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Emergency Cardiac CT for Suspected Acute Coronary Syndrome: Qualitative and Quantitative Assessment of Coronary, Pulmonary, and Aortic Image Quality

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Abstract

OBJECTIVE—The purpose of this study was to determine whether a dedicated coronary CT protocol provides adequate contrast enhancement and artifact-free depiction of coronary, pulmonary, and aortic circulation.

MATERIALS AND METHODS—Dedicated coronary 64-MDCT data sets of 50 patients (27 men; mean age, 54 ± 12.4 years) consecutively admitted from the emergency department with suspected acute coronary syndrome were analyzed. Two independent observers graded overall coronary arterial image quality and qualitative and quantitative contrast opacification, motion, and streak artifacts within the pulmonary arteries and aorta.

RESULTS—Coronary image quality was excellent in 48 patients (96%) and moderate in two patients (4%). Eleven left main and 22 left upper lobar pulmonary arteries were not visualized. Qualitative evaluation showed pulmonary arterial tree opacification to be excellent except for the right and left lower lateral and posterior segmental branches (52–54% rate of poor opacification). Quantitative evaluation showed four central (8%), six lobar (8%), and 206 segmental (29%) branches had poor contrast opacification (< 200 HU). Nineteen right upper lobar arteries (38%) were slightly and one was severely affected by streak artifact. At the segmental pulmonary artery level, marked differences in contrast enhancement were detected between the upper (292 ± 72 HU) and both the middle (249 ± 85 HU) and the lower lobes (248 ± 76 HU) ($p < 0.01$). Mean aortic opacification was 300 ± 34 HU with excellent contrast homogeneity without severe motion or streak artifacts.

CONCLUSION—In the evaluation of patients presenting to the emergency department with suspected acute coronary syndrome, a dedicated coronary CT protocol enables excellent assessment of the coronary arteries and proximal ascending aorta but does not depict the pulmonary vasculature well enough for exclusion of pulmonary embolism.

Keywords

aortic disease; chest pain; coronary angiography; CT; pulmonary embolism; radiography

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The use of coronary CT as a possible triage tool for patients presenting to the emergency department with chest pain is currently an area of intense research interest. Early, accurate triage of these patients remains difficult. Chest pain history [1,2], a single set of established biochemical markers for myocardial necrosis (troponin I, troponin T, creatine kinase MB) [3, 4], and results of initial 12-lead ECG do not identify patients who can be safely discharged without further diagnostic testing [5–7]. As a consequence, the threshold for admitting patients remains low, and more than 85% of patients are discharged after additional observation and testing without a diagnosis of acute coronary syndrome (ACS) [8,9]. Despite this conservative practice, 2–8% of patients who are discharged from the emergency department experience ACS within the next 30 days [1,10–12].

Initial data suggest noninvasive coronary CT assessment of coronary artery disease has excellent performance characteristics for excluding ACS in patients presenting to the emergency department with possible myocardial ischemia (negative predictive value, 98–100%) [13]. A 2007 consensus statement by the North American Society of Cardiovascular Imaging and the European Society of Cardiac Radiology [14] on patients presenting to the emergency department with chest pain suggests that cardiac CT may play an important role in evaluation. Two main MDCT protocols are being evaluated: a dedicated coronary CT protocol advocated for patients with suspected ACS and a triple-rule-out CT protocol for patients with more nonspecific symptoms. The triple-rule-out CT protocol is designed to opacify the coronary, pulmonary, and aortic circulation to assess for pulmonary embolism (PE) and aortic dissection in addition to ACS. Quantitative studies [15,16] of triple-rule out CT with multiphase contrast infusions have shown excellent opacification of all three vascular systems. Disadvantages include low diagnostic accuracy in the detection and exclusion of clinically significant coronary stenosis (one study showed a sensitivity of 73% [17], another a specificity of 77% [18]), significantly higher radiation exposure, longer breath-hold, and increased volume of contrast material.

Because the precise role of the triple-rule-out protocol is still being evaluated, a dedicated coronary CT protocol is recommended for patients presenting to the emergency department with suspected ACS [14]. However, the ability of a dedicated coronary CT protocol to adequately opacify the aortic and pulmonary arteries in addition to the coronary arteries is unknown. The impetus behind this study was concern among readers of coronary CT scans about whether use of a dedicated coronary CT protocol would cause the readers to miss incidental PE and aortic dissection on images. The aims of this study were to quantitatively and qualitatively evaluate the ability of a dedicated coronary CT protocol to simultaneously provide adequate contrast enhancement and artifact-free depiction of the coronary arteries, the pulmonary vasculature, and the thoracic aorta in patients presenting to the emergency department with suspected ACS.

