

Comparison of Egg and Banana Sign, Carina Crossover Sign in Prediction of Pulmonary Embolism: A Cross-sectional Study

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ABSTRACT

Introduction: Acute pulmonary embolism is a life-threatening condition that can lead to sudden death. Pulmonary Artery Hypertension (PAH) can be found in the setting of acute pulmonary embolism. The Egg and Banana sign and Carina Crossover (CCO) sign are seen in PAH, which are present on Computed Tomographic scans (CT scans).

Aim: To determine the accuracy of CT scans, the Egg and Banana sign, and CCO sign seen in PAH in the evaluation of pulmonary embolism.

Materials and Methods: This retrospective, cross-sectional study was conducted from May 2019 to May 2021 in the Department of Radiodiagnosis at Father Muller Medical College Hospital in Mangalore, Karnataka, India. The CT scans of 102 consecutive patients who underwent CT Pulmonary Angiography (CTPA) for suspected pulmonary embolism were evaluated for the presence of the CCO sign and Egg and Banana sign. The CCO sign was considered positive when the right Pulmonary Artery (PA) was seen crossing anterior to the carina at its bifurcation. The Egg

and Banana sign was considered present when the PA was found lateral to the aortic arch, with the PA described as the Egg and the arch as the Banana. The results were statistically analysed using Statistical Package for Social Sciences version 3.0.

Results: Pulmonary embolism was seen in 26 out of 102 cases, with a mean age of 60.2 ± 16.27 years. Pulmonary embolism was absent in 76 cases with a mean age of 55.8 ± 17.11 . An equal gender distribution was seen in 26 cases of pulmonary embolism. The Egg and Banana sign was found in 8 out of 26 patients with pulmonary embolism and had a specificity of 78.9%, negative predictive value of 76.92%, and diagnostic accuracy of 66%. The CCO sign was seen in 14 out of 26 cases of pulmonary embolism and had a higher specificity of 81.58% and diagnostic accuracy of 74.51%. The CCO sign had a statistically significant value in detecting pulmonary embolism.

Conclusion: According to the study, the CCO sign had a higher accuracy in detecting pulmonary embolism compared to the Egg and Banana sign. The accuracy was further improved when combined with other signs of pulmonary embolism.

Keywords: Pulmonary angiography, Pulmonary artery hypertension, Radiology

INTRODUCTION

Pulmonary embolism is a life-threatening condition that requires immediate and accurate diagnosis for effective management. However, diagnosing pulmonary embolism in a clinical setting can be challenging. Accurate diagnosis often relies on imaging modalities such as CTPA [1]. On a CTPA, pulmonary embolism can be detected by identifying filling defects in the pulmonary artery and its branches [2]. Other indirect signs of pulmonary embolism on CT include ventricular septal bowing and an increased ratio of the right ventricle's diameter to the left ventricle's diameter [2].

The Egg and Banana sign and CCO sign are signs described in PAH [3,4]. PAH is defined as an elevation in mean arterial pressure of over 25mmHg in the pulmonary circulation [5]. The Egg and Banana sign refers to the visualisation of the main pulmonary artery at the same level as the aortic arch. The pulmonary artery, with its rounded configuration, is referred to as the "Egg," while the cross-section of the aortic arch is referred to as the "Banana" [3]. The CCO sign, on the other hand, involves the visualisation of the right pulmonary artery crossing anterior to the carina at its bifurcation [4].

It's important to note that the Egg and Banana sign and CCO sign are primarily described in the context of pulmonary hypertension. This study takes a novel approach by exploring the use of these signs in detecting pulmonary embolism. As far as our knowledge goes, there have been no similar studies for comparison. Therefore, the present study aims to evaluate the diagnostic accuracy of the Egg and Banana sign and the CCO sign in the detection of pulmonary embolism.

