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Computed Tomography Pulmonary Angiography Assessment of Pulmonary Embolism and Associated Cardiac Conditions

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A B S T R A C T

Pulmonary embolism (PE) is a serious disease in which clots block arteries of the lungs, making it difficult for a person to breathe and ride the heart. A quick and accurate diagnosis is important to prevent life threatening complications. CTPA is most reliable test for detection of PE as it provides a clear picture of the pulmonary artery. However, concerns such as radiation exposure and the effects of contrast pigments on the kidneys underscore the need for further research to make testing safer and more effective. Evaluation of the role of CTPA in the assessment of PE with associated cardiac conditions. The CTPA is made when a patient lies on his back, raises his arms and holds his breath temporarily. Inject contrast dye (50-100 mL) into a 4-5ml/s vein followed by salt solution. When contrast reaches the pulmonary artery, the scan begins automatically. Captures thin layers of images from the lungs to the heart and helps you recognize blood clots (PE) and other lung problems. After scanning, patients are monitored for responses and drinking water is recommended to rinse contrast. Gender based data is tabulated in descriptive statistics with a highest frequency of male which is 31(51.7%) than females which is 29(48.3%). The tabulated statistical data of TVR shows frequency of 24(40%), RVOT stenosis shows frequency of 5(8.3%), sub-valvular stenosis shows frequency of 1(1.7%), complete pulmonary atresia shows frequency of 6(10%), pulmonary atrial stenosis shows frequency of 1(1.7%), PE shows frequency of 10(16.7%), sub-segmental PE shows frequency of 5(8.3%), levocardia and situs solitus shows frequency of 10(16.7%), IVS shows frequency of 1(1.7%), VSD shows frequency of 6(10%), normal CTPA shows frequency of 30(50%) patients for total number of 60. Our study conclude that PE can lead to right ventricular pressure overload, resulting in tricuspid valve regurgitation and associated cardiac conditions such as RVOT stenosis, sub-valvular stenosis, complete pulmonary atresia, and sub-segmental PE. CTPA proves effective in detecting both PE and these related heart abnormalities

Keywords: Computed Tomography Pulmonary Angiography, pulmonary embolism, Assessment, Cardiac conditions.

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INTRODUCTION

Pulmonary embolism (PE) is a critical condition characterized by the obstruction of blood flow in the pulmonary artery, primarily due to blood clots that often originate from the lower limbs. The pathophysiology of PE is explained by the Virchow triad, which includes venous stasis, endothelial injury, and hypercoagulability. Despite being a leading cause of mortality in hospitals, PE frequently presents with subtle or atypical symptoms, making diagnosis challenging. Common manifestations include sudden dyspnea, pleuritic chest pain, and hypoxia, while atypical symptoms may include cough, fever, and abdominal pain. Risk factors for PE encompass a history of venous thromboembolism, malignancies, and various medical conditions that predispose patients to clot formation (Kaptein et al, 2021), (Freud et al, 2022).

The diagnosis of PE is primarily achieved through computed tomography pulmonary angiography (CTPA), which provides a detailed visualization of the pulmonary vasculature. CTPA not only confirms the presence of emboli but also aids in assessing associated cardiac conditions such as right ventricular dysfunction and tricuspid valve regurgitation. Understanding these cardiac alterations is crucial, as they can significantly influence treatment decisions and patient prognosis. Furthermore, the integration of artificial intelligence in analyzing CTPA data has the potential to enhance diagnostic accuracy and efficiency, thereby improving patient outcomes (Shah et al, 2022), (Getinge et al, 2023). Recent studies have highlighted the importance of quantifying clot burden and assessing associated cardiac conditions in patients with PE. For instance, the Qanadli and Mastora indices provide valuable insights into the severity of PE and its impact on right heart function. Additionally, research has shown that factors such as age, comorbidities, and clot burden are critical in predicting mortality and complications in PE patients. By focusing on these parameters, healthcare providers can better stratify risk and tailor treatment strategies, ultimately leading to improved management of this life-threatening condition (Zantonelli et al, 2022).

Qanadli et al. and Mastora et al. conducted studies in 2022 that evaluated the severity of acute pulmonary embolism (APE) using CTPA. They introduced the CT Obstruction Index (CTOI), which quantifies clot burden based on thrombus location and obstruction degree. A CTOI of 20% or higher indicates high-risk patients, while lower values suggest a lower risk. The Mastora index builds on this by incorporating additional findings such as pulmonary hypertension. Their research demonstrated a correlation between higher CTOI values and increased right atrial size, reduced left atrial size, and a greater likelihood of right ventricular dysfunction, with CTOI values exceeding 40% predicting significantly higher mortality rates in patients without comorbidities (Bělohlávek et al, 2022).

