Original Article

Vascular air embolism after contrast administration on 64 row multiple detector computed tomography: A prospective analysis

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ABSTRACT

Background: Vascular air embolism is being progressively reported as a nonfatal event with increase in use of computed tomography (CT) as a diagnostic modality. This study was undertaken to study the frequency and site of vascular air embolism in patients undergoing contrast-enhanced CT (CECT) and analyze CT parameters that influence its prevalence and final outcome. **Materials and Methods:** This was a prospective study approved by departmental ethics committee. Presence and location of air emboli in 200 patients who underwent CT scan of chest on a 64 detector scanner was recorded. We analyzed the role of various factors that could influence the prevalence of air embolism after injection of contrast in CECT scans. These factors included the amount of contrast injected, rate of flow of injection of contrast, site of injection of contrast, and size of intravenous access line. **Results:** Iatrogenic vascular air emboli were seen in 14 patients (7% of total). The locations of air emboli were main pulmonary artery in 12 (6% of total), left brachiocephalic vein in 3 (1.5% of total), right atrial appendage in 4 (2% of total), and superior vena cava (SVC) in 1 (0.5%) patient. There was no association between volume of contrast, flow rate, site and size of intravenous access, and presence of air emboli. **Conclusion:** Radiologists as well as referring physicians should be aware of vascular air embolism, which can occur after contrast injection in patients undergoing CT scan. Age, volume of contrast, flow rate of pressure injector, and site and size of venous cannula do not influence the likelihood or incidence of detection of venous air emboli on CT scans.

KEY WORDS: Air, contrast, computed tomography, embolism, vascular

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INTRODUCTION

Vascular air embolism during or after contrast-enhanced computed tomography (CECT) scan is being progressively reported as a nonfatal event with increase in the use of CT as a diagnostic modality.[1-3] Most of these events of venous air embolism are asymptomatic. Patients with known risk factors such as right-to-left intracardiac shunt or pulmonary arteriovenous malformation, are reported to be at a higher risk of having neurological deficits from even small amounts of venous air.[1-2] Great vigilance is recommended in this group of patients to prevent air embolism during administration of intravenous contrast.

A small air embolism usually does not require any intervention other than observation.[3] Although accidental injection of 100 cc of air has been reported as fatal, multiple factors such as body position, injection speed, total amount of air injected, and general health status play a part in fatal cases of venous air embolism.[1,2] The morbidity is believed to be caused by entrapment of air in the right ventricular flow tract, which precipitates circulatory failure. The main pulmonary artery, axillary, and subclavian veins are reported as the most common locations for air entrapment.[1]

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Recent studies have suggested that smaller volumes of venous air emboli may not be detected clinically but may be identified on CT scans of the chest[1] or head.[4] Although these small amounts of air do not have clinical implications and are often asymptomatic, the radiologists and referring physicians should be aware that such small venous air emboli do occur frequently to preclude a search for other sources of the gas.

Only a few studies are available in the literature dealing with the incidental nonfatal venous air embolism seen after CT examination, especially the CECT using power injectors.

We performed this study to evaluate the frequency and site of vascular air embolism in patients undergoing CECT and further tried to analyze whether age and the four common CT parameters (volume of contrast, rate of flow of contrast, site of injection, and size of intravenous access line through, which contrast is injected) can influence its prevalence and final outcome.

MATERIALS AND METHODS

This was a prospective study approved by the departmental ethics committee. Two hundred patients who underwent chest scans as well as the thoracic and pulmonary angiographic studies over a period of six months were included in this study.

The nursing staff (on duty for cannulating the patients for CT), CT technologists, as well as the reporting radiologists were unaware of the parameters studied to eliminate any potential element of bias. The size of cannula used, the site of intravenous access, the flow rate, and volume of contrast used were recorded.

All CT scans were performed on a 64-slice MDCT scanner (TOSHIBA AQUILION [V3.30ER001 Toshiba America Medical System]) and were analyzed using the Aquarius Intuition workstation (TERRARECON version 3.4). Dual head pressure injector (Medrad Stellant model) was used for contrast injection. The type of the intravenous (IV) cannula used was determined by the age of the patient and the size of the peripheral veins. The site of intravenous access was however determined randomly. The flow rate of injection of contrast was adjusted according to the need of the CT study to be performed, as well as keeping in mind the size of IV cannula used.

Non-ionic iodinated contrast was used in all patients and the amount of contrast to be injected varied, depending on the weight of the patient. After gaining the intravenous access, 10 mL of isotonic normal saline was infused to check for the patency of the cannula. The required amount of contrast was loaded into the power injector. The tubing of the injector was then connected to the IV cannula. At each step it was ensured by the technologist that air was ejected from the infusion bottle as well as by connecting tube and the whole system from the infusion bottle to the cannula was free from visible air. CT scan was performed with the patient lying supine right from the start till the end of the study. Two experienced radiologists analyzed the scans separately and identified the presence of air foci in the systemic veins as well in the pulmonary artery and heart chambers.