MATERIALS AND METHODS

This retrospective, cross-sectional study was conducted at Father Muller Medical College and Hospital in Mangalore, Karnataka, India. Data of the individuals were obtained from the hospital information system between May 2019 and May 2021. The data was then analysed from May 2021 to August 2021. Institutional Ethics Clearance was obtained (IEC number-FMIEC/CCM/1042/2021) prior to the commencement of the study.

Inclusion criteria: The study included patients aged ≥ 18 years who had undergone CTPA for suspected pulmonary embolism. Pulmonary embolism was identified as a filling defect observed in the pulmonary artery and its branches during the CTPA study, supported by clinical symptoms such as sudden onset of breathlessness, chest pain, tachycardia, and elevated D-dimer levels [6].

Exclusion criteria: Subjects with a diagnosis other than pulmonary embolism were excluded from the study.

Sample size estimation: A total of 102 patients who had undergone CTPA for pulmonary embolism during the study period were enrolled in the study using purposive sampling.

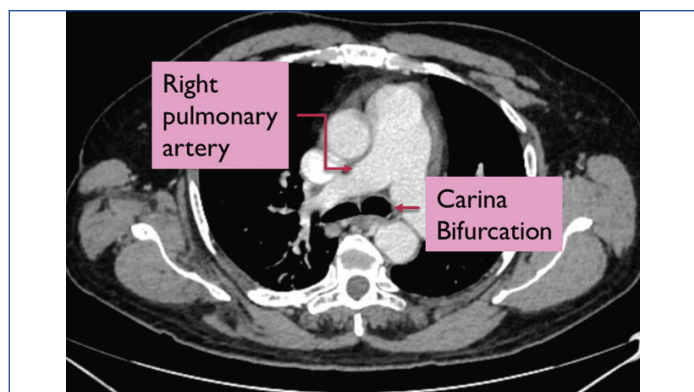
Study Procedure

CT acquisition: CT acquisition: A Siemens 128-slice CT scanner was used to obtain chest images in the cranio-caudal direction. The images were acquired while the patient held their breath after taking a deep inspiration, covering the area from the apices to the diaphragm. The imaging technique involved a plain CT scan followed by contrast-enhanced CTPA. The plain CT scan had a slice thickness of 1.25 mm and a pitch of one. The CTPA utilised the bolus tracking method. A pressure injector was used to administer

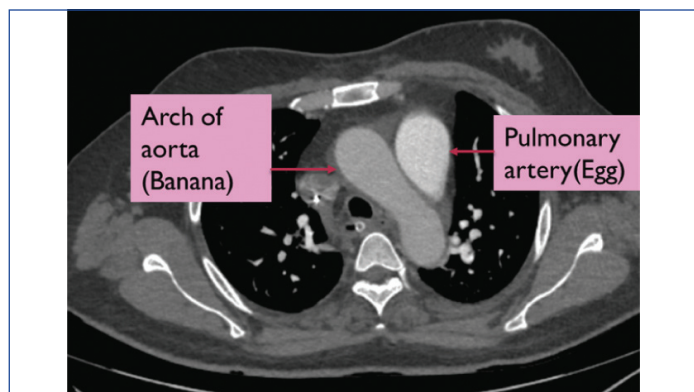
the contrast at a rate of 60 mL/min, followed by a 100 mL bolus of saline chaser. Once optimal opacification of the pulmonary arterial system was achieved, the CTPA images were obtained.

CT interpretation: A radiologist with training in detecting pulmonary embolism in CTPA reviewed all 102 studies. The radiologist assessed whether pulmonary embolism was present or absent in all suspected cases that had undergone CTPA. Additionally, the radiologist determined the presence or absence of the Egg and Banana sign and the CCO sign.

Signs: The CCO sign [4] was considered positive when the right pulmonary artery was observed crossing anterior to the carina at its bifurcation [Table/Fig-1]. The Egg and Banana sign [5] was considered present when the pulmonary artery was identified lateral to the aortic arch, with the pulmonary artery referred to as the “Egg” and the aortic arch as the “Banana” [Table/Fig-2]. The presence or absence of the Egg and Banana sign and the CCO sign were assessed in all suspected cases of pulmonary embolism. All measurements were taken on the mediastinal window of the CTPA.



