techniques desirable. Magnetic resonance angiography is an appealing alternative, but the risk of necrotizing systemic fibrosis in patients with severe renal failure and scanner availability limits its use (9). Standard CT with intravenous CM is another alternative. However, in patients with renal impairment, this implies an increased risk of CI-AKI.

In cases where patients have limited imaging options or when other imaging options have failed, a CT venogram with a total of >3.6 g iodine, bilaterally injected, might be helpful as an additional way to determine stenosis of the thoracic venous system, especially in cases of suspected SVC syndrome. Furthermore, the anatomical information from CT, including information about collateral vessels, helps making the diagnosis and would be of value to guide interventionalists when planning treatment for the patient (5,10).

Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

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