# Diagnostic Yield of Pulmonary CT Angiography in the Evaluation of Pulmonary Embolisms Treated at the Puerto Rico Medical Center from 2008 to 2012

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**Objective: The objective of this study was to determine the diagnostic yield of pulmonary CT angiography (PCTA) in the evaluation of pulmonary embolisms treated at the Puerto Rico Medical Center from 2008 to 2012.**

**Methods: A total of 1,004 CT angiograms were reviewed in the evaluation of pulmonary embolisms. Patient records covering from 2008 to 2012 were obtained from the picture archiving and communication system (PACS) of the Puerto Rico Medical Center. Follow-up studies and those of pediatric patients were excluded from the study. The results were recorded as either positive or negative for pulmonary embolism, according to the final report rendered by board-certified radiologists.**

**Results: Of the 1,004 patient records reviewed, 964 were included in the study. Forty-six out of the total studies reviewed were positive, while a total of 918 studies were negative. A mean diagnostic yield of 4.8% (SD = 0.63) was obtained.**

**Conclusion: At the Puerto Rico Medical Center, the mean diagnostic yield in the evaluation of pulmonary embolism using PCTA was 4.8%, which is in concordance with those of several previous studies, all of which had similar low yields. New diagnostic algorithms for efficiently employing PCTA for the evaluation of pulmonary embolisms are discussed herein. [*P R Health Sci J 2016;35:16-19*]**

*Key words: CT Angiography, Pulmonary embolism, Diagnostic yield*

Pulmonary embolism (PE) represents the third most common cause of cardiovascular death after ischemic heart disease and stroke (1). If a PE is left untreated, mortality can increase to as high as 65% within the first hour and 92.2% in the first 2.5 hours (1, 2). When appropriate treatment is instituted in a timely fashion, however, death occurs in less than 10% of patients (3). A diagnosis of PE can be a major challenge for clinicians since its signs and symptoms are nonspecific. Imaging, therefore, has always played a crucial role in the diagnosis and management of this often fatal disorder. Historically, ventilation-perfusion (V/Q) scintigraphy had been the noninvasive diagnostic imaging modality of choice, while conventional (catheter-based) pulmonary angiography was regarded as the gold-standard. Over the past decade, pulmonary CT angiography (PCTA) has emerged as the single first-line test in the diagnosis of PE, for a number of reasons, which include its high specificity, sensitivity, and negative predictive value as well as its ability to provide important prognostic information when PE is present and to provide alternate diagnoses when it is not.

In recent years, the utilization of pulmonary CT angiography has increased substantially, while the yield of pulmonary embolism remains low (4, 5). Lee et al (6), for example, reported a fivefold increase in the number of pulmonary CT angiograms at one large academic institution from 2001 to 2007. Several studies, on the other hand, have reported low yields (ranging from 6% to 10%) of pulmonary embolism (2, 4). These numbers suggest that a possibly inappropriate use of PCTA as a screening tool rather than a diagnostic one may be occurring. Clearly, this is not desirable. The overutilization of a study with a low diagnostic yield represents a financial burden that could further strain an already overburdened healthcare system. Additional concerns include the risk of intravenous contrast-associated complications and the cumulative effect of ionizing radiation exposure (7, 8, 9).

The objective of this initial study was to determine the diagnostic yield of PCTA in the evaluation of pulmonary embolisms treated at the Puerto Rico Medical Center from 2008 to 2012. A brief review of the recommended diagnostic algorithms that can be used in the evaluation of pulmonary embolisms follows. Finally, future directions for potential research are discussed.

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*The authors have no conflicts of interest to disclose*.

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## Subjects and Methods

After obtaining Institutional Review Board approval (protocol B0050113), we conducted a retrospective review of the CT angiograms that had been performed (from January 1, 2008, to June 31, 2012) by the Radiology Department at ASEM Hospital at the Puerto Rico Medical Center to rule out pulmonary embolism; a total of 1004 patient records were reviewed. Patients were selected from the Radiology Department's picture archiving and communication system (PACS) database. Studies pertaining to patients younger than 18 years of age and follow-up studies (i.e. examinations of patients with previous diagnoses of pulmonary embolism) were not included. Results were recorded as either positive or negative for pulmonary embolism, according to the final report rendered by board-certified radiologists. From the total of 1004, 40 studies were excluded because their corresponding images and final reports were unavailable.