[Table/Fig-1]: Carina Crossover (CCO) sign.



[Table/Fig-2]: Egg and Banana sign.

STATISTICAL ANALYSIS

The data obtained from the study was tabulated in an Excel sheet and analysed using SPSS software version 3.0. Continuous variables were presented as mean, standard deviation, and range. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated using 2x2 contingency tables and expressed as percentage values with 95% confidence intervals. Statistical significance was considered present when the p-value was less than 0.05.

RESULTS

Out of 102 patients, 26 (25.5%) were diagnosed with pulmonary embolism. Among them, 13 were females (50%) and the remaining 13 were males (50%), with a mean age of 60.2±16.27 years. The disease-free group comprised 76 (74.5%) individuals, with a mean age of 55.8±17.11 years [Table/Fig-3].

The Egg and Banana sign was observed in 8 (30.8%) out of the 26 patients with pulmonary embolism, while the remaining 18 (69.2%) cases did not exhibit this sign [Table/Fig-4].

Gender	Pulmonary embolism				Total	
	Present		Absent		Count	%
	Count	%	Count	%		
Female	13	50	31	40.8	44	43.1
Male	13	50	45	59.2	58	56.9
Total	26	100	76	100	102	100
Mean age (in years)	60.2±16.27		55.8±17.11			

[Table/Fig-3]: Age and gender distribution of pulmonary embolism.

Egg and Banana sign	Pulmonary embolism				Total	
	Present		Absent		Count	%
	Count	%	Count	%		
Present	8	30.8	16	21.1	24	23.5
Absent	18	69.2	60	78.9	78	76.5
Total	26	100	76	100	102	100

[Table/Fig-4]: Results of egg and banana sign.

p=0.422

The CCO sign was present in 14 (53.85%) out of the 26 cases of pulmonary embolism, while it was absent in the remaining 12 (46.2%) cases [Table/Fig-5]. The sensitivity and specificity of the Egg and Banana sign in detecting pulmonary embolism were 30.77% and 78.95%, respectively. The positive predictive value was 33.33% and the negative predictive value was 76.92%. The diagnostic accuracy was found to be 66.67% (p-value=0.422).

Carina crossover sign	Pulmonary embolism				Total	
	Present		Absent		Count	%
	Count	%	Count	%		
Present	14	53.8	14	18.4	28	27.5
Absent	12	46.2	62	81.6	74	72.5
Total	26	100	76	100	102	100

[Table/Fig-5]: Results of Carina Crossover (CCO) sign.

p-value=0.001

The CCO sign demonstrated a sensitivity of 53.85% and a specificity of 81.58%. The positive predictive value was 50% and the negative predictive value was 83.78%. The diagnostic accuracy of the CCO sign was 74.51% (p-value=0.001) [Table/Fig-6].

Signs		Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy	p-value
Egg and banana	Value	30.77%	78.95%	33.33%	76.92%	66.67%	0.422
	95% CI	14.33% to 51.79%	68.08% to 87.46%	19.53% to 50.73%	71.56% to 81.54%	56.64% to 75.69%	
Carina crossover	Value	53.85%	81.58%	50.00%	83.78%	74.51%	0.001
	95% CI	33.37% to 73.41%	71.03% to 89.55%	35.62% to 64.38%	77.09% to 88.80%	64.92% to 82.62%	

[Table/Fig-6]: Diagnostic testing accuracy of Egg and Banana sign and Carina Crossover (CCO) sign.

DISCUSSION

The diagnosis of pulmonary embolism can be challenging in clinical practice [1]. Various tests have been proposed for the diagnosis and timely management of pulmonary embolism, with CT angiography being used as a primary modality for detection. The sensitivity and specificity of the Egg and Banana sign in detecting pulmonary embolism were found to be 30.77% and 78.95%, respectively. The positive predictive value was 33.33% and the negative predictive value was 76.92%. The CCO sign showed a sensitivity of 53.85% and a specificity of 81.58%.