Materials and Methods

Patient Population

We retrospectively analyzed the coronary CT data sets of 50 patients (27 men, 23 women; mean age, 54 ± 12.4 years; range, 33–89 years) consecutively admitted from the emergency department in May and June 2004 with acute chest pain but normal or nondiagnostic ECG findings. Inclusion criteria were age older than 18 years, no or nondiagnostic ECG findings of myocardial infarction, initially normal levels of cardiac biomarkers, admission to rule out myocardial infarction, sinus rhythm, and ability to perform a breath-hold for longer than 10 seconds. Exclusion criteria were elevated levels of cardiac biomarkers, ECG changes diagnostic of myocardial infarction, hemodynamic instability, allergy to contrast media, serum creatine concentration greater than 1.3 mg/dL, metformin treatment, and hyperthyroidism. The

institutional review board approved the study, and informed consent was obtained from all patients.

CT Protocol

Cardiac MDCT scans were obtained with a 64-MDCT scanner (Sensation 64, Siemens Medical Solutions). A β -blocker (metoprolol) was administered to 21 patients (mean dose, 12 mg; range, 5–35 mg), and the resulting mean heart rate during scan acquisition was 64 ± 9 beats/min (range, 48–87 beats/min). The coronary CT protocol used at our institution is as follows: collimation, 0.6 mm; tube voltage, 120 kVp; tube current, 850 mAs with tube current modulation; image reconstruction slice thickness, 0.75 mm with 0.5-mm increment; and dedicated cardiac field of view 12–16 cm from carina to apex of the heart. Patients received two 300- μ g tablets of sublingual nitroglycerin immediately before CT acquisition to induce coronary artery dilation. After administration of a timing bolus (20 mL of contrast medium injected at 5 mL/s with a region of interest [ROI] placed over the ascending aorta) to ascertain the optimum time to begin scan acquisition, images were acquired during a single breath-hold in mid-inspiration with administration of 65–90 mL of iodinated contrast medium (iodixanol, Visipaque 370, GE Healthcare) at 5 mL/s followed by a 20-mL saline bolus chaser at 5 mL/s. Images were acquired in a craniocaudal direction. Retrospective ECG-gated reconstructions at 60–70% of the R-R interval were used to obtain coronary image sets with no or minimal motion artifact [19]. Images of the pulmonary arteries and aorta that were read were from similar phases. All images were viewed on a 3D workstation (Leonardo, Siemens Medical Solutions).

Image Analysis

Coronary arteries—Multiplanar reformations were used for optimal evaluation of each coronary artery. Coronary artery evaluation was assessed qualitatively by one reader not involved in the scoring of pulmonary arteries or aorta. The reader graded the overall quality of images of the coronary circulation on a 3-point scale as excellent, adequate, or poor. The following definitions were applied to the coronary scoring system: images were graded as excellent in the absence of any image-degrading artifacts related to motion, noise, or calcification; images were graded as adequate in the presence of image-degrading artifacts but with a high level of confidence in assessment for hemodynamically significant stenosis; images were graded as poor if image-degrading artifacts resulted in assessment for hemodynamically significant stenosis with a low level of confidence.

Pulmonary arteries—The pulmonary arteries were evaluated qualitatively and quantitatively with a 27-segment model [20]. In qualitative assessment, one reader independently evaluated opacification of the pulmonary vessel lumen, presence of motion artifact, and presence of streak artifact. Vessel lumen opacification was identified as homogeneous or heterogeneous contrast opacification by means of comparison with areas of homogeneous contrast opacification such as the heart chambers and great vessels. Motion was identified on the basis of the presence of blurred parenchymal detail and the seagull-wing appearance of pulmonary vessels [20]. Streak artifact was identified as linear radiopaque lines traversing a vessel and identifiable from a source such as a dense collection of contrast material or an ECG lead. Each category was qualitatively scored on a 3-point scale as excellent, adequate, or poor. Images were graded as excellent in the absence of any image-degrading artifacts; adequate image quality allowed assessment of vessels with moderate confidence; poor image quality allowed assessment of vessels with low confidence.