All PCTA examinations were performed using 16- or 64-multidetector CT (MDCT) scanners. The parameters for the 16-MDCT scanners (Brilliance CT, Philips Healthcare, Best, The Netherlands) were the following: 120 kV, 150 mAs, 0.75 mm collimation; gantry rotation time, 0.5 seconds; pitch, 1.0. The parameters for the 64-MDCT scanners (Brilliance CT) were the following: 120 kV, 175 mAs, 0.625 mm collimation; gantry rotation time, 0.4 seconds; pitch, 1.0. Images were obtained helically in a caudocranial direction through the chest after the peripheral intravenous administration of 100 mL of nonionic low-osmolality iodinated contrast medium (Optiray 350; Tyco Healthcare, Montreal, QC, Canada) injected at a flow rate of 4 mL/s with bolus tracking triggered over the main pulmonary artery at 120 Hounsfield units. Images were reviewed in a PACS viewer (Kodak Carestream PACS, Carestream Health, Inc., Rochester, NY) using several window levels and creating multiplanar reformats interactively, as deemed necessary by the interpreting board-certified radiologists.

## Results

Our results are summarized in Table 1. The number of Pulmonary CT angiograms steadily increased every year of our study; the percentage of cases positive for PE, nonetheless, remained consistently low ranging from 4.1% (lowest) to 5.4% (highest). A total of 964 examinations were included in our study. Forty-six of our patients had positive results for PE. The mean diagnostic yield was 4.8% (SD = 0.63).

## Discussion

The advent of multidetector-row helical computed tomography has allowed for the noninvasive detection of pulmonary embolisms by means of a pulmonary CT angiogram. PCTA generates high-resolution images of the pulmonary vasculature down to the sixth-order subsegmental level, thereby offering a variety of advantages over pulmonary angiography and V/Q scanning (10). For example, multidetector PCTA has increased sensitivity and decreased the rate of false negatives (1). According to Stein et al, the sensitivity and specificity of multidetector PCTA range from 83% to 96% (11, 12). However, its high negative predictive value, which ranges from 96% to 99%, is regarded as its strongest feature (13, 14, 15). Therefore, a negative PCTA safely rules out PE while providing alternative diagnoses; this latter information adds value to the study (16).

**Table 1**. Diagnostic yields from January 1, 2008 to June 30, 2012

| Year | 2008 | 2009 | 2010 | 2011 | 2012 (Jan–June) |
|---|---|---|---|---|---|
| Positive PE | 6 | 11 | 11 | 10 | 8 |
| Negative PE | 140 | 194 | 217 | 228 | 139 |
| Total | 146 | 205 | 228 | 238 | 147 |
| Yield | 4.1% | 5.3% | 4.8% | 4.2% | 5.4% |
| Mean Yield | 4.8% | | | | |

Number of Pulmonary CT Angiograms positive and negative for Pulmonary Embolism (PE) for each year and their corresponding dignostic yields.

Tsai et al (17) reported that pulmonary atelectasis and pneumonia are the most common alternative diagnoses that are clinically mistaken for PE. Early detection of these conditions prevents management delay, thus decreasing complications and prolonged hospitalizations for patients. In addition to furnishing alternative diagnoses when PE is not present, PCTA is capable of providing prognostic information in cases that are positive for PE. For example, it has been established that patients exhibiting, in PCTA, a right ventricular/left ventricular diameter ratio above 0.9 have higher risk of mortality within 30 days of suffering from a PE than do those patients whose right ventricular/left ventricular ratios are 0.9 or lower (15).

While the many advantages of PCTA have driven an increase in utilization rates, the procedure does not come without some concerns. Aside from the inherent cost of the study, the primary concern relates to the potential impact of the ionizing radiation on the patient while being examined with PCTA. CT is the most significant source of radiation exposure for the healthcare population (15). In particular, women are at high risk of developing radiation-associated cancers (13). Exposure to radiation may lead to the development of breast cancer in young females (13, 18). The risk of breast cancer increases by 14% after a 10mGy dose (of radiation) to the breast (8). Studies have reported that 3 in 1000 20-year-old women will develop breast cancer if evaluated with PCTA (19).