The presence of air embolus, its location, as well as its size were recorded and the findings were confirmed and reviewed by both radiologists in consensus.

The air emboli were categorized into small, moderate, and large depending on either the size or number of air emboli [Table 1].

In addition, presence of air emboli was also analyzed with the following variables:

- Amount of contrast injected (<50 mL and >50 mL)
- The flow rate (<2.4 mL/s and > 2.4 mL/s)
- The site of intravenous access (upper extremity/lower extremity/right/left)
- IV cannula gauge size.

Those patients who showed the presence of incidental venous air emboli were observed for a period of 12 h for development of any possible complications by a radiology senior resident (fellow). The statistical analysis was performed using the Pearson's Chi-square test.

RESULTS

Of the 200 patients, there were 107 males (53.5%) and 93 females (46.5%). The age of the patients ranged from 3 months to 82 years (mean 38.5 ± 23.7 years).

Incidental air emboli were seen in 14 patients (7% of total). A total of 20 definite air emboli were identified at CT scans. The location of air emboli were as follows:

- Main pulmonary artery in 12 patients (6% of total) [Figure 1]
- Left brachiocephalic vein in three patients (1.5% of total)
- Right atrial appendage in four patients (2% of total) [Figure 2]
- Superior vena cava in one patient (0.5% of total).

Seventeen small and three moderate-sized emboli were seen. Large emboli were not encountered in this study nor were any air contrast levels seen after the CT examination.

Table 1: Classification of size of air emboli

Type of embolus	Size of air embolus (diameter in cm)	Number of air emboli
Small	<1	1-3
Moderate	1-2	>3
Large	>2	Presence of air-contrast level

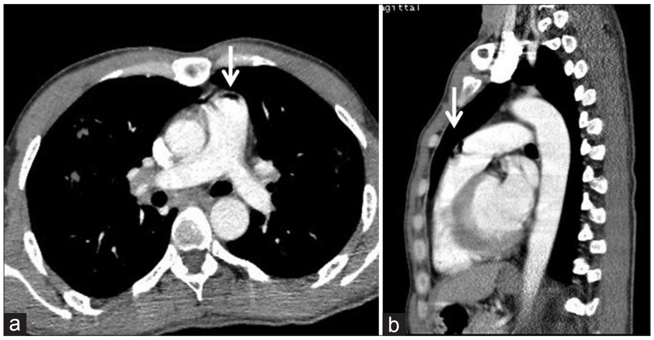

Figure 1: (a) Axial and (b) sagittal computed tomography images of a 34-year-old man showing air emboli in main pulmonary artery (arrows in a and b)

The various parameters analyzed are summarized in Tables 2 and 3.

Fourteen patients encountered in this study with the presence of air emboli did not show any signs or symptoms of discomfort. As a precautionary measure, all these patients were made to lie in left lateral decubitus along with head down position and vitals were monitored. These patients were kept under observation for a period of at least 12 h and were discharged subsequently.

DISCUSSION

Venous air embolism after intravenous administration of contrast before CT scanning has been reported to occur in 11%-23% of patients.[2] Accidental injection of 100 cc of air has been reported as fatal, however, multiple factors such as body position, injection speed, total amount of air injected, and general health status play a part in fatal cases of venous air embolism.[1,2] It is possible to detect cases of subclinical venous air embolism on CT as immediately after the contrast injection, head,[4] or thorax[1] can be scanned and analyzed for smaller volumes of venous air emboli, which may not be detected clinically.

Limited studies are available in the literature dealing with the incidental nonfatal venous air embolism that is seen after the CT examination, especially the CECT using power injectors. Woodring *et al*. reported an incidence of 23% of venous air embolism after CECT examination of the chest.[1] Groell *et al*. reported incidence of venous air embolism to be 11.7% for CECT examination and 5.5% for noncontrast scans.[5] The only assuring fact is that these cases of subclinical venous air embolism do not cause significant morbidity as well as mortality as seen in both of these studies. The results of our study indicate that out of the total 200 patients who underwent CT scans of the chest, the incidence of incidental venous air embolism was only 7%.

The air bubbles rise to the most nondependent areas in a vessel or cardiac chamber owing to the buoyancy of air in a fluid medium. In our study, the most common location of air embolus was seen in main pulmonary artery (5.52%) followed by right atrial appendage (2.2%), left brachiocephalic vein (1.65%), and superior vena cava (0.55%). Air emboli were detected in multiple sites in four patients (2.20%).