In the quantitative evaluation, two readers independently placed ROIs in the center of each pulmonary artery segment to measure mean $\pm$ SD attenuation. The ROI was sized to be one-half the diameter of the respective vessel and positioned to avoid streak artifacts where possible.

Whenever possible, the ROI was obtained from the central portion of the pulmonary vessel. Selection within each of the respective pulmonary artery levels was through an area of optimal and diffuse contrast opacification through three consecutive CT slices. The ROI was obtained from the center slice to avoid volume averaging.

Aorta—The aorta was evaluated qualitatively and quantitatively at three levels: aortic sinuses, most cranial level of the scan range, and most caudal level of the scan range. One reader qualitatively evaluated aortic lumen opacification and presence of motion and streak artifacts using the same 3-point scale as for the pulmonary arteries. In the quantitative evaluation, the same reader, using a technique similar to that used for assessment of the pulmonary arteries, placed ROIs in the center of the aorta at each level and measured mean $\pm$ SD attenuation. Homogeneity of contrast delivery was assessed by recording of the mean $\pm$ SD contrast opacification of one large ROI covering the length of the descending aorta.

Statistical Analysis

Results are mean $\pm$ SD. Comparisons between groups were made with paired Student's *t* tests. Interobserver agreement for quantitative assessment was evaluated with Bland-Altman analysis. A value of $p < 0.05$ was considered significant.

Results

Qualitative Evaluation

Coronary arteries—Coronary arterial image quality was graded as moderate in two patients and excellent in 48 (96%).

Pulmonary arteries—Eleven left main and 22 left upper lobar pulmonary arteries were not visualized. Main pulmonary artery opacification was excellent in 92% of the patients (Table 1). Lobar artery opacification was excellent in 85% of the patients; the right lower lobe artery had the poorest opacification (eight patients had markedly reduced opacification). Segmental pulmonary artery opacification was decreased, and the fraction of segments with excellent image quality varied from 52% to 85%. The right and left lateral and posterior segmental branches had the poorest opacification (52–54%). The main pulmonary artery exhibited minimal motion artifact in one patient but was scored as excellent in the others. Streak artifact predominantly affected right-sided vessels, most commonly the right upper lobe pulmonary artery and the right upper lobe anterior segmental branch. This finding was most often caused by a dense collection of contrast material in the superior vena cava (SVC) (23 of 50 patients). Other causes included ECG lead placement on the anterior chest wall in one patient and the presence of spinal fixation hardware in another patient. Only two patients had streak artifacts severe enough to hinder vessel lumen interpretation.

Aorta—Overall contrast opacification was excellent in 92% of the ROIs except in the most caudal aspect of the scan range, in which 8% of ROIs had suboptimal opacification. Three ROIs were slightly suboptimal, and one was markedly suboptimal (Table 2). Streak was the most prevalent artifact, usually at the level of the sinuses (14%). Four of these artifacts were caused by a dense collection of contrast material in the SVC, two were caused by ECG leads on the anterior chest wall, and one was caused by spinal fixation hardware. In the descending aorta, streak artifact was caused by a pacemaker wire and spinal fixation hardware. Motion artifact was undetected in most portions of the aorta except the sinuses (6% of aortas had slight motion artifact) and the caudal aspect of the scan range (2% had slight motion artifact).

Quantitative Evaluation

Pulmonary arteries—Among visualized vessels, four central (8%), six lobar (8%), and 206 segmental (29%) pulmonary arteries exhibited contrast opacification of less than 200 HU. The poorest opacification was detected in the right lower lobe lateral segmental artery (44% < 200 HU) (Table 3) (Figs. 1 and 2). The upper lobe pulmonary vessels had superior contrast opacification of greater than 200 HU (93%) relative to the lower lobe vessels (73%). In a comparison of left and right lungs, no significant differences in mean enhancement were detected between main (307 vs 304 HU, p = not significant) and lobar level (291 vs 294 HU, p = not significant) branches. However, a significant difference was detected between enhancement of the right and that of the left lung at the segmental artery level (258 vs 263 HU, p < 0.05). In a comparison of upper, middle, and lower lobes, significant differences were found between the upper and middle lobes at the lobar level (304 vs 283 HU, p < 0.01) and between the upper and middle (293 vs 249 HU, p < 0.01) and upper and lower (293 HU vs. 248 HU, p < 0.01) lobes at the segmental pulmonary artery level.

