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ARTICLE in JBR-BTR: ORGANE DE LA SOCIÉTÉ ROYALE BELGE DE RADIOLOGIE (SRBR) = ORGAAN VAN DE KONINKLIJKE BELGISCHE VERENIGING VOOR RADIOLOGIE (KBVR) - OCTOBER 2013

Source: PubMed

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A CASE OF MASSIVE TRANSIENT REDUCTION OF ATTENUATION OF IODINE CONTRAST BOLUS DURING COMPUTED TOMOGRAPHY PULMONARY ANGIOGRAPHY: WHY AND HOW TO AVOID IT

B. Coulier, S. Van den Broeck

We report an incidental case of combined disproportionate deep inspiration and breath-old artifacts producing during computed tomography pulmonary angiography performed to exclude pulmonary embolism in a 69 year-old patient. These known but unwelcome cumulated artifacts may cause transient major attenuation or interruption of the contrast bolus which may occasionally obscure or mimic an embolus. We shortly review the mechanisms of these classical artifacts and the adequate breathing instructions to avoid them are remembered.

Key-word: Embolism, pulmonary.

Case report

A 69-year-old smoker suffering from chronic obstructive pulmonary disease presented to our emergency department with complaints of unproductive cough and increasing dyspnea. There was a recent history of bronchitis treated with amoxicillin and clarithromycine. Arterial gasometry confirmed moderate respiratory acidosis. D-dimers were moderately elevated at 65 mcg/100 ml (nl < 50).

CT pulmonary angiography was asked to specifically rule out associated pulmonary embolism.

CT pulmonary angiography was performed with a 64-row MDCT (Lightspeed Ultra, GE Medical System, and Milwaukee, WI) and following our local classical protocol.

During this protocol non ionic contrast (Optiray 300, Guerbet, France) is injected at a rate of 3.5 ml/s via a 18-20-gauge needle. The technical parameters are 100 Kv, 0.5 sec rotation time, auto mA regulation and a pitch of 0.984. The delay before starting the acquisition varies from 12 to 30 sec. It is determined by a compromise between the level of HU automatically measured on a reference cut positioned in the main pulmonary artery (SmarPrep, General Electric, Wisc) and/or by the operator’s visual appreciation of the whiteness of this artery. The acquisition time requires a technical delay of 9 seconds followed by a mean time of 4 seconds to scan the entire chest. With these parameters the total examination time varies from 25 to 43 sec and the amount of injected contrast from about 85 cc to an automatically blocked maximum of 120 cc. Saline injection of 20 cc automatically follows.

The inspiratory and breath hold instructions are given to the patient during the technical delay of 9 seconds before scanning. Thus the required time of breath hold is about 12 seconds. The patient’s arms are positioned above the head but comfortably lying on a big cushion, a positioning classically guaranteeing in our experience a minimum compression of the veins entering the chest.

Immediately after the offset of inspiration, a dense column of contrast medium flows within the aorta. This column reaches the periphery of the previously intensely enhanced pulmonary arteries. The pulmonary arterial iodine appeared acutely diluted by volutes of unenhanced blood and a nearly complete and premature wash out of the main pulmonary artery was drastically observed contrasting with the high density of the aorta. An unusual collapse of the superior vena cava was also found in association with massive blockage and retrograde reflux of contrast within dilated caval veins.

These abnormalities were finally attributed to massive and combined “deep inspiration” and “breath-hold” artifacts. Retrospectively it appears that these caricature artifacts were probably the result of a combination of inadequate breathing instructions and disproportionally exaggerated respiratory maneuvers performed of the patient.

Discussion

For CT pulmonary angiography, optimal contrast opacification of the vessels depends on several factors including adequate injection delay and duration, scan duration, injection rate, total volume of contrast administered and concentration of iodine content of the contrast medium (1-3). Strictly adequate breathing instructions also appear essential for optimal diagnosis.

