Diagnosis of Pulmonary Embolism by 64-detector MDCT combined with Doppler Ultrasonography and Indirect CTV of the Leg: A Different Protocol

Poster No.: E-0063
Congress: ESTI 2012
Type: Scientific Exhibit
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Keywords: Pulmonary vessels, Veins / Vena cava, CT-Angiography, Ultrasound-Colour Doppler, Computer Applications-Detection, diagnosis, Embolism / Thrombosis
DOI: 10.1594/esti2012/E-0063

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Objectives

Pulmonary tromboembolism (PTE) and venous thromboembolism (VTE) are common disorders which can be fatal and require urgent treatment [1]. It is the most frequently encountered emergency condition observed following surgical intervention, delivery, long bed rest and trauma [2]. Mortality rate for patients not receiving treatment is 25-30%, while it is 5-8% for patients receiving treatment.

Pulmonary embolism can present with myriad manifestations. In many of the cases, diagnosis is made in autopsy. Clinical prediction rules and laboratory tests are employed to assess the possibility of pulmonary embolism. Definitive diagnosis is often made via imaging methods [3].

Ninety percent of the PTE cases results from deep ven trombosis (DVT) [4]. Different diagnostic methods are used for PTE and DVT, which are two different components of the thromboembolic disease.

Today, among these methods BTA for the diagnosis of PTE and RDUS for DVT have been established as the initial and baseline imaging methods [5,6].

However, during application of these two different methods there may be some problems such as the need for separate space and extra time, difficulties in patient transfer, delay in the diagnosis and failure to use RDUS effectively in some patients.

Recently, in patients undergoing CTA for PTE, venous structures below the level of diaphragm have been assessed with CT venography sections obtained after waiting for some time based on the supposition that adequate opacification would be attained without administration of additional contrast medium. Thrombi in the deep venous system that could lead to PTE can be investigated with so-called indirect CTV method just after pulmonary CTA without a need for extra contrast medium [6,7].

The aim of this study was to investigate the contribution of CTA in the diagnosis in cases with a presumptive PTE diagnosis. In addition we aimed to assess lower limb deep veins via indirect venography and RDUS and find out the role of these two investigations in the diagnosis of DVT.
Materials and Methods

Forty-six patients including 22 male (average age: 48.7) and 24 female (mean age: 63.4) who were referred to the CT Unit at Radiology Department of our hospital with a presumptive PTE diagnosis between June 2009 and May 2010 and were diagnosed with embolism in pulmonary artery and its branches, were included in the study.

CTA and CTV were performed with 64 detector multislice CT (Sensation 64, Siemens Medical Solutions, Erlangen, Germany). Before the procedure a vascular access was attained on antecubital vein with a 18-20 G catheter. Patients were appropriately positioned to be able to examine lower extremities as well. 100 mL nonionic contrast medium was infused by means of an automated injector at a rate of 4 mL/second from the antecubital vein. Sections were started to be taken just after contrast density reached 180 HU at pulmonary truncus. Twenty milliliter and 40 mL isotonic saline were injected via automatic injector before and after contrast medium injection, respectively. The patients were asked to hold their breath during the examination. Investigation was performed at supine position with hands over head level to preclude artefacts. CT imaging parameters from the level of diaphragm to the lung apex: 100 kv, 135 mAs, 64x0.6 colimation, pitch value 0.9 and start delay 5 seconds. Then reconstruction images were created as 1 and 5 mm section thicknesses. Vascular structures were evaluated from the images with 1 mm section thickness. Pulmonary paranchymal structures were evaluated from images with 5 mm section thickness.

Indirect CTV was performed as to range from iliac crests to the level of femoral heads and from popliteal fossa up to 10 cm proximal of it. This procedure was started 3 minutes after contrast administration and extra contrast was not used for indirect CTV. CTV images were acquired at cranio-caudal direction with the following imaging parameters: 120 kv, 100 mAs, 64x0.6 colimation, section interval 0.8 mm and section thickness 2 mm. Pulmonary CTA and CTV images were evaluated in terms of PTE and DVT, respectively. Whether venous opacification degree is optimal was checked via density measurement in the main femoral vein. Whereas the minimum and maximum values measured from main femoral vein were 75 and 140 Hounsfield Units (HU), respectively, the mean value was determined as 95 HU. In 3 patients, values <70 HU was measured, hence these patients were excluded due to insufficient contrast density.

After CTA procedure in patients who were referred with symptoms suggestive of pulmonary embolism such as shortness of breath, chest pain and hemoptysis CT images were evaluated rapidly within 1-2 minutes. Confirmation of pulmonary embolus during this procedure was deemed as a necessary inclusion criterion in this study. In all 46 patients included in the final analysis pulmonary embolism was documented with CTA.

