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Original Article

Radiology Section

Comparison of Colour Doppler Ultrasonography and Indirect Computed Tomography Venography for the Diagnosis of Deep Venous Thrombosis in Patients with Suspected Pulmonary Thromboembolism at a Tertiary Care Centre in Chennai, Tamil Nadu, India

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ABSTRACT

Introduction: Pulmonary Thromboembolism (PTE) and Venous Thromboembolism (VTE) are prevalent conditions with a high mortality rate and need immediate medical attention. The initial and standard imaging techniques are Computed Tomography Pulmonary Angiography (CTPA) for the diagnosis of PTE and Colour Doppler Ultrasonography (CDUS) for Deep Vein Thrombosis (DVT). However, there can be some issues when using these two different approaches, like the requirement for a separate area and more time. With the so-called indirect Computed Tomography Venography (CTV) approach, thrombi in the deep venous system that may cause PTE can be examined right after pulmonary CT Angiography (CTA) without the need for additional contrast agent.

Aim: To determine the accuracy of indirect CTV for the diagnosis of deep venous thrombosis in patients with suspected PTE.

Materials and Methods: This cross-sectional study was conducted in the Department of Radiology in Government Stanley Medical College, Chennai, Tamil Nadu, India, India from June 2021 to May 2022. A total of 50 patients with a probable diagnosis of PTE and was established with CTA were included. All 50 patients underwent indirect CTV and CDU on the same day. For indirect CTV lower extremities between the iliac crest and the popliteal region were scanned without administration of extra contrast medium. Colour Doppler Ultrasound (CDUS) was considered as Gold standard. To find the efficacy of CTV in determining DVT the Receiver Operating Characteristics curve (ROC) was used.

Results: Of the total 50 patients, who were enrolled in the study, 21 (42%) patients were females and 29 (58%) patients were males. The mean age of the study subjects was 43.5±12.1 years. Among these DVT was detected in 25/50 patients (50.0%) by Doppler Sonography, Similarly DVT was detected in 23/50 patients (46%) by CTV. The sensitivity of CTV was 76% and the specificity was 84%, Positive Predictive Value (PPV) of 82.6%, Negative Predictive Values (NPV) of 77.8%. The p-value and kappa value between CTV and CDUS was calculated as 0.0005 and 0.600, respectively.

Conclusion: According to the results of the present study, a combined CTA indirect CTV method can determine the DVT with a moderate level of sensitivity and specificity.

Keywords: Contrast media, Lower limb, Pulmonary artery

INTRODUCTION

The PTE and VTE are common conditions that are fatal and require urgent treatment [1]. It is the common emergency seen after surgery, childbirth, prolonged bed rest, and trauma [2]. The likelihood of pulmonary embolism is evaluated by clinical prognosis and laboratory studies. Utilising imaging tools, a definitive diagnosis is frequently made [3]. DVT is the primary aetiology of PTE in 90% of patients [4]. PTE and DVT, two distinct thromboembolism components, are diagnosed using various techniques. Today, among these techniques, CDUS for the detection of DVT and CTPA for the diagnosis of PTE has emerged as the first fundamental imaging modalities [5,6]. However, applying these two different methods separately can lead to the following problems: Need for extra space and time, difficulty in moving the patient, delay in diagnosis, and failure to use CDUS effectively in some patients.

Recently, in patients undergoing CTA for PTE, venous structures below the level of iliac crest have been assessed with CT venography sections obtained after a given waiting period, based on the assumption that adequate opacification would be attained without administration of additional contrast medium [6,7].

The aim of the present study was to determine the accuracy of indirect CTV for the diagnosis of deep venous thrombosis in patients with suspected PTE.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Radiology in Government Stanley Medical College Chennai, Tamil Nadu, India from June 2021 to May 2022 after obtaining Ethical Committee clearance (20210692).

