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## Case Report

# A rapid caliber change in the inferior vena cava during multiphasic contrast-enhanced computed tomography may signal an acute anaphylactic reaction to nonionic contrast medium

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## ABSTRACT

Severe anaphylactic reactions to an intravenous nonionic iodine contrast medium (NICM) are uncommon but can result in permanent morbidity or death if not managed appropriately. An anaphylactic reaction to a NICM typically manifests as clinical symptoms that include an itchy nose, sneezing, and skin redness. To our knowledge, a rapid change in the caliber of the inferior vena cava (IVC) during multiphasic contrast-enhanced computed tomography (CT) has not been reported. Here, we report the computed tomographic findings in three cases of hypovolemic shock caused by an anaphylactic reaction to a NICM. We suspect that a decrease in caliber of the IVC during multiphasic contrast-enhanced CT may

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be a predictor of an allergic-like reaction to an NICM. Patients in whom physicians and radiographers detect a rapid caliber change in the IVC during multiphasic contrast-enhanced CT should be managed carefully.

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## Introduction

Computed tomography (CT) with nonionic iodine contrast medium (NICM) is becoming an increasingly common radiologic examination worldwide. NICMs are generally considered safe, and adverse events are uncommon [1,2]. However, acute adverse reactions to these agents are important in clinical practice because they are unpredictable and uncomfortable for patients [3]. Anaphylactic reactions to intravenous NICMs range from mild flushing to cardiopulmonary arrest and occur in about 1% of patients [2,4]. During multiphasic contrast-enhanced CT, several of our patients have experienced a rapid change in the caliber of the inferior vena cava (IVC), suggesting hypovolemic shock caused by an anaphylactic reaction to an intravenous NICM. To the best of our knowledge, this rapid change in the caliber of the IVC during multiphasic contrast-enhanced CT in association with an anaphylactic reaction has not been reported. Here, we report three cases of hypovolemic shock and discuss their CT findings.

## Case reports

### Patient 1

A 68-year-old man with hepatocellular carcinoma and no history of allergy was referred for abdominopelvic CT (Aquilion Precision; Toshiba Medical Systems, Tokyo, Japan) and received an intravenous injection of 100 mL of non-ionic iodinated contrast material containing 300 mg I/mL at a rate of 3 mL per second. For bolus tracking, a region of interest was placed in the thoracoabdominal aorta junction, with a trigger set to start at 100 HU. Scanning was initiated 10 seconds later. The scanning was performed as follows: (1) unenhanced CT, (2) a bolus-triggered arterial phase, (3) 25 seconds after the start of the arterial phase acquisition (portal phase), and (4) 180 seconds after the start of the arterial phase acquisition (venous phase).

During multiphasic contrast-enhanced CT, the patient had several adverse reactions to the contrast medium, including cough, chest discomfort, and tachycardia. After the CT examination, the patient remained awake and alert despite having a low blood pressure (systolic 54 mmHg, diastolic unmeasurable). These symptoms resolved about 30 minutes later.

The caliber of the IVC had not decreased on the unenhanced, arterial, and portal phases (Figs. 1a–c) and had increased on the portal phase (Fig. 1c). However, the venous phase contrast-enhanced CT images showed that the IVC was flattened or diminished at the lower levels of the infrahepatic portion (Fig. 1d). There were no additional features of