El-Menyaret et al. (2016) further explored the effects of various CTPA parameters in patients diagnosed with PE. Their study included 45 patients, revealing that those who succumbed to the condition were, on average, 13 years older than survivors, with cancer patients exhibiting notably higher mortality rates. A high clot burden, indicated by a Qanadli Score greater than 18, was associated with obesity, hypertension, elevated D-dimer levels, and signs of heart strain. Although a score above 17.5 predicted heart dysfunction, markers of heart strain did not correlate with mortality. This study underscored the significance of CTPA in assessing PE risk while calling for larger studies to validate these findings (Mert et al, 2019).

The integration of artificial intelligence in the assessment of CTPA parameters offers significant advantages, including enhanced accuracy and efficiency in diagnosing PE. By automating the analysis of complex imaging data, AI can reduce costs and expedite the evaluation process, allowing for timely interventions in critical cases. Additionally, the identification of specific risk factors and cardiac alterations associated with PE can lead to more personalized treatment approaches, improving patient outcomes and reducing the incidence of complications (Swanson et al, 2020). Moreover, understanding the relationship between PE and associated cardiac conditions, such as right ventricular dysfunction and tricuspid valve regurgitation, is essential for comprehensive patient management. By recognizing these interconnections, healthcare providers can implement targeted therapies that address both the embolic event and its cardiovascular implications, ultimately enhancing the overall quality of care for patients with PE (Alekseeva et al, 2010).

In conclusion, the study of pulmonary embolism and its associated cardiac conditions is vital for improving diagnostic accuracy and treatment outcomes. CTPA serves as the gold standard for diagnosing PE while also providing insights into related cardiac issues. By leveraging advanced imaging techniques and understanding the underlying risk factors, healthcare professionals can better stratify patients, tailor interventions, and ultimately enhance clinical care for those affected by this life-threatening condition (Barrios et al, 2018).

MATERIAL AND METHODS

Study Design

A descriptive mutual testing research was performed.

Settings

Data collected from Punjab C.T. Scan and Digital X-Ray Centre.

Study Duration

4 months

Sample Size

The prevalence of pulmonary embolism is 0.5% and the sample size for this study is 60 (Fountain et al, 2024).

Sampling Technique

Convenience participant selection method

Sample Selection

Inclusion Criteria

Participants aged 1-78 years Pulmonary angiography for the subject’s computed tomography pulmonary embolism was included in the study (Dabbouseh et al, 2019) (12).

Exclusion Criteria

1. Uncooperative patients.
2. Contraindications to contrast media.

Data Collection Procedure

Data on patients, including demographics, symptoms, and imaging findings, were collected with consent and stored in Microsoft Excel and SPSS. CTPA preparation involved fasting, hydration, allergy assessment, IV access, breath-holding during the scan, and removal of metal objects to ensure safety and effectiveness (Yaghoobpoor et al, 2024).

Data Analysis

The statistical analysis was carried out using SPSS version 2025. The data distribution was investigated using descriptive analysis. Variables on a continuum were reviewed using central tendency and dispersion while categorical variables were analyzed in terms of frequency and percentage. The collected data were systematically organized and securely stored in Microsoft Office applications to ensure accurate and reliable results (Kwok et al, 2022).

RESULTS

Out of 60 patients 29 were females and 31 were males, but the results do not affect by the gender. Both male and female patients have same chances to develop the disease.