A transient attenuation or interruption of the contrast bolus has been described as a physiologic artifact associated with initial inspiration immediately before the scan. This artifact can sometimes result in poor opacification of the pulmonary arteries during CT pulmonary angiography (1-3). This unwelcome artifact can have negative consequences for the diagnosis of pulmonary embolism: an embolus may potentially be obscured or hidden within an insufficiently opacified pulmonary artery; reciprocally a focal interruption of the contrast medium column can mimic an embolus (4).

It has been suggested that transient attenuation or interruption of the contrast bolus during CT pulmonary angiography might be related to inappropriate suspended deep inspiration through several mechanisms including an altered contrast medium flow dynamics during forced inspiration and resulting in the passage of a bolus of non opacified blood from the inferior vena cava entering the right heart (suction mechanism), an acutely reduced delivery of contrast medium via the superior vena cava to the right atrium secondary to a sudden rise in intra-thoracic pressure during end-inspiratory breath-hold and/or inappropriate simultaneous Valsalva maneuver, and accessorially a preferential flow of contrast medium.
Different respiratory maneuvers (1). When intrathoracic pressure remains constant, as during breath-holds at end-inspiration and end-expiration, the IVC to SVC flow ratio is very similar to that during free breathing, the ratio of IVC flow to SVC flow being approximately 2:1.

This flow ratio reduces during Valsalva maneuver which produces also the greatest decrease in venous return from the IVC and therefore would be expected to result in the best contrast opacification of the pulmonary arteries through the SVC. In daily practice it would be difficult, however, for most patients to sustain excessive inspiration in the phenomenon.

In a recent study MRI has been used for noninvasive evaluation of the manner in which the superior vena cava (SVC) and inferior vena cava (IVC) contributions to systemic venous return to the thorax vary with different respiratory maneuvers (1). When intrathoracic pressure remains constant, as during breath-holds at end-inspiration and end-expiration, the IVC to SVC flow ratio is very similar to that during free breathing, the ratio of IVC flow to SVC flow being approximately 2:1.

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Fig. 1 — Curvilinear MPR views of the pulmonary arteries – bifurcation (A), right (B) and left (C) arteries – illustrate a massive prograde irruption of unenhanced blood within the previously enhanced arteries. Volutes of unenhanced blood acutely dilute the iodine contrast. The nearly complete wash out of the pulmonary artery (black star) drastically contrasts with the high density of the aorta (white star).
The inspiratory IVC flow may increase only 15% in a subject but 140% in another in the series of Kuzo (1). A possible mechanism may be that diaphragmatic descent during inspiration increases intraabdominal pressure. With positive intraabdominal pressure and negative intrathoracic pressure, the greater pressure gradient along the IVC than along the SVC results in greater augmentation of IVC flow (9).

In our caricature reported case the intense inspiratory attenuation artifact has probably been amplified by an involuntary concomitant equivalent of Valsalva maneuver during the “breath-hold” at the end of the exaggerated deep inspiration. This “breath hold” produced acute positive intrathoracic pressure after the initial negative pressure generated by the inspiration (8). The result was an immediate collapse of the superior vena cava and a blockage of the contrast column with intense reflux in the cervical and jugular venous system (8) (Fig. 2, 3). In other words, the dilution of the contrast caused by the augmentation of the unenhanced IVC flow during the deep inspiration has been amplified by the nearly simultaneous blockage of the enhanced SVC flow by the Valsalva maneuver.

High-flow injection – 5 to 7 cc/sec – could represent an alternative to avoid the described artifact but this type of injection which requires constant high quality and safe intravenous catheters, a condition not easily achievable seven days a week in current clinical practice especially in elderly or altered patients.

To reduce inspiration and breath-hold associated artifacts authors have promoted expiratory CT pulmonary angiography and have concluded that expiratory scanning could be used as an optimal protocol for dedicated pulmonary artery imaging. However, this protocol suffers from inferior parenchymal imaging and should probably be reserved for failed inspiratory breath-hold CT pulmonary angiography (4,10).

We conclude that, in clinical practice, breathing instructions would be unambiguously appropriate to avoid the inspiration artifact as much as possible. Instructions such as “stop breathing” or “hold your breath” appear the most appropriate but others such as “take a deep breath and hold it” or “take a deep breath and block your breath” would be absolutely avoid.
References