Inclusion and Exclusion criteria: Patients with a presumptive diagnosis of pulmonary embolism which was confirmed by CT pulmonary angiogram were included in the present study. Patients who have contrast hypersensitivity, all pregnant patients, children less than 18 years, patients with renal failure, and those patients who are not willing to give consent to the study.

Sample size calculation: The sample size was calculated based on a previous study by Nayman A and Odev K in which sensitivity to determine PE was 81.8% with indirect CTV of the leg [8].

Study Procedure

The CTA and CTV were performed using a multislice CT with 128 detectors (GE-Optima 660). An 18-20 Gauge catheter was used to provide vascular access before the procedure in the antecubital vein. The patient was positioned properly to allow for a full examination of the lower extremities. An autoinjector was used to administer 60 mL of non ionic contrast at a rate of 3 mL/sec through the antecubital vein. Prior to and following the administration of the contrast medium, automated injectors were used to administer 10 mL and 20 mL of isotonic saline, respectively.

In order to prevent breathing artifacts, the patients were instructed to hold their breath throughout the examination. The investigation was performed at the supine position with hands over head level to avoid artifacts. From the lung apex to the diaphragm, CTPA was done. Then, reconstruction images with 1 mm section thicknesses were created. Vascular structures were assessed using images with a 1 mm slice thickness. Images with a 1 mm section thickness were used to assess the pulmonary parenchymal structures. From the iliac crests to the popliteal fossa, indirect CTV was carried out. Indirect CTV was performed three minutes after contrast was administered, without the use of any extra contrast. With a slice thickness of 2 mm, CTV images were obtained craniocaudally. The evaluation of PTE and DVT was done using pulmonary CTA and CTV images, respectively. Utilising density measurements in the main femoral vein, it was determined whether the level of venous opacification was optimum. Opacification of atleast 70 HU was considered adequate.

Doppler ultrasonography was performed for all patients on the same day (Mindray DC-60). Patients in the supine position using high-frequency linear probe lower limb veins were first examined with B-mode (brightness mode) gray-scale sonography in transverse, and longitudinal views followed by CDUS examination in which the direction of flow, filling of the vessel can be assessed and spectral doppler wave form was obtained from small interrogation region (sample volume) in the vessel of the target, which gives characteristic waveform and velocity of flow of the target vessels.

For each examined vessel, the following were determined:

1) Presence or absence of the vessel image on real-time imaging;
2) Compressibility of the vessel;
3) Presence or absence of intraluminal echogenic material;
4) Presence or absence of a flow (Doppler signal) within the vessel.

Diagnostic Criteria

The presence of hypodense filling defect in the pulmonary artery and its branches, was accepted as direct diagnostic criteria for pulmonary embolism. Auxillary diagnostic criteria were peripheral wedge of airspace opacity, mosaic attenuation, and enlarged pulmonary artery. According to these criteria, the presence and location of pulmonary embolism was made. Similarly analysis of CTV was made, observation of a hypodense filled defect within the vein on consecutive CTV slices was accepted as a direct diagnostic criterion for DVT. Auxiliary diagnostic criteria were venous widening, infiltration/fat stranding in the perivenous fat tissue. In the study, CDUS was accepted as the gold standard.

STATISTICAL ANALYSIS

The collected data were analysed with IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 23.0. (Armonk, NY: IBM Corp). To describe about the data descriptive statistics frequency analysis, percentage analysis were used for categorical variables and the mean and Standard Deviation (SD) were used for continuous variables. Sensitivity, Specificity, PPV and NPV and accuracy, and Cohen kappa was used to find the agreement. In all the above statistical tools the probability value of 0.05 was considered as significant.

RESULTS

Of the total 50 patients, who were enrolled in the study, 21 patients were females and 29 patients were males. The mean age of the study subjects was 43.5±12.1 years and the age distribution is summarised in the [Table/Fig-1].