Studies conducted by Strijen et al., [7] and Coche et al., [8] have reported higher sensitivity and specificity for CT angiography in

detecting pulmonary embolism, with values of 87% to 96% and 86% to 91%, respectively. However, the accurate assessment of pulmonary embolism on CT angiography relies on the experience of the radiologist [7-9]. Misdiagnosis can occur due to various patient-related, technical, and anatomical factors [10].

In emergency situations, there is a need for simple signs to determine pulmonary embolism. CT angiography has been used to predict the severity of pulmonary embolism, assessing factors such as the RV/LV ratio, ventricular septal bowing, and embolic burden [11].

Pulmonary hypertension refers to an elevation in the mean pulmonary arterial pressure above 25 mmHg in the pulmonary circulation. This measurement of mean arterial pressure usually involves an invasive technique. However, CTPA has provided a non-invasive method for assessing pulmonary hypertension. Corson et al., [12] conducted a study assessing the cutoff of 29 mm of PA diameter in predicting pulmonary hypertension. They found that a cutoff of 29 mm of the main PA had 95% sensitivity in distinguishing pulmonary hypertension from normal individuals. Devaraj et al., [13] conducted a study showing that the ratio of the diameter of the main PA to the diameter of the aorta had a significant correlation with the main PA pressure. Therefore, this ratio could be used as a CT marker for diagnosing pulmonary hypertension.

Various studies have described the use of these signs in pulmonary hypertension [3,4]. In a study by Scelsi et al., the Egg and Banana sign showed a specificity of 85% and a positive predictive value of 85% in cases with higher mean arterial pulmonary pressure [3]. Similarly, Nair et al., found that the CCO sign had a specificity of 91% and a positive predictive value of 90% when the PA diameter was above 3 cm [4].

Pulmonary hypertension can be seen in the setting of acute pulmonary embolism [14], which served as the basis for our study. We observed a statistically significant correlation between the CCO sign and pulmonary embolism. The CCO sign demonstrated an increased specificity of 81.58%, a negative predictive value of 83.78%, and a diagnostic accuracy of 74.51% in detecting pulmonary embolism. These findings are comparable to the higher specificity of the CCO sign in detecting pulmonary hypertension in a previous study [5].

Out of the 14 cases that showed the CCO sign in pulmonary embolism, 10 were found to have associated pulmonary hypertension. However, the Egg and Banana sign and the ratio of PA to aorta did not show a significant correlation in detecting pulmonary embolism. The Egg and Banana sign has previously shown a stronger correlation with pulmonary hypertension [3]. This sign is believed to be due to elongation of the PA secondary to elevated pulmonary pressure and vascular remodeling [15]. The mean time of presentation of symptoms of pulmonary hypertension following pulmonary embolism is around 131 days. [16]. The phase of remodeling occurs over a duration of time, which may explain the lower correlation of this sign with pulmonary embolism.

Limitation(s)

Limitations of our study include the small sample size and limited available literature for comparison of results. Further research in this field is necessary.

CONCLUSION(S)

The Egg and Banana sign had a specificity of 78.9%, a negative predictive value of 76.95%, and a diagnostic accuracy of 66%. On the other hand, the CCO sign showed a higher specificity of 81.58%, a negative predictive value of 83.78%, and a diagnostic accuracy of 74%. The CCO sign can be used as an additional marker for detecting pulmonary embolism in an acute setting. However, further research is needed to identify accurate signs for the identification of pulmonary embolism, which can help improve its effective and efficient diagnosis.

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PLAGIARISM CHECKING METHODS: [Jan H et al.]

- Plagiarism X-checker: Aug 27, 2022
- Manual Googling: Feb 08, 2022
- iThenticate Software: Mar 07, 2023 (15%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Aug 26, 2022**
Date of Peer Review: **Nov 24, 2022**
Date of Acceptance: **Mar 09, 2023**
Date of Publishing: **Mar 01, 2024**