Table 1: Of Gender

		Frequency	Percent
Valid	Female	29	48.3
	Male	31	51.7
	Total	60	100.0

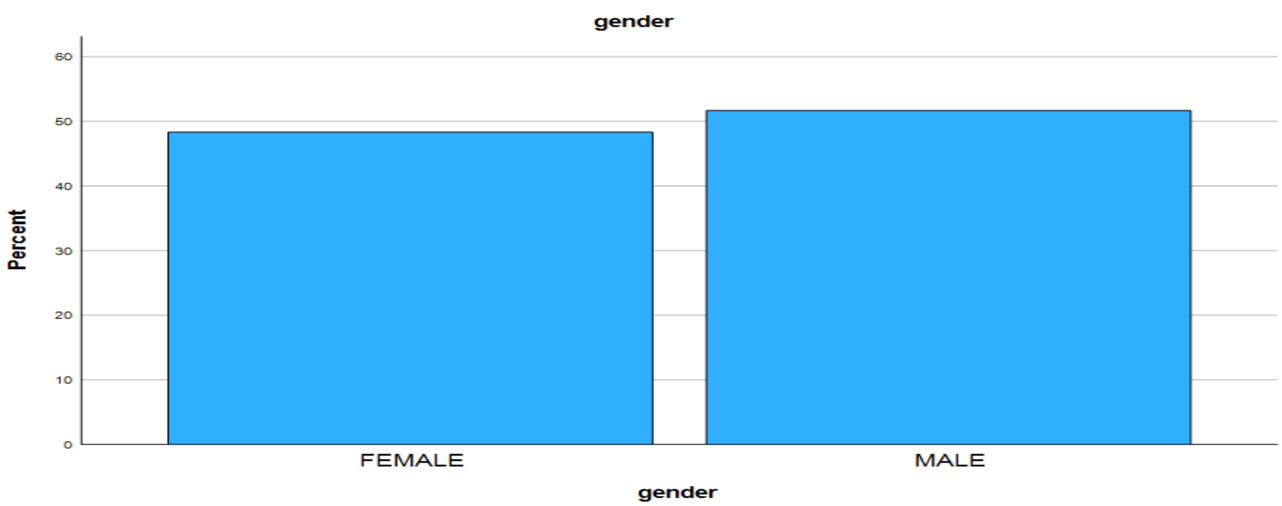

Figure 1: Of Gender. This figure represents the percentage of male 51.7% and female 48.3% patients taken in this research study.

Table 2: Of Age.

N	Valid	60
	Missing	0
Mean		31.6667
Median		36.0000
Mode		1.00
Minimum		1.00
Maximum		74.00

Tricuspid Valve Regurgitation

24 patients out of 60 patients that undergone CTPA were diagnosed with tricuspid valve regurgitation.

Table 3: Of Tricuspid valve regurgitation.

		Frequency	Percent
Valid	NO	36	60.0
	YES	24	40.0
	Total	60	100.0

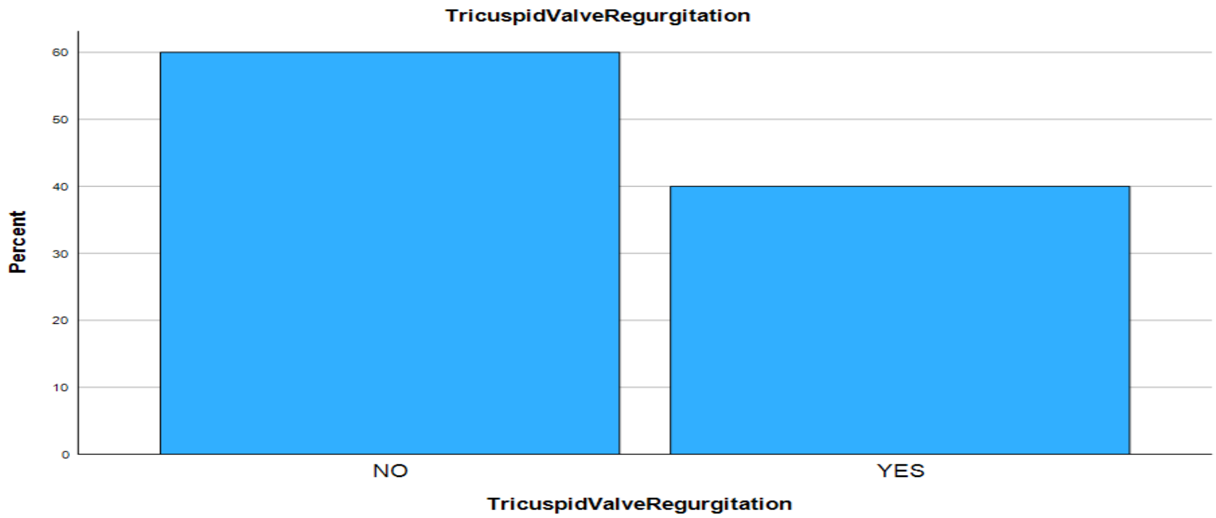

Figure 3: Figure of Tricuspid valve regurgitation. This figure represents the percentage of patients with tricuspid valve regurgitation is 40%.

Table 4: Of RVOT stenosis.