At the Puerto Rico Medical Center, the mean diagnostic yield of PCTA was 4.8%, which is in concordance with what was found by previous studies by Soo Hoo, Donohoo, and Costantino, all of which reported similar low diagnostic yields (3.1%, 6.8%, and 10%, respectively) (9, 18, 2). This suggests a possible overutilization of PCTA. As Donohoo et al (4) report, the

increased availability of CT scans, along with lower physicians' thresholds for test utilization, may account for the increased the use of PCTA, leading to low diagnostic yields (4).

In an effort to advise physicians on the diagnosis of acute pulmonary embolism, in 2007 the PIOPED II investigators published recommendations using diagnostic pathways. Making an objective clinical assessment using scoring indexes, such as Well's modified criteria, is the first step in the pathways. Then, by stratifying the patient's clinical probability of suffering from PE as low, intermediate, or high, the treating physician can decide on the appropriate subsequent approach. For patients with a low or intermediate probability, a D-dimer rapid enzyme-linked immunsorbent assay (ELISA) should be ordered first. If negative, a PE can be safely ruled out. However, if the result suggests a high positive value, a PCTA should follow (20). A study conducted by Soo Hoo et al (9) showed an increase in diagnostic yields, from 3% to 16%, after implementing these algorithms. Clearly, a diagnostic algorithm that includes clinical assessment and rapid ELISA positively leverages the utility of PCTA in the diagnosis of PE.

Other algorithms for patients with high clinical probability state that such patients should receive a PCTA with lower extremity CT venography if a prior history of deep venous thrombosis (DVT) exists. If a given patient has no prior history of DVT, PCTA alone suffices. In both cases, when PCTA is positive for PE, treatment is warranted for emboli lodged in large or segmental vessels. On the other hand, for those emboli found at the sub-segmental level, treatment is indicated only if the cardiopulmonary reserve is compromised. In a case in which the patient is unstable, echocardiography is first performed, followed by PCTA when clinically feasible (18).

New research has been exploring the creation of algorithms for pregnant women, a special group of the healthcare population at risk of PE. PE remains the main cause of maternal death in the UK (21). Therefore, early detection and treatment are vital to ensure maternal and fetal safety. There is some controversy regarding the use of PCTA in pregnant patients, however, since it exposes the mother, and the fetus, to a variable degree of ionizing radiation. In the past, the use of V/Q scans has been only 40% diagnostic in this population, resulting in diagnostic delays, incremental costs, and additional radiation exposure (21). An article by Cutts et al (22) presents a diagnostic algorithm beginning with ultrasonography. If thrombosis is present in the deep veins of the legs, then treatment is indicated; if not, a chest x-ray should be performed. In patients with abnormal chest x-rays, PCTA is indicated, and treatment should follow if there is evidence of a PE. A normal chest x-ray, however, should be followed by a perfusion scan instead of PCTA. A normal perfusion scan will suffice to safely exclude PE. When the perfusion scan is non-diagnostic, then PCTA should be performed. D-dimer assays are unreliable in pregnant patients since the levels of those patients are physiologically increased, especially during the second and third trimesters (21).

Aside from the revised diagnostic algorithms, new PCTA parameters for the evaluation of PE aim to effectively determine the prognosis of patients suffering from a PE. These new parameters are as follows: interventricular septum position, inferior vena cava contrast reflux, right ventricular diameter/left ventricular diameter ratio, 4-chamber views, and 3-dimensional right ventricle volume/left ventricle volume ratio (Figure 2). Of these, the right ventricle/left ventricle diameter ratio, determined by cross-axial images from PCTA, is the best parameter for identifying right-sided heart failure in patients suffering from an acute PE. When combined with cardiac markers such as troponin I and N-terminal-pro-b-type natriuretic peptide (NT-proBNP), the accuracy of these parameters in the diagnosis of right-sided heart failure increases (23).