Aorta—Statistically significant differences in aortic contrast opacification were found between the level of the aortic sinuses in the ascending aorta (318 HU) and the most cranial aspect of the scan range (304 HU), most caudal aspect of the scan range (285 HU), and level of the sinuses (300 HU) in the descending aorta (p < 0.001) (Table 2) (Fig. 3). However, absolute differences in mean attenuation between the various levels were small. Mean variation in image noise for the entire scan range was minimal ($\pm$ 34 HU).

Reproducibility of Measurements

Bland-Altman analysis showed that for contrast opacification of the main pulmonary artery, there was no evidence of systematic error in scoring between the two observers. At the lobar and segmental pulmonary artery levels, observer 1 scored systematically lower than observer 2 (bias -7.3 ± 68 [2 SD] and -8.5 ± 66 [2 SD], respectively) (Fig. 4).

Discussion

In this study, we found that image quality and contrast enhancement were excellent within the coronary arteries and proximal ascending aorta in consecutively admitted patients undergoing CT with a dedicated coronary protocol for ACS suspected in the emergency department. However, 11 left main and 22 left upper lobar pulmonary arteries were not visualized.

At qualitative evaluation, our dedicated coronary CT protocol rendered almost motion-free images of the thoracic aorta [21–23]. Minor motion artifacts were present at the level of the aortic sinuses in three of 50 patients (6%) and at the most caudal aspect of the scan range in one of 50 patients (2%). The latter patient also had limited opacification of the descending thoracic aorta at the most caudal aspect of the scan range because of suboptimal scan timing relative to the contrast injection. However, overall contrast enhancement in the aorta was homogeneous over the entire scan range. The SD was small (34 HU), representing a surrogate quality assurance measurement of homogeneous contrast enhancement in the coronary arteries.

Streak artifact was present in eight patients. This artifact was caused by a dense collection of contrast material in the SVC in four patients, ECG wires in two patients, pacemaker wires in one patient, and a spinal pedicle fixation screw in one patient. The most extensive artifact across the entire scan range of the aorta was from metal (pacemaker wires and a pedicle screw). Dense collection of contrast material in the SVC particularly affected the right pulmonary artery and anterior segmental branch of the right upper lobe (20% and 19%, respectively). Such artifacts highlight the importance of the use of a saline bolus chaser after contrast administration and careful ECG lead placement off the anterior part of the chest. Scanning technique has been

emphasized by other authors. Batra et al. [24] assessed the image quality of 275 consecutively acquired non-ECG-gated CT angiograms of the thoracic aorta for suspected or known aortic dissection. In that study, severe streak artifact resulted from dense collection of contrast material in the brachiocephalic veins and SVC and the presence of pacemaker wires. These findings are in contrast to our finding that no pulmonary artery segment was affected by severe streak artifact, likely because of the use of a saline bolus chaser.

Eleven left main and 22 left upper lobar pulmonary arteries were not visualized with our dedicated coronary CT protocol. Therefore, for exclusion of all PEs, formal CT pulmonary angiography appears necessary. For pulmonary artery segments visualized on dedicated coronary CT, our results show excellent image quality and mean contrast enhancement. Vessel opacification decreased both with progressive pulmonary arterial branching and from the upper to the lower lobes. Because of this phenomenon, evaluation for PE in visualized arteries may best be performed on a case-by-case basis. The variability is related to the contrast bolus, most of which has passed into the aorta at the start of acquisition. Such scanning-time characteristics have implications for PE detection because most PEs are known to occur in the lower lobes [25]. This finding suggests that caudocranial acquisition for coronary CT would improve detection of PE. Nevertheless, quantitative assessment showed greater than 200-HU attenuation in almost all segments except the right lower lobe lateral and posterior segmental branches. Optimum contrast opacification for depiction of PE is complex and related to both window settings and the presence of partial versus total vessel occlusion by the embolus [26]. Even allowing for 2 SD on either side of this measurement, contrast opacification greater than 200 HU should allow confidence in identification of PE [27]. Our results are further evidence that use of half-scan cardiac-specific algorithms does not impair the quality of images of the pulmonary artery circulation.