		Frequency	Percent
Valid	NO	55	91.7
	YES	5	8.3
	Total	60	100.0

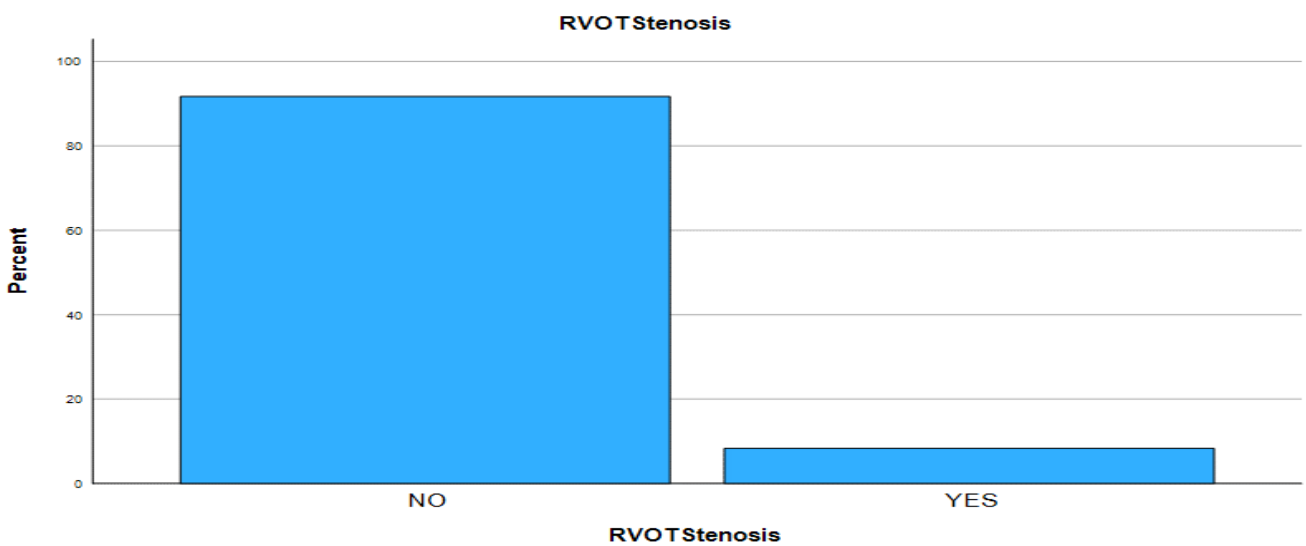

Figure 4: Figure of RVOT stenosis. This figure represents the percentage of patients with RVOT Stenosis is 8.3%.

Table 5: Of sub-valvular stenosis.

		Frequency	Percent
Valid	NO	59	98.3
	YES	1	1.7
	Total	60	100.0

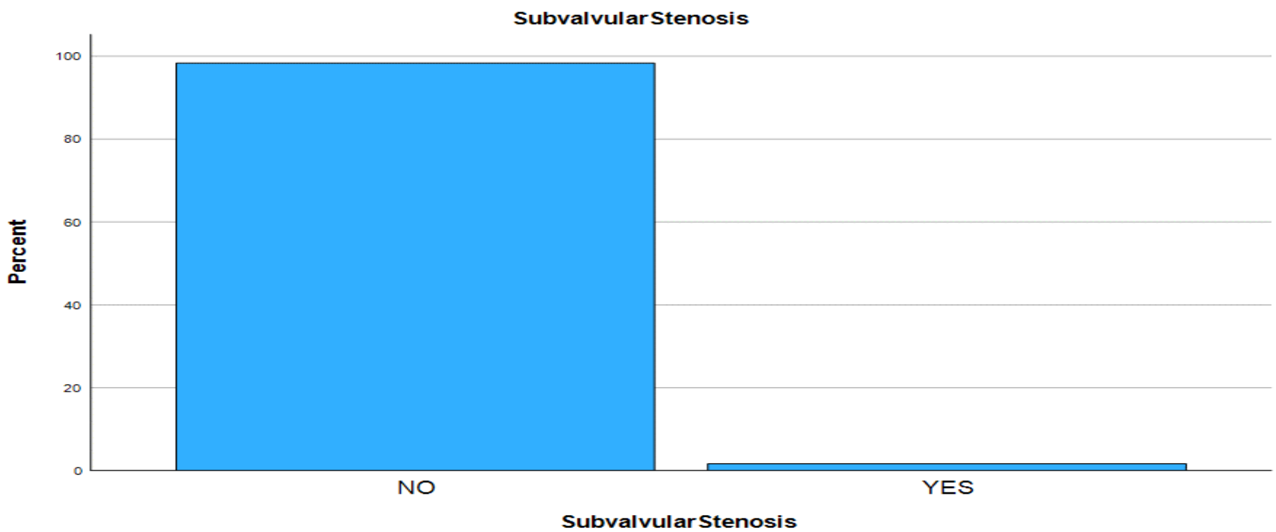

Figure 5: Figure of sub-valvular stenosis. This figure represents the percentage of patients with sub-valvular stenosis is 1.7%.