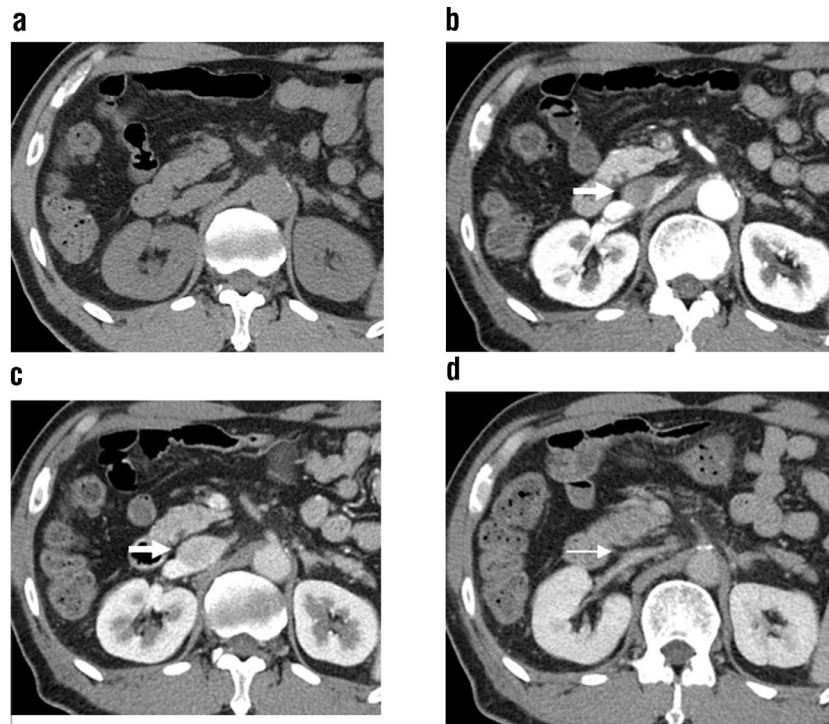
hypoperfusion complex for reasons other than anaphylactoid shock [5,6], such as decreased enhancement of the viscera, increased mucosal enhancement and luminal dilatation of the small bowel, mural thickening and fluid-filled loops in the small bowel, a dense small-caliber aorta, intensely enhancing kidneys and mesenteric vasculature, the halo sign around the IVC, or peripancreatic edema. Dynamic contrast-enhanced magnetic resonance imaging performed four months later (not shown) did not reveal any abnormal findings in the IVC.

### Patient 2

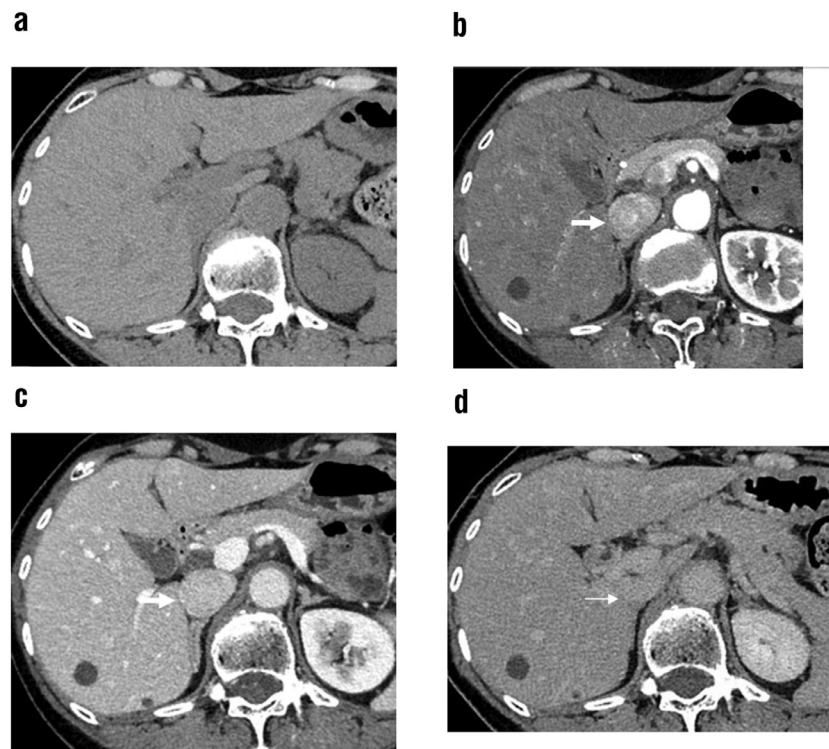
A 64-year-old woman with renal cell carcinoma and no history of allergy underwent abdominopelvic CT (SOMATOM Definition Flash; Siemens AG, München, Germany) using the same protocol as in patient 1. During multiphasic contrast-enhanced CT, the patient had several adverse reactions to the contrast medium, including cough and generalized redness. After the examination, the patient could open her eyes on command despite having a low blood pressure (89/35 mmHg). These symptoms resolved about 20 minutes later. The caliber of the IVC had not decreased on the unenhanced, arterial, and portal phases (Figs. 2a–c) and had increased slightly on the arterial and portal phases (Figs. 1b and c). However, the contrast-enhanced CT images on the venous phase revealed that the IVC was flattened or diminished at multiple levels of the infrahepatic portion (Fig. 2d). Additional features of hypoperfusion complex [5,6] were not seen. Magnetic resonance imaging performed six months later did not reveal any abnormal findings in the IVC (not shown).