Age (in years)	Frequency (n)	Percentage (%)
Upto 30	9	18.0
31-40	13	26.0
41-50	14	28.0
51-60	10	20.0
Above 60	4	8.0
Total	50	100.0

[Table/Fig-1]: Age distribution of the cases studied.

Co-morbidities were present in 22 patients, hypertensive (n=6), diabetic (n=10), Tuberculosis (TB) (n=2), Chronic Obstructive Pulmonary Disease (COPD) (n=4). The signs and symptoms of DVT were present in 26/50 patients (52.0%), and previous history of DVT was present in six patients. Right pulmonary artery, partial thrombus has the highest percentage (18.0%), and left pulmonary subsegmental arteries, partial thrombus has the lowest percentage (2.0%) [Table/Fig-2].

Location of pulmonary embolism	Frequency (n)	Percentage (%)
Main pulmonary artery, partial thrombus	3	6.0
Left pulmonary artery, partial thrombus	4	8.0
Left pulmonary artery, complete thrombus	2	4.0
Left pulmonary segmental arteries, partial thrombus	4	8.0
Left pulmonary segmental arteries, complete thrombus	1	2.0
Left pulmonary subsegmental arteries, partial thrombus	1	2.0
Right pulmonary artery, partial thrombus	9	18.0
Right pulmonary segmental arteries, partial thrombus	7	14.0
Right pulmonary subsegmental arteries, partial thrombus	2	4.0
Right and left pulmonary artery, partial thrombus	6	12.0
Right and left pulmonary artery, complete thrombus	4	8.0
Right and Left pulmonary segmental arteries, partial thrombus	2	4.0
Right and left pulmonary subsegmental arteries, partial thrombus	3	6.0
Right and left pulmonary subsegmental arteries, complete thrombus	2	4.0
Total	50	100.0

[Table/Fig-2]: Location of pulmonary embolism in pulmonary arteries.

The DVT was detected in 25/50 patients (50.0%) by doppler sonography, Similarly DVT was detected in 23/50 patients (46%) by CTV. Pathologies other than pulmonary embolism like COPD, inguinal hernia, and TB cardiomegaly were also detected In CTA and indirect CTV [Table/Fig-3].

The ROC curve shows the area of the curve was 0.800, p-value=0.0005 with 95% CI 0.671 to 0.929 [Table/Fig-4,5].

The sensitivity was 76%, specificity was 84%, PPV was 82.6%, NPV was 77.8% and diagnostic accuracy of 80.0%, p-value and kappa value between CTV and CDUS were calculated as 0.0005 and 0.600, respectively [Table/Fig-6].

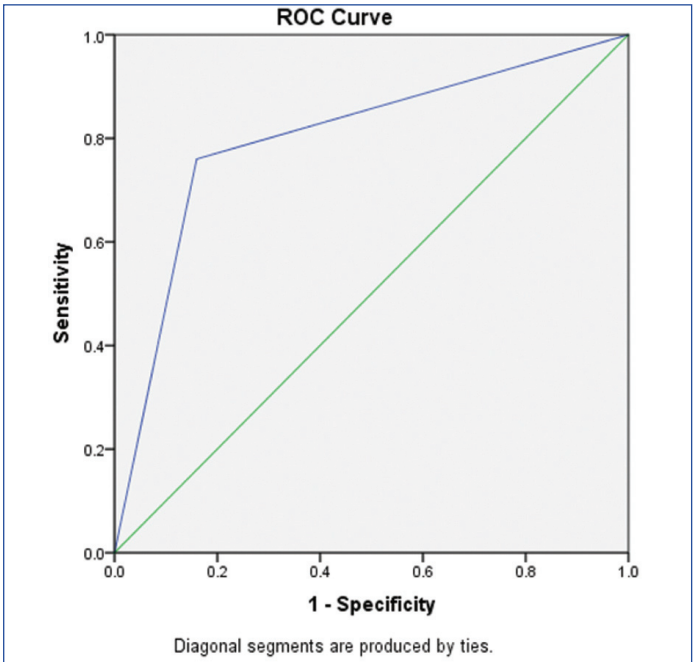
In one of the case, pulmonary embolism was present right and left pulmonary arteries causing partial obstruction [Table/Fig-7a]. DVT was detected through indirect CTV in the right femoral vein and