Table 6: Of complete pulmonary atresia.

		Frequency	Percent
Valid	NO	54	90.0
	YES	6	10.0
	Total	60	100.0

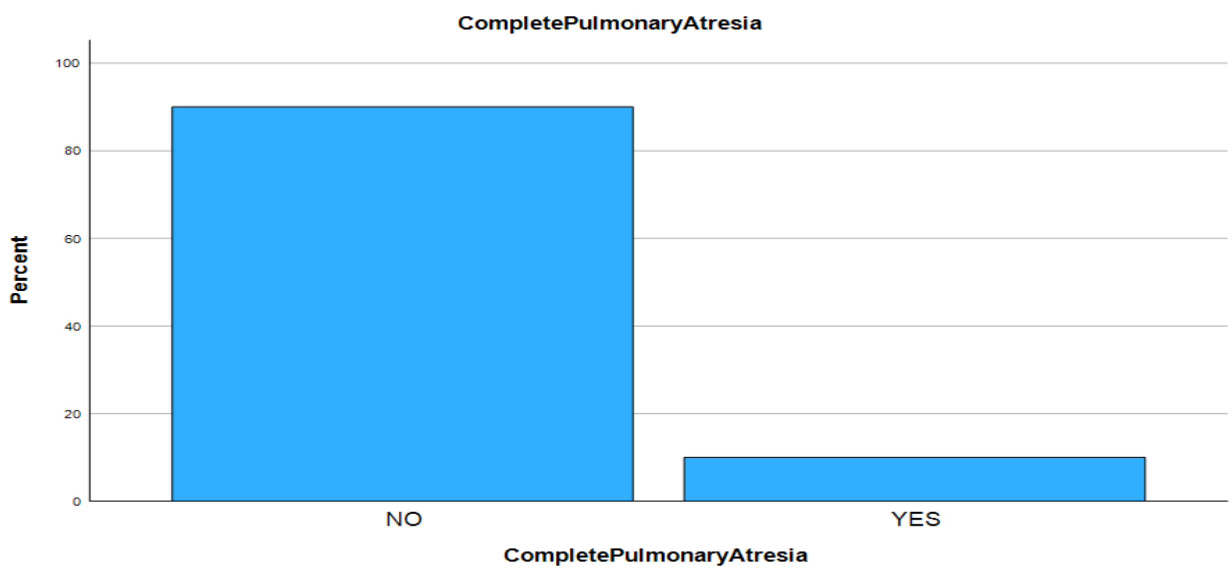

Figure 6: Figure of complete pulmonary atresia. This figure represents the percentage of complete pulmonary atresia is 10%.

Table 7: Of Levocardia and Situs solitis.