### Patient 3

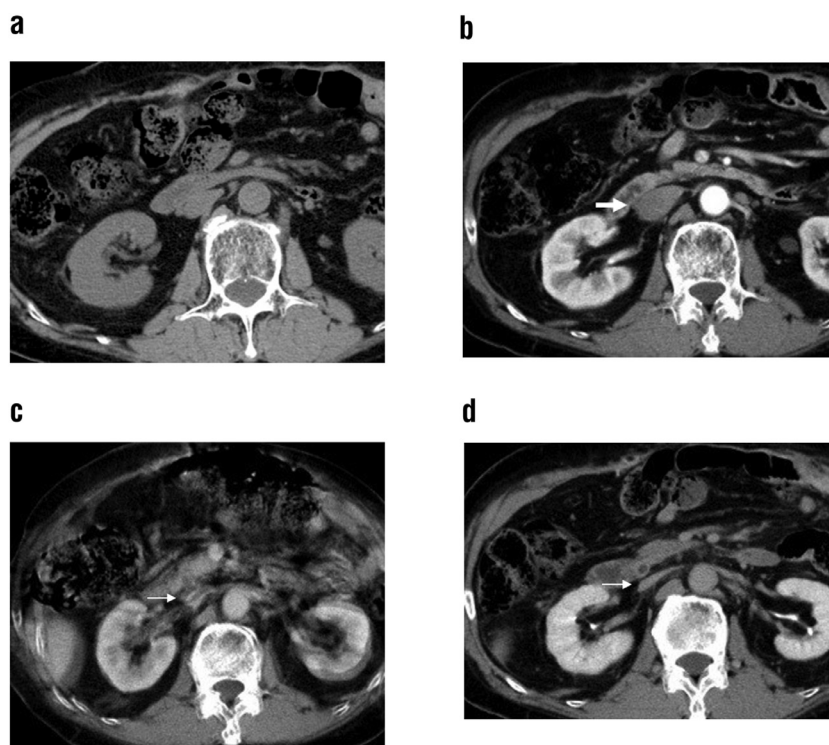
A 68-year-old man with hepatocellular carcinoma and no history of allergy underwent abdominopelvic CT (SOMATOM Definition Flash) using the same protocol as in patient 1. During multiphasic contrast-enhanced CT, the patient had several adverse reactions to the contrast medium, including an itchy nose, sneezing, and skin redness. After the examination, the patient remained awake and alert despite having a low blood pressure (79/46 mmHg). These symptoms resolved about 5 minutes later. The caliber of the IVC had not decreased on the unenhanced and arterial phases (Figs. 3a and b) and had increased on the arterial phase (Fig. 1b). However, the portal and venous phase contrast-enhanced CT images revealed that the IVC was flattened or diminished at the level of the infrahepatic portion (Figs. 3c and d). No additional features of hypoperfusion complex [5,6] were seen. Magnetic resonance imaging performed seven months later (not shown) revealed no abnormalities in the IVC.



**Fig. 1** – Multiphase contrast-enhanced CT images for a 68-year-old man with hepatocellular carcinoma. (a–c) The caliber of the IVC is not diminished on the unenhanced (a), arterial (b), or portal (c) phases. The caliber of the IVC is expanded (thick arrow) on the arterial (b) and portal phase (c). (d) Venous phase contrast-enhanced images reveal a flattened IVC (thin arrow) at the level of the hilum of the right kidney.



