Recognition and Avoidance of Artifacts in Computed Tomography Pulmonary Angiography (CTPA)

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Learning objectives

When performing and interpreting Computed Tomography Pulmonary Angiography (CTPA), it is important for the radiographer and interpreting radiologist to be aware of artifacts which can lead to an indeterminate CTPA or incorrect interpretation. When optimizing image quality, it is necessary to understand why artifacts occur and how they can be prevented or reduced though physics, patient, pathology and scanner related factors. In this presentation we discuss the common artifacts that can affect CTPA and how these can be avoided. The specific learning objectives are:

1. To recognize that artifacts in CTPA can lead to errors in interpretation
2. To understand the artifacts most commonly encountered in CTPA
3. To understand how artifacts can be reduced in CTPA

Images for this section:
**Fig. 1:** This image demonstrates a non-occlusive pulmonary embolus in the right lower lobe pulmonary artery.
Background

Pulmonary embolism is a common and potentially fatal condition and as such rapid and correct diagnosis important. Computed Tomography Pulmonary Angiography (CTPA) has in most centers become the imaging investigation of choice for pulmonary embolism due to its high sensitivity and specificity (1), speed and convenience. Unfortunately, the quality of CTPA images can be significantly affected by artifacts, in some cases to the extent of rendering the scans non-diagnostic (2). Furthermore, artifacts can in some instances simulate pulmonary emboli, leading to incorrect interpretation and thus affecting management of the patient. Three of the most common artifacts encountered are motion artifact, flow artifact, and streak artifact.

Motion Artifact

The most common artifact affecting CTPA is motion artifact arising from respiratory motion. This artifact can result in blurring and hypodensities resembling pulmonary emboli due to partial volume averaging (3). With the advent of multi-detector computed tomography (MDCT) and the acquisition of the scan with a single breath hold, motion artifact is mainly a problem in patients with dyspnea and strategies in such patients include providing supplemental oxygen, reducing scan times by reducing the volume of coverage and ensuring patients complete a breath-hold before scan initiation. Erroneous interpretation can be reduced by reviewing scans of suspected pulmonary emboli on the lung window (window width, 1,500 H; window level, -600), which demonstrates blurring due to respiratory motion more clearly than a pulmonary embolism specific window (window width, 700 H; window level, 100 H). Motion artifact should also be suspected when there is a significant change in vessel position on adjacent slices (4).

Flow Artifact

Flow artifacts result from inadequate mixing between the injected contrast and blood. This in turns causes interruption of contrast material in the pulmonary arteries manifesting as poor opacification of pulmonary artery segments compared to the segments more proximally and distally. The artifact has been shown to result from an increase in flow of blood from the inferior venae cava (IVC) to the right side of the heart (5). Avoiding pre-scan hyperventilation which is unnecessary with the use of fast MDCT scanners can reduce flow artifact as exaggerated respiratory movements increases the flow of contrast from the IVC to the right atrium (4). Flow artifacts may require repeat CTPA if thrombus is suspected in the poorly opacified arteries.

Streak Artifact
The two main causes of streak artifacts in CTPA are the presence of metals such as surgical clips, and dense contrast in the superior vena cava (SVC). Streak artifacts due to objects can be minimized by removing all possible metallic hardware and by not including arms in the scan field. Streak artifacts from contrast in the SVC can be reduced by reduced by using a saline bolus immediately after contrast injection.

**Imaging findings OR Procedure details**

We present two cases demonstrating artifacts encountered during CTPA. In both cases, the indication for CTPA was suspected pulmonary embolism based on clinical information.

**Technique for Scans**

The technique for scan acquisition for both cases was as follows:

- CTPA was performed using a 64 channel computed tomography scanner in a craniocaudal direction.
- Patients were positioned supine with arms resting on the gantry above their heads. Anterior-posterior and lateral scout scans were performed, with a scan range from the apices (2 cm above the 1st rib) to the diaphragm (2 cm below the lowest costophrenic recess).
- 80 mL of contrast (Optiray 350 mgI/mL) was intravenously injected at a flow rate of 4.5 mL/s using dynamic bolus tracking. A 50 mL saline chaser injected at 4.5 mL/s was employed.
- The scan parameters were: detector width 64 x 0.625 mm; pitch 0.984:1; rotation time 0.4 s; exposure factors 120 kVp, 350 mA, with z-axis modulation; scanning time from 2.9 - 4 s

**Case 1**

A 69 year old male patient developed acute shortness of breath following spinal fusion surgery 5 days earlier. He was being anti-coagulated post-operatively on a prophylactic dose of subcutaneous heparin. A CTPA was ordered urgently and selected axial slices are shown in Figure 2 and Figure 3. Figure 2 demonstrates streak artifact due to the spinal rods which significantly degraded the quality of the images. The artifact can be seen to extend across the left main pulmonary artery. Streak artifact was also caused by monitoring leads external to the patient, which is a common occurrence. Figure 3-
an axial slice at a higher level shows streak artifact due to dense contrast in the left brachiocephalic vein draining into the SVC.

**Case 2**

A 59 year old female with previously diagnosed left lower lobe lung carcinoma presented with worsening shortness of breath. An urgent CTPA was performed and it was noted the patient was from a non-english speaking background and was not able to follow commands properly. When the scans were reviewed, there was a query regarding a subsegmental branch of the right upper lobe being low in density and possibly representing a pulmonary embolus (Figure 4). When the same slice was reviewed on a lung window (Figure 5), it was seen clearly that this was most likely due to respiratory motion.

**Images for this section:**

![Image of CT scan showing streak artifact due to spinal rods](image_url)

**Fig. 2:** This image demonstrates the effect of streak artifact due to the spinal rods which has resulted in low density lines across the left main pulmonary artery
Fig. 3: This image of the same patient at a lower level demonstrates streak artifact from dense contrast in the left brachiocephalic vein draining into superior vena cava. The spinal rods are again seen to generally degrade the quality of the image.
Fig. 4: This figure demonstrates a selected axial slice of a CTPA performed in a patient with worsening shortness of breath on a background of small cell lung cancer. There was a query over a possible hypodensity in one of the subsegmental branches supplying the right upper lobe.
**Fig. 5:** This image represents the same axial slice as Figure 4 with a lung specific window. Respiratory motion can be seen more easily on this window and explains the query over the possible abnormality in the subsegmental branch of the right upper lobe.
Conclusion

CTPA has been shown to have high sensitivity and specificity in the diagnosis of pulmonary embolism and as such in most institutions has become the first choice of investigation for suspected pulmonary embolism. Artifacts, which are most commonly due to patient and scanner factors can lead to incorrect interpretation or degrade the quality to the point of rendering the scan non diagnostic. As such it is essential that radiographers and radiologists are aware of the influence of artifacts on the interpretation of scans and understand how they are caused and can be avoided

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References