Pathologies other than pulmonary embolism in CTAta and indirect CTV	Frequency (n)	Percentage (%)
Adnexal cyst	2	4.0
Atherosclerotic changes in aorta	3	6.0
Atherosclerotic changes in aorta, cardiomegaly	1	2.0
Atherosclerotic changes in aorta	2	4.0
Bilateral inguinal lymphadenopathy	2	4.0
Cardiomegaly	3	6.0
Copd	1	2.0
Free fluid in pelvis	4	8.0
Inguinal hernia	1	2.0
Pleural effusion	4	8.0
Pneumonia	2	4.0
Pulmonary hypertension features	2	4.0
Pulmonary infarct	2	4.0
Subsegmental atelectasis in lung fields	5	10.0
TB	1	2.0
Nil	15	30.0
Total	50	100.0

[Table/Fig-3]: Pathologies other than pulmonary embolism which is detected in Computed Tomography Pulmonary Angiography (CTPA) and Indirect Computed Tomography Venography (CTV).

Area	Std. Error[a]	p-value	95% CI	
			LB	UB
0.800	0.066	0.0005**	0.671	0.929

[Table/Fig-4]: Receiver Operating Characteristic (ROC) curve.
**Highly Statistical Significant at p<0.01 level

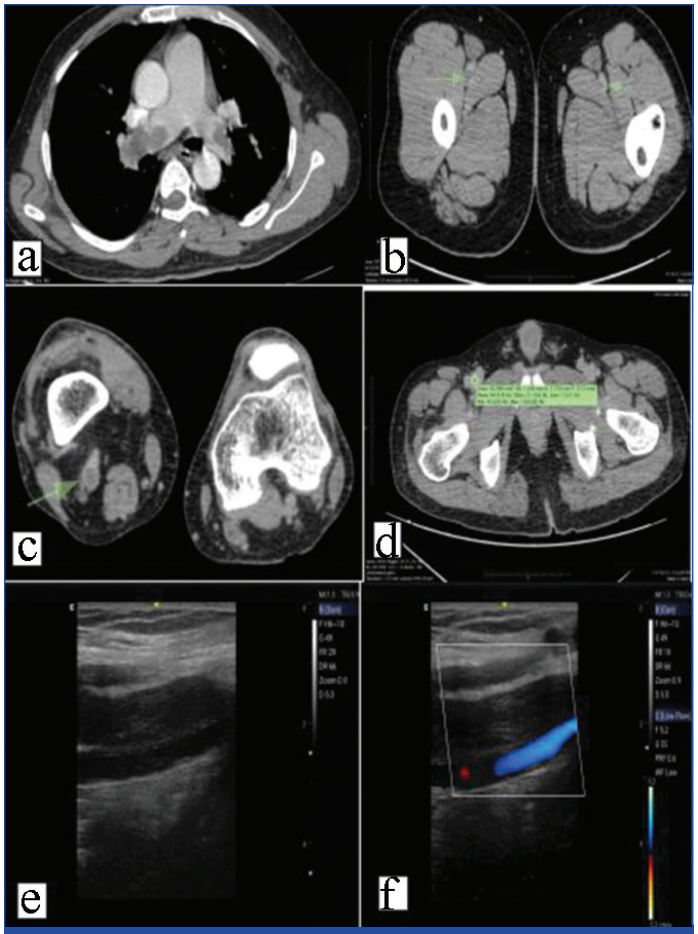


[Table/Fig-5]: ROC curve.