**Fig. 2** – Multiphase contrast-enhanced CT images for a 64-year-old woman with renal cell carcinoma. (a–c) The caliber of the IVC is not diminished on the unenhanced (a), arterial (b), or portal (c) phases. The caliber of the IVC had been slightly expanded (thick arrow) on the arterial (b) and portal (c) phases. (d) Venous phase contrast-enhanced CT images reveal a diminished IVC caliber (thin arrow) at the level of the hepatic portion.



**Fig. 3 – Multi-phasic contrast-enhanced CT images for a 68-year-old man with hepatocellular carcinoma. (a, b) The IVC caliber is been diminished on the unenhanced (a) and arterial (b) phases. The caliber of the IVC had been expanded (thick arrow) on the arterial phase (b). Portal (c) and venous (d) phase contrast-enhanced images reveal that the IVC is flattened (thin arrow) at the level of the hilum of the right kidney. Motion artifact caused by sneezing appears on the portal phase (c).**

## Discussion

The American College of Radiology guidelines [7] classify acute adverse reactions as allergic-like or physiologic and organize them according to severity as follows: mild (signs and symptoms are self-limited without evidence of progression); moderate (signs and symptoms are more pronounced and usually require medical management); or severe (when signs and symptoms are life-threatening and can result in permanent morbidity or death if not managed appropriately).

The CT features of hypovolemic shock for reasons other than an anaphylactoid reaction to an NICM include decreased enhancement of the viscera, increased mucosal enhancement and luminal dilatation of the small bowel, mural thickening and fluid-filled loops in the small bowel, a dense small-caliber aorta, intensely enhancing kidneys and mesenteric vasculature, a halo sign and flattening of the IVC, and peripancreatic edema [5,6]. Our patients with anaphylactic shock did not have CT findings suggestive of hypovolemic shock [5,6] other than flattening of the IVC. Moreover, the changes in caliber were dynamic, with the IVC expanding on arterial and/or portal phases and becoming flat with a slit-like shape during multiphase contrast-enhanced CT in these patients. To our knowledge, simultaneous flattening of the IVC in association with an allergic-like reaction to an NICM and a rapid change in the caliber of the IVC during CT has not been reported in the literature before.

Expansion of the IVC on the arterial and/or portal phases may be a response to the rapid volume overload of NICM. A decrease in the caliber of the IVC in the setting of hypoperfusion has been defined as flattening of the infrahepatic portion of the IVC (<9 mm) over at least three sections obtained at 1 cm intervals [8]. The decreased caliber of the IVC in patients with hypovolemia is most likely attributable to decreased venous return and the sympathetic response. The duration and timing of hypovolemic shock could be part of the reason for the difference in CT features between an anaphylactic reaction to NICM and hypovolemic shock complex. Demonstration of a collapsed IVC could precede clinical detection of shock [5,8]. We suspect that the decrease in caliber of the IVC during multiphase contrast-enhanced CT may be a predictor of an allergic-like reaction to NICM. If physicians and radiographers detect a rapid change in the caliber of the IVC during CT, the patient should be managed carefully and not moved from the CT bed immediately after the examination. A study in a larger number of patients will be needed to determine how often this change in caliber occurs, the correlation between the change in caliber and the severity of hypovolemic shock, and the time lag between the start of injection of the NICM and detection of the decrease in caliber of the IVC, which may predict an induced allergic-like reaction to NICM.

In conclusion, the hypoperfusion complex that develops in response to an anaphylactic reaction to an NICM is an indicator of a tenuous hemodynamic status and can be identified as a rapid change in the caliber of the IVC on multiphase

contrast-enhanced CT scans. This finding could be a marker of a severe allergic-like reaction to NICM. Appropriate management of these patients depends on accurate and timely interpretation of these CT findings.

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