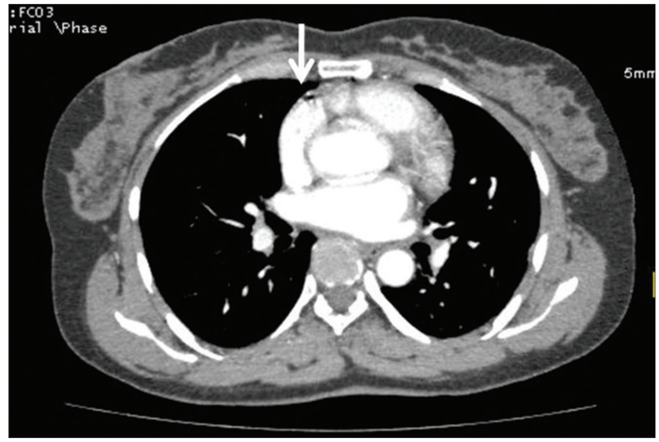

Figure 2: Axial computed tomography image of a 45-year-old woman showing air emboli (arrow) in the right atrial appendage

Table 2: Various parameters studied in the study group (*n*=200)

Parameter	No. of patients (%)	Venous air emboli (%)	*P*
Volume of contrast (mL)			0.239
≤50	72 (36)	3 (4.2)	
>50	128 (64)	11 (8.6)	
Flow rate (mL/s)			0.422
≤2.0	62 (31)	3 (4.8)	
>2.0	138 (69)	11 (8)	
Site of cannula for contrast injection			0.110
Right arm	169 (84.5)	14 (8.2)	
Left arm	29 (14.5)		
Right foot	2 (1)		
Left foot			

Table 3: Size of cannula used for contrast injection

IV cannula gauge size	No. of patients (%)	Venous air emboli (%)
18 G	141 (70.5)	11 (7.8)
20 G	13 (6.5)	-
22 G	20 (7)	1 (0.5)
24 G	26 (13)	2

P value: 0.739

Applying the nonparametrical statistical tests, the predictor parameters of the amount of contrast, flow rate, the IV cannula gauge size, and the site of injection yielded nonsignificant *P* values. These parameters were also not statistically significant as far as Groell *et al*.[5] were concerned. According to Price *et al*.,[6] intravenous administration of contrast material injected under pressure could result in large amounts of venous air embolism. Ball *et al*. reported a case of a large venous embolus as CT power injector was not appropriately primed with contrast.[7] No large embolus was encountered in our study even with the use of power injectors. This may be due to the fact that there has been meticulous monitoring of the whole system to be free of visible air.

The beam-hardening artifacts due to high contrast agent concentration in central veins can cause differences in the interpretation. Areas of low attenuation due to beam hardening can be misinterpreted as air bubbles, especially in the central veins. The image display parameters on the workstation for each image were altered to avoid any confusion. A relatively high window width (400–1600 HU) and a window center of approximately 40 HU were used for interpretation. Lung window settings (1600 HU and −600 HU) were also used to be sure about the presence of venous air emboli. These venous air emboli appeared as small round areas at most instances with irregular margins showing low attenuation with negative CT numbers in the range of −600 to −1000 HU. By doing so, the technical artifacts and presence of nonvascular air foci in mediastinum, pleura, and pericardium can be excluded.

Cor pulmonale and asystole can be the end result of entry of large volumes of air at a rapid rate.[8] The phenomenon of air lock occurs resulting in pulmonary outflow tract obstruction, consequently diminishing the cardiac output from right heart. This results in increase in central venous pressure and decrease in systemic and pulmonary arterial pressures.[9] The microbubbles in the pulmonary arterioles can cause impedance of the blood flow resulting in vasoconstriction. Another hypothesis states that there can be secondary tissue damage due to release of inflammatory mediators and oxygen free radicals.

The clinical manifestations of venous air embolism include acute shortness of breath, chest pain, feeling of impending death, cyanosis, hypotension, pulmonary edema, paralysis, and seizures, gasping, or immediate coughing.[10,11] This can also lead to sudden cardiac arrest resulting in morbidity and possibly mortality as well. There exists a distinct possibility of air bubbles entering into the left heart due to presence of right to left shunts such as patent foramen ovale, septal defects, and other. Also, intrapulmonary vascular shunting due to arteriovenous malformation or due to pulmonary vascular dilatation as seen in cirrhotic patients could be few of the occult causes of paradoxical air embolism.[12] None of the patients in our study had any complaint pointing toward fatal venous embolism.

The immediate treatment in cases of venous air embolism is to make use of the Durant position, that is, make the patient lie in left lateral decubitus with head down.[13] The possible hypothesis is that this position helps to keep the air bubble toward the apex of the right ventricle so that the possibility of the bubble obstructing the outflow tract or gaining access to the pulmonary arterial system would be minimized. In addition to it, 100% oxygen and if possible hyperbaric oxygen should be given immediately. The rationale is that there will be increased oxygenation of the tissues and there will be reabsorption of nitrogen into the blood.[14] The hyperbaric oxygen can also cause compression of the air bubbles and if given within 6 h it can be really useful in cases of cerebral air embolism.[15]

It is important to perform careful observation of the cannula, checking for any visible free air in the tubing or in the infusion bottle before loading the contrast, which should go a long way in minimizing the incidence of venous air embolism after CT examination.

CONCLUSION

To conclude, radiologists and physicians should be aware of vascular air embolism, which is a common iatrogenic benign finding detected on CT scan. Asymptomatic venous air emboli do occur frequently and should suggest the diagnosis in the proper given clinical background to preclude a search for other sources of air.

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