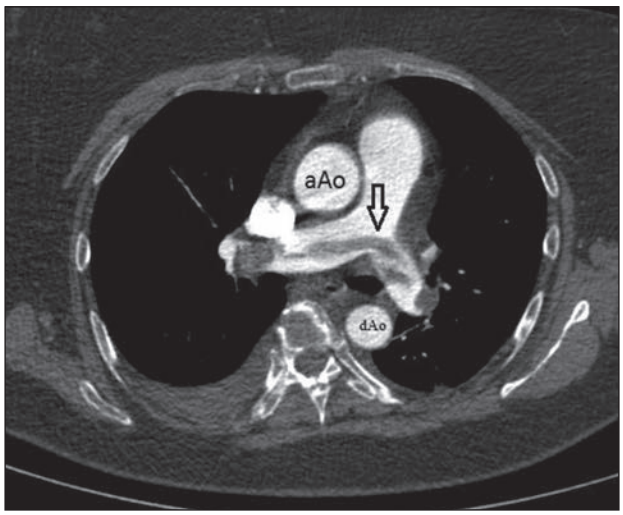


**Figure 1**. Axial image of a pulmonary CT angiogram demonstrating a saddle embolus (open black arrow) straddling the main pulmonary artery bifurcation (aAo, ascending aorta; dA0, descending aorta).

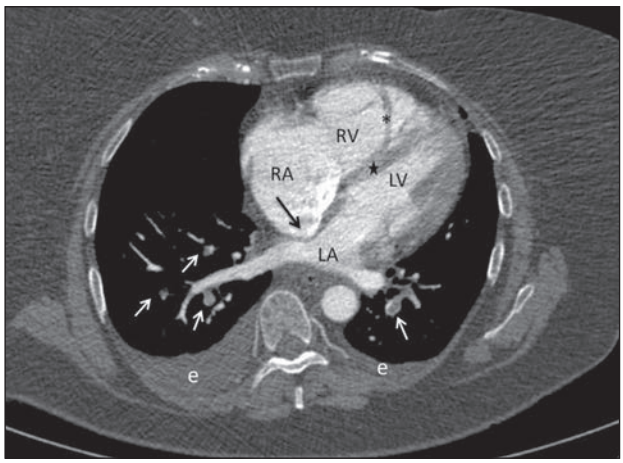


**Figure 2**. Axial image of a pulmonary CT angiogram at the level of the right ventricle moderator band (asterisk) demonstrating flattening of the interventricular septum (black star), leftward bowing of the interatrial septum (black arrow), and enlargement of the right ventricle (RV) and right atrium (RA), all indicative of right heart strain. Several bilateral subsegmental pulmonary arterial emboli are shown (white arrows). Bilateral pleural effusions (e), larger on the right, are present.

New investigative approaches seek to use dual-energy computed tomography (DE-CT) scans for the evaluation of PE. This new modality allows the clear visualization not only of the pulmonary vasculature but also of the distribution of iodine in the lung parenchyma, representative of perfusion. Hence, a defect in iodine distribution is considered a perfusion defect secondary to PE. According to Geyer et al (24), DE-CT perfusion assessments correlate with clinical outcomes. In fact, DE-CTs may even identify low-risk patients who do not require intensive therapy (25).

## Conclusion

Our study revealed a diagnostic yield of 4.8% for PCTA in the evaluation of PEs that were treated at the Puerto Rico Medical Center, which does not differ greatly from other yields reported by similar studies in the continental United States. We believe that the implementation of the diagnostic algorithms hereby discussed is an attainable goal that can improve both patient safety and the utilization efficiency of PCTA. Future areas of research should investigate the impact of such pathways in the diagnostic yield. Moreover, the aforementioned PCTA parameters can be used in our clinical setting to ascertain if, in fact, they help determine prognosis in our patient population.

## Resumen

Objetivo: Determinar el rendimiento diagnóstico de la angiotomografía computarizada pulmonar (PCTA, por sus siglas en inglés) en la evaluación de embolias pulmonares tratadas en el Centro Médico de Puerto Rico desde el 2008 hasta el 2012. Métodos: Un total de 1,004 estudios en la evaluación de embolias pulmonares fueron revisados. Estudios de seguimiento y de pacientes pediátricos fueron excluidos. Los resultados fueron reportados como positivos o negativos según determinado por Radiólogos certificados. Resultados: De los 1,004 expedientes evaluados, se incluyeron 964 en el estudio. De éstos, 46 estudios fueron positivos mientras 918 estudios resultaron negativos. Se obtuvo un rendimiento promedio de 4.8%. Conclusión: En el Centro Médico de Puerto Rico, el rendimiento diagnóstico promedio de la PCTA en la evaluación de embolias pulmonares es 4.8%, el cual es comparable con otros estudios que demuestran similares rendimientos bajos. Discutimos nuevos algoritmos diagnósticos para mejorar el rendimiento de la PCTA como herramienta en la evaluación de embolias pulmonares.

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