Several limitations of our study should be noted. We emphasize that our primary focus was pulmonary and aortic image quality analysis. We did not correlate our coronary images with invasive coronary angiograms. Nor was it our intention to evaluate a triple-rule-out CT protocol, and we appropriately used a correspondingly shorter scan range in our dedicated coronary CT protocol. Therefore, the aortic arch was not visualized in most of the data sets, although isolated arch dissection is rare [28]. The impetus behind this study was that readers of cardiac CT scans are concerned about missing PE and aortic dissection on images obtained with a dedicated coronary CT protocol. We used a single contrast infusion followed by a bolus chaser rather than multiphasic contrast infusion.

Studies [15,16] have shown excellent pulmonary and aortic opacification with double- or triple-infusion protocols, and we might have obtained more consistent opacification of the visualized pulmonary circulation with a multiphase infusion, but that would have necessitated an increase in contrast volume. Such multiphasic infusions are being developed in line with triple-rule-out CT protocols. Triple-rule-out protocols have evolved from dedicated coronary CT protocols to include a longer scan range that includes the apices and lung bases and an increased volume of contrast material to ensure opacification of the pulmonary vasculature. The flow rate of contrast material may be decreased according to the length of acquisition. The advantages are offset by apparently lower diagnostic accuracy in the detection and exclusion of marked coronary stenosis.

In studies by White et al. [17] and Johnson et al. [18], the sensitivities were 83% and 94% and the specificities were 96% and 77% for triple-rule-out CT detection or exclusion of marked coronary stenosis compared with values for invasive coronary angiography. These results are in contrast to those of dedicated coronary 64-MDCT, a meta-analysis of which showed a sensitivity of 93% and specificity of 97% [29]. Triple-rule-out protocols also require higher radiation doses, of particular concern to young women. There also is an inherent increase in

breath-hold time to approximately 21 seconds [18]. Use of the latest generation of dual-source CT scanners may minimize these limitations [30,31]. Finally, interpretation of triple-rule-out CT scans incurs additional time for readers. Before widespread implementation, triple-rule-out CT requires further evaluation with large numbers of patients to determine the efficacy and applications.

In patients with suspected ACS presenting to the emergency department for the primary purpose of evaluation of the coronary arteries, a dedicated coronary CT protocol provides excellent-quality images of the coronary arteries and proximal ascending aorta but images of the pulmonary vasculature insufficient for exclusion of PE.

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Fig. 1.

58-year-old man who presented to emergency department with acute chest pain.

A and **B**, Right-sided pulmonary arterial circulation (**A**) and left-sided pulmonary arterial circulation (**B**) coronary CT scans show mean contrast enhancement (HU) of pulmonary arterial segments. Mean vessel opacification decreases in craniocaudal direction as contrast agent passes from pulmonary to systemic circulation during dedicated cardiac MDCT acquisition. apic = apical; seg = segment; ant = anterior; post = posterior; rul = right upper lobe; rpa = right pulmonary artery; rll = right lower lobe; rml = right middle lobe; sup = superior; med = medial; lat = lateral; lul = left upper lobe; lpa = left pulmonary artery; III = left lower lobe; ling = lingula; inf = inferior.

Fig. 2.

Graph shows mean changes in attenuation from central pulmonary artery to main branch, lobar, and segmental pulmonary artery levels for each lobe. Mean attenuation decreased from 292 ± 72 HU for upper lobe segmental vessels to 248 ± 76 HU for lower lobe segmental vessels ($p < 0.001$).

Fig. 3. 51-year-old man who presented to emergency department with acute chest pain. CT scan shows mean qualitative attenuation results for aorta at level of aortic sinus and most cranial and caudal aspects of scan range. Regions of interest were placed at five levels in thoracic aorta (level of sinuses of descending aorta not shown) and on entire scan range of descending aorta, which provide overall assessment of contrast opacification throughout scan.

Fig. 4.

Scatterplots show results of Bland-Altman analysis for interobserver agreement in qualitative scoring of pulmonary arteries. No systematic bias was recorded for main pulmonary artery, but observer 2 systematically scored lobar and segmental pulmonary arteries lower than did observer 1.

A, Main pulmonary artery.

B, Lobar pulmonary artery.

C, Segmental pulmonary artery.