CTV for DVT	Doppler sonography for DVT		Total
	Present	Absent	
Present	19	4	23
Absent	6	21	27
Total	25	25	50

[Table/Fig-6]: Comparison of Computed Tomography Venography (CTV) with Doppler Sonography for detection of Deep vein thrombosis (DVT).
Sensitivity=76.0%, Specificity=84.0%, PPV=82.6%, NPV=77.8%, Accuracy=80.0%

popliteal veins [Table/Fig-7b,c], venous opacification degree was +84 HU [Table/Fig-7d], the findings found in CTV was confirmed by doppler sonography [Table/Fig-7e,f].



[Table/Fig-7]: a) Computed Tomography Pulmonary Angiography (CTPA) showing filling defects in Bilateral pulmonary arteries causing partial obstruction; b) Indirect CTV shows filling defect in right femoral vein (Arrow) indicating DVT, note the left femoral vein opacification and collapsed (Arrowhead); c) Indirect CTV shows filling defect in right popliteal vein (Arrow) indicating DVT, note there is increase in the size of right popliteal vein compared to other side indicating acute thrombus; d) Venous opacification degree is optimal was checked by density measurement in the main femoral vein. (>70 Hounsfield unit is considered adequate) in this case Mean Hounsfield unit was 84, hence adequate; e,f) Echogenic material noted in femoral vein, colour doppler shows no colour flow in femoral vein, colour flow was noted in femoral artery.

DISCUSSION

Venous thromboembolic disease is common disorders that contribute significantly to morbidity and mortality. The Prospective Investigation of Pulmonary Embolism Diagnosis II (PIOPED II) investigators [1] recommend that, clinical assessment should be performed before imaging and with an objective method. Most PIOPED II investigators recommend CTA and CTV for patients with a high probability of PE based on clinical assessment [1].

In a study by Duwe KM et al., 74 patients underwent indirect CTV with CT pulmonary angiography and used lower extremity venous ultrasonography as standard [9]. In their study, CTV had a specificity of 94%, sensitivity of 89%, a NPV of 98% and PPV of 64%. Loud PA et al., performed indirect CTV after CT pulmonary angiography and used lower extremity venous sonography as the standard [10]. In that study, the sensitivity and specificity of CTV were 97% and 100%, respectively, for the evaluation of femoropopliteal DVT. Loud PA et al., also found 17% of DVT in the pelvic or abdominal veins could not be imaged by sonography [10]. In a study by Baldt MM et al., compared CTV with conventional venography as a standard [11]. In this study, CTV for DVT analysis found a sensitivity of 100%, a specificity of 96%, a PPV of 91%, and a NPV of 100%.

In a study by Karaoglu O et al., Pulmonary embolism was determined in a total of 19 patients out of 80 patients [12]. Six patients had DVT on CTV examination, even though the CDUS findings were normal. CDUS findings were considered as the gold standard, the sensitivity of CTV in determining DVT was found to be 100%, specificity 91%, PPV 60%, NPV 100%. In study by Taffoni MJ et al.,

indirect CTV, along with CT pulmonary angiography, was performed in 61 symptomatic ICU patients, with lower extremity duplex venous sonography performed within 24 hours [4]. CTV and sonography were compared with an outcome standard. The sensitivity and specificity of CTV were 70% and 96%, respectively, with a PPV of 77% and a NPV of 94%.

In a study by Garcia-Bolado A and Del Cura JL, they compared the diagnostic value of the indirect CTV vs Doppler ultrasound, the current "gold standard" for the diagnosis of DVT in patients, in which DVT was the primary consideration [13]. In this comparison, they obtained specificity 95.0%, NPV 93.2%, sensitivity 58.8% and PPV 66.7%.

The present study and the prior literature differ further in that, only cases with a diagnosis of pulmonary embolism were included to do indirect CTV. The present study did not calculate the radiation dose that the patients got. But according to a prior study in the literature, dosage values in a typical extremities CT examination, ranging from 7.25 to 8.26 millisieverts (mSv) were not excessive [13]. No independent radiation dosage estimate was performed because these values were within permitted bounds.