		Frequency	Percent
Valid	NO	50	83.3
	YES	10	16.7
	Total	60	100.0

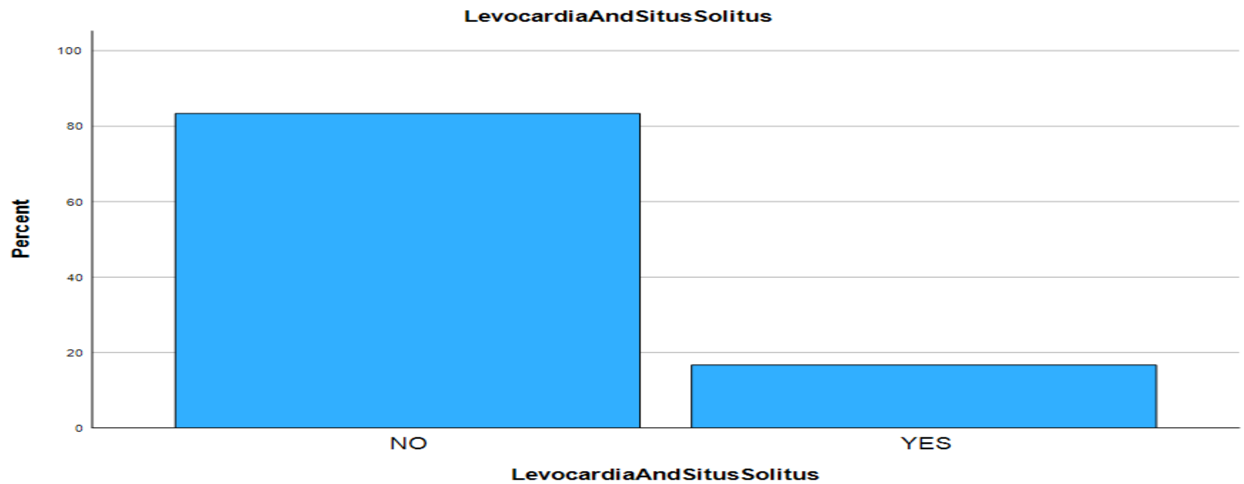

Figure 7: Figure of Levocardia and Situs solitis. This figure represents the percentage of levocardia and situs solitus is 16.7%.

Table 8: Of IVS.

		Frequency	Percent
Valid	NO	59	98.3
	YES	1	1.7
	Total	60	100.0

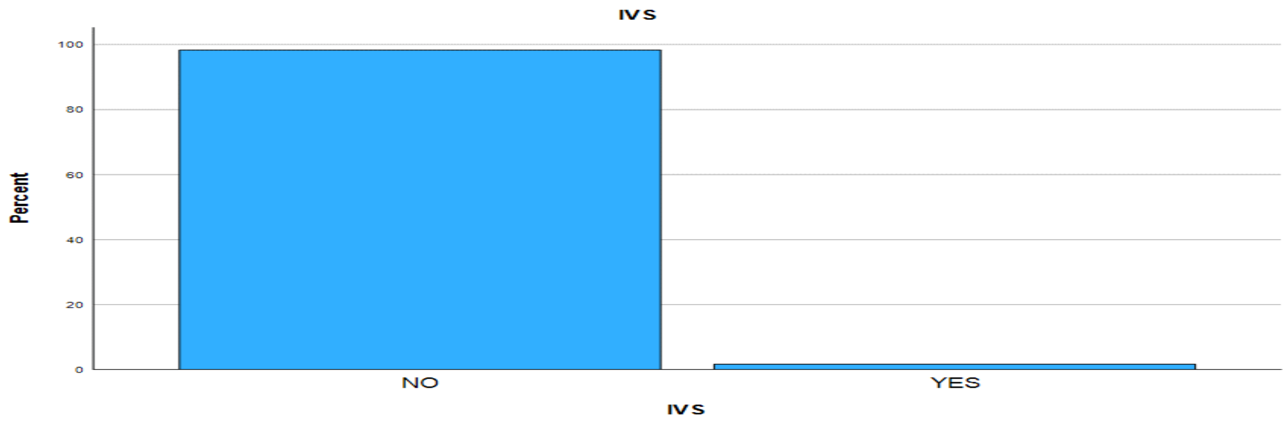

Figure 7: Figure of IVS. This figure represents the percentage of IVS is 1.7%.

Table 9: Of VSD.

		Frequency	Percent
Valid	NO	54	90.0
	YES	6	10.0
	Total	60	100.0

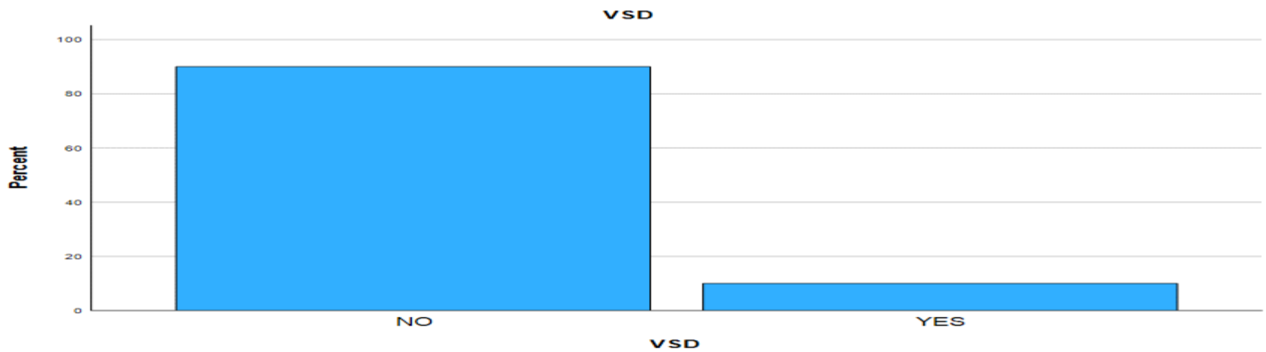

Figure 9: Figure of VSD. This figure represents the percentage of VSD is 10.0%.