TABLE 1

Results of Qualitative Assessment of CT Scans of Pulmonary Arteries

Vessel	Opacification				Motion				Streak			
	Excellent	Slightly Suboptimal	Markedly Suboptimal	%	Excellent	Slightly Suboptimal	Markedly Suboptimal	%	Excellent	Slightly Suboptimal	Markedly Suboptimal	%
Major pulmonary vessels												
Main PA	46	3	1	92	49	1	0	98	50	0	0	96
Left PA	34	4	1	87	39	0	0	100	39	0	0	100
Right PA	44	4	2	88	49	1	0	98	30	20	0	60
Lobar pulmonary vessels												
Right upper	46	2	2	92	50	0	0	100	30	19	1	46
Right middle	42	3	5	84	49	0	0	100	49	0	0	100
Right lower	38	4	8	76	50	0	0	100	50	0	0	100
Left upper	26	0	2	92	28	0	0	100	28	0	0	100
Lingular	41	2	5	85	48	0	0	100	48	0	0	100
Left lower	40	5	5	80	49	1	0	98	50	0	0	100
Segmental pulmonary arteries												
Right upper apical	12	4	3	63	19	0	0	100	18	0	1	95
Right upper anterior	33	0	0	79	33	0	0	100	28	5	0	85
Right upper posterior	14	2	2	78	18	0	0	100	18	0	0	100
Right middle medial	34	7	9	68	50	0	0	100	50	0	0	100
Right middle lateral	34	7	9	68	50	0	0	100	50	0	0	100
Right lower apical	40	3	7	80	50	0	0	100	50	0	0	100
Right lower anterior	19	10	11	58	50	0	0	100	50	0	0	100
Right lower lateral	27	12	11	53	49	0	0	100	49	0	0	100
Right lower posterior	26	13	11	52	50	0	0	100	50	0	0	100
Right lower medial	41	8	11	62	50	0	0	100	50	0	0	100
Left upper anterior	23	2	2	85	27	0	0	100	27	0	0	100
Left apicoposterior	26	2	2	80	30	0	0	100	30	0	0	100
Lingular superior	39	5	5	79	49	0	0	100	49	0	0	100
Lingular inferior	40	5	5	80	50	0	0	100	50	0	0	100
Left lower apical	39	3	7	80	49	0	0	100	49	0	0	100
Left lower anteromedial	30	10	10	60	50	0	0	100	50	0	0	100
Left lower lateral	26	14	10	52	50	0	0	100	50	0	0	100
Left lower posterior	27	13	10	54	50	0	0	100	50	0	0	100

Note—Except for the percentages, values are numbers of patients. % = percentage of optimal artery segments, PA = pulmonary artery.

TABLE 2

Results of Qualitative and Quantitative Assessment of CT Scans of Aorta

Aorta Level	Opacification				Motion				Streak			Mean ± SD Attenuation (HU)	
	Excellent	Slightly Suboptimal	Markedly Suboptimal	%	Excellent	Slightly Suboptimal	Markedly Suboptimal	%	Excellent	Slightly Suboptimal	Markedly Suboptimal		%
Ascending Most cranial aspect of scan range	48	2	0	96	50	0	0	100	50	0	0	100	304 ± 21
Sinuses Descending	48	2	0	96	47	3	0	94	43	7	0	86	318 ± 23
Most cranial aspect of scan range	48	2	0	96	50	0	0	100	48	2	0	96	282 ± 20
Sinuses Most caudal aspect of scan range	48 46	2 3	0 1	96 92	50 49	0 1	0 0	100 98	48 50	2 0	0 0	96 100	300 ± 20 285 ± 29

Note—Except for the percentages, values are numbers of patients. % = percentage of optimal artery segments.

TABLE 3

Pulmonary Artery Contrast Opacification

Artery	Left Lung	Right Lung	Upper Lobes	Middle Lobe and Lingula	Lower Lobes	Mean
Main pulmonary artery	—	—	—	—	—	319 ± 21
Main branch pulmonary artery	305 ± 24	307 ± 24	—	—	—	306 ± 80
Lobar	295 ± 82	289 ± 81	303 ± 66	285 ± 84 ^a	290 ± 87	293 ± 81
Segmental	260 ± 72	247 ± 76 ^{a,b}	292 ± 72 ^c	249 ± 85 ^d	248 ± 76 ^{d,e}	253 ± 74

Note—Values are mean ± SD. Dash [—] indicates not applicable.

^a $p < 0.05$.

^b Comparison between right and left sides.

^c Comparison between upper and middle/lingular lobes.

^d $p < 0.01$.

^e Comparison between upper and lower lobes.