Limitation(s)

Small sample size, patients with metallic implants, obesity, extreme leg oedema and patient compliance were the limiting factors in the present study.

CONCLUSION(S)

The Multi-detector Computed Tomography-Pulmonary Angiography (MDCT-PA) is the first-line imaging study for patients with clinically suspected PE. Direct visualisation and quantification of thromboembolic material is the major advantage of this technique, combined CTPA-indirect CTV identify DVT at a moderate level of sensitivity and specificity. When early diagnosis is crucial to detect VTE, this method can be used as an alternative to CDUS. However, additional studies with larger sample sizes are needed to validate or confirm the findings of the present study.

REFERENCES

[1] Stein PD, Woodard PK, Weg JG. Diagnostic pathways in acute pulmonary embolism: Recommendations of the PIOPED II investigators. Radiology. 2007;242:15-21.
[2] Yankelevitz DF, Gamsu G, Shah A, Rademaker J, Shaham D, Buckshee N, et al. Optimization of combined CT pulmonary angiography with lower extremity CT Venography. AJR Am J Roentgenol. 2000;174(1):67-69.
[3] Kalva SP, Jagannathan JP, Hahn PF, Wicky TS. Venous thromboembolism: Indirect CT venography during CT pulmonary angiography—should the pelvis be imaged? Radiology. 2008;246:605-11.
[4] Taffoni MJ, Ravenel JG, Ackerman SJ. Prospective comparison of indirect CT venography versus venous sonography in ICU patients. AJR. 2005;185:457-62.
[5] Loud PA, Katz DS, Klippenstein DL, Shah Grossman ZD. Combined CT venography pulmonary angiography in suspected thromboembolic disease: Diagnostic accuracy for venous evaluation. AJR. 2000;174:61-65.
[6] Torbicki A, Perrier A, Konstantinides S, Guidelines on diagnosis and management of acute pulmonary embolism. Eur Heart J. 2000;21:1301-36.
[7] Nazaroğlu H, Ozmen CA, Akay HO, Kilinç I, Bilici A. 64-MDCT pulmonary angiography and CT venography in the diagnosis of thromboembolic disease. AJR. 2009;192:654-61.
[8] Nayman A, Odev K. Diagnosis of pulmonary embolism by 64-detector MDCT combined with doppler ultrasonography and indirect CTV of the leg: A different protocol. Eur J Gen Med. 2013;10(1):07-13.
[9] Duwe KM, Shiau M, Budorick NE, Austin JH, Berkmen YM. Evaluation of the lower extremity veins in patients with suspected pulmonary embolism: A retrospective comparison of helical CT venography and sonography. AJR. 2000;175:1525-31.
[10] Loud PA, Katz DS, Bruce DA, Klippenstein DL, Grossman ZD. Deep venous thrombosis with suspected pulmonary thromboembolism: Detection with combined CT venography and pulmonary angiography. Radiology. 2001;219(2):498-502.
[11] Baldt MM, Zontsich T, Stumpflen A. Deep venous thrombosis of the lower extremity: Efficacy of spiral CT venography compared with conventional venography in diagnosis. Radiology. 1996;200:423-28.
[12] Karaoglu O, Tertemiz KC, Yilmaz E, Akkoclu A, Çullu N, Elibol C, et al. The place of indirect venography tests after pulmonary computed tomography angiography in the diagnosis of pulmonary thromboemboli. Kardiochir Torakochirurgia Pol [Internet]. 2014;11(4):445-51. [cited 2022 Dec 24].
[13] Garcia-Bolado A, Del Cura JL. CT venography vs ultrasound in the diagnosis of thromboembolic disease in patients with clinical suspicion of pulmonary embolism. Emergency Radiology. 2007;14(6):403-09.

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