Table 10: Of normal CTPA.

		Frequency	Percent
Valid	NO	30	50.0
	YES	30	50.0
	Total	60	100.0

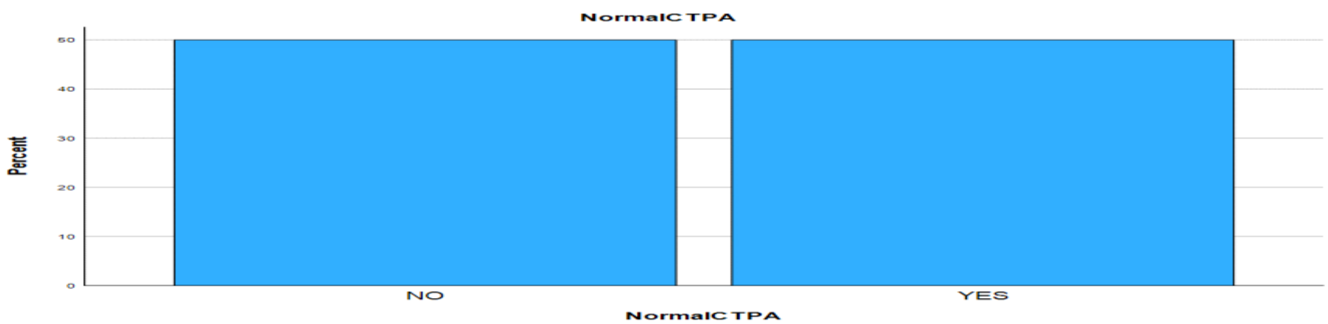

Figure 10: Figure of normal CTPA. This figure represents the percentage of normal CTPA patients is 50%.

Correlations

Tricuspid Valve Regurgitation and PE Crosstabulation

Out of 60 participants 24 participants had tricuspid valve regurgitation but 10 participants were diagnosed with pulmonary embolism having tricuspid valve regurgitation.

		Pulmonary Embolism		Total
		NO	YES	
Tricuspid Valve Regurgitation	NO	36	0	36
	YES	14	10	24
Total		50	10	60

Tricuspid Valve Regurgitation and Pulmonary Embolism Crosstabulation.

		Tricuspid Valve Regurgitation	Pulmonary Embolism
Tricuspid Valve Regurgitation	Pearson Correlation	1	.548**
	Sig. (2-tailed)		<.001
	N	60	60
Pulmonary Embolism	Pearson Correlation	.548**	1
	Sig. (2-tailed)	<.001	
	N	60	60

DISCUSSION

In this retrospective study, Kevin Ong M.D., Gannon Yu et al. all patients diagnosed between January 2004 and December 2010 were divided into three groups between January 2004 and January 2010. Underlying diseases associated with severe TR were determined in 91% of cases, with 9% diagnosed as self-originating TR (Kwok et al, 2022). Patients with idiopathic TR were older (78 ± 10 years) and had increased incidence of irregular heart beat compared to organic patients or functional TR. It is associated with high BP in lungs and/or left ventricular dysfunction (Schönfeld et al, 2024). In short, marked TR was a high extent in women in 1.2% of cases undergoing echocardiography. Functional TR was the most common cause, while organic TR increased the lower proportion. Idiopathic tricuspid insufficiency was observed in a minor number of elderly cases who are at greater risk to suffer from cardiac arrhythmia42 (Eng et al, 2004).

In this study, Jae-Hyeong Park, Jun Hyung Kim et al. Between August 2007 and May 2011, consecutive PE patients were engraved positively. Systolic RV function was measured using systolic distal and tricuspid ring-type systolic velocity (TASV). 50 cases were analyzed. The average RV group area was 26.2 ± 10.8%, RV TEI index 0.78 ± 0.35, TR VMAX 3.8 ± 0.5 m/s and PVR 3.5 ± 1.2 WU (Cozzi et al, 2021). The tack was 16±4 mm and the TASV was 11.7±4.0 cm/s. PAPSE presented strong link with RVFAC, RV TEI -Index, log B and PVR. Similarly, TASV was significantly correlated with RVFAC (r=0.605, p<0.001), RV TEI index, log BNP and PVR. The optimal Tapse cutoff for observation of reduced ejection fraction was 1.75 cm, true positive rate was 87% and true negative rate was 91%. The highest TASV cutoff was 13.8 cm/s, sensitivity was 86% and specificity was 78%, but there was no important variation in detection of RV dysfunction among Tapse and TASV. Overall, Tapse and TASV displayed strong alignment with traditional cardiovascular ultrasound criteria of RV functions as well as log BNP figures, creating useful tools for detecting impaired RV function in individuals with APE43 (Boon et al, 2022).

Joe F, Jos J.M et al retrospectively conducted an imaging-based comparison based on HIPAA by a single institution. It included 21 patients who obscured both the multi planar and 4D flow cardiac MRI between 2015 and January 2017 (Henning et al, 2022). This study evaluated the reproducibility of the overview in the evaluation of Inter techniques (4D River vs. 2D-PC), Inter methods (direct to indirect measurements), Interobserver servers, and ERIAD Rivers (RFV), Congressional Groups (RF) and Volumes (RVOL). Statistical analyses included Pearson correlations, Brand-Altman statistics, and intraclass correlation coefficients (Ong et al 2014). The results showed strong agreement between 4D flow and multifaceted MRI regardless of the method used for quantification (r = 0.813 0.985) (Park et al 2012). Direct measurement of the reflux jet via 4D flow MRI showed excellent observer (r = 0.976â0.999) and interobserver (r = 0.861â0.992) consistency, correlating traditional indirect methods based on stroke volume and forward outlet valve flow. A reliable alternative to the traditional multifaceted MRI44 (Feneis et al, 2018).

Our study was conducted on CTPA assessment of pulmonary embolism to differentially diagnose tricuspid valve regurgitation (Bach et al, 2015). We had 60 patients of CTPA of age group ranging from 1 year to 74 years. Gender based data is tabulated in descriptive statistics with a highest frequency of male which is 31(51.7%) than females which is 29(48.3%) (Ranii et al, 2006). The tabulated statistical data of tricuspid valve regurgitation shows frequency of 24(40%) patients for total number of 60. The tabulated statistical data of RVOT stenosis shows frequency of 5(8.3%) patients for total number of 60 (Nagel et al, 2019). The tabulated statistical data of sub-valvular stenosis shows frequency of 1(1.7%) patient for total number of 60. The tabulated statistical data of complete pulmonary atresia shows frequency of 6(10%) patients for total number of 60 (Low et al, 2023). The tabulated statistical data of pulmonary atrial stenosis shows frequency of 1(1.7%) patient for total number of 60. The tabulated statistical data of pulmonary embolism shows frequency of 10(16.7%) patients for total number of 60 (Shujaat et al, 2013). The tabulated statistical data of sub-segmental pulmonary embolism shows frequency of 5(8.3%) patients for total number of 60.

The tabulated statistical data of levocardia and situs solitus shows frequency of 10(16.7%) patients for total number of 60 (Safriel et al, 2002). The tabulated statistical data of IVS shows frequency of 1(1.7%) patient for total number of 60. The tabulated statistical data of VSD shows frequency of 6(10%) patients for total number of 60. The tabulated statistical data of normal CTPA shows frequency of 30 (50%) patients for total number of 60. crosstabulation of tricuspid valve regurgitation and pulmonary embolism showed that all the patients with pulmonary embolism had tricuspid valve regurgitation in them, but RVOT Stenosis, Sub-valvular Stenosis, Complete Pulmonary Atresia, Pulmonary Embolism, Sub-segmental Pulmonary Embolism also cause tricuspid valve regurgitation in patients (Schissler et al, 2013 and Weiss et al, 2006).

CONCLUSION

Our study demonstrates that pulmonary embolism (PE) induces right ventricular pressure overload, leading to tricuspid valve regurgitation and associated cardiac abnormalities such as RVOT stenosis, pulmonary atresia, and sub-segmental PE, with CTPA effectively detecting both PE and these cardiac complications; however, limitations including small sample size and single-center design restrict broader generalizability, necessitating future multi-center studies with larger cohorts to validate findings while recommending low-dose CTPA protocols, alternative imaging like MRI/V/Q scans, and AI-assisted diagnostics to reduce radiation risks and observer variability.

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