An experienced radiologist made a detailed examination beginning from main pulmonary arteries to subsegmentary branches with regards to presence of emboli which was confirmed with a filling defect. All of the cases which were deemed to have pulmonary
emboli were confirmed after detailed examination as well. During this thorough examination, lung paranchyma in the imaging area and extravascular structures in the CTV sections were also assessed. Indirekt CTV sections were assessed by the radiologist who was blinded to doppler ultrasound results. On the same day of indirect CTV, all patients underwent renal doppler ultrasound examination comprising an aria starting from vena cava inferior distal part to the popliteal vein trifurcation.

RDUS procedure was carried out with the color doppler device, “GE Logiq S6”. The venous structures from the main femoral vein to the level of popliteal vein trifurcation were evaluated with linear probe (10 MHz), while the distal segment of the inferior vena cava and iliac veins were evaluated with a convex probe (3.5 MHz). First, grey scale images and the diameter of veins, the changes in diameters with respiration, response to compression, the structure of the vessel wall and the lumen were evaluated. Later, it was documented whether there was flow in the lumen via color doppler investigation, and if there was any, the form of the flow was analysed and reported. The presence of thrombus in the lumen, the degree of vessel response to the compression (decrease or disappearance), absence of flow in the doppler or various other findings (recanalised flow, collaterals, etc.) were deemed as the criteria for the diagnosis of DVT.

After all these findings were documented, indirect CTV results were compared with USG results. The sensitivity and specificity of CTV in the diagnosis of DVT were investigated.
Results

Forty-six patients included in the study underwent CTA and indirect CTV carried out with a 64-detector multislice CT. Since one patient died before doppler investigation and the another one had extreme edema in the lower extremity, they could not undergo doppler investigation and they were excluded from the study. In total, there were 47 patients who underwent doppler examination. PTE localizations according to the number of patients and DVT localizations are shown in tables 1 and 2, respectively (figures 1-4). At least 70 HU of contrast density in measurements of femoral vein with indirect CTV was stipulated as a prerequisite. The mean value for our patients was found to be 95 HU. As three of the patients had a contrast density level below 70 HU, they were not included in the study.

In the evaluation of CTV, additional pathologic findings identified except from DVT (figures 3-4) (table 3) were also recorded. The data for two patients were excluded, as they did not take doppler investigation, and the total number of excluded patients was three. All of the 46 patients included in the study had PTE.

In the present study, D-dimer test was performed in 14 patients, and all of them had positive results. As there wasn't available kit in our hospital at that time, the rest of the patients did not undergo the test.

Indirect CTV versus Doppler: Sensitivity, specificity, positive predictive value and negative predictive value were calculated as 81.8%, 91.6%, 90% and 84.6%, respectively. Indirect CTV and Doppler USG were found to be consistent (kappa value: 0.738). SPSS package program was used for statistical analysis.

The mean radiation dose received by the patients for pulmonary CTA, inguinal CTV and popliteal CTV were found as 2.43 mSv, 0.45 mSv, and 0.0072 mSv, respectively. The mean total dose was calculated as 2.89 mSv.
Fig. 1: Case 1.A. Emboli in the right and left branches of pulmonary artery (arrows) in the coronal curved MIP reformatted images B. Embolus in the right descending branch of pulmonary artery in coronal MIP reformatted images C. Filling defects in bilateral main femoral veins (arrows) in indirect CTV and popliteal veins (D.) (arrows) E. Absence of flow in the right femoral vein in Doppler (arrow) F. Echogenic thrombus in the left main femoral vein (arrow) G. While flow can be seen in right popliteal artery, hypoechogenic thrombi are evident in right popliteal vein (G.) and left popliteal vein (H.) lumens

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Fig. 2: Case 2. A. Filling defect in the descending segmentary branch of the right pulmonary artery (arrow) in pulmonary CTA B. Hypodense filling defect in the right popliteal vein in indirect CTV. Left popliteal vein is normal C. Thrombus in the right popliteal vein in Doppler Ultrasound

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**Fig. 3:** Case 3. A. Indirect CTV showing an artefact due to bilateral knee implant, B. Thrombus in the right popliteal vein (arrow), C. Intraabdominal free fluid in the same patient

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Fig. 4: Case 4. In sections of indirect CTV A. Filling defect in right main pulmonary artery, B. Thrombus in the left popliteal vein (arrow) C. Note sacral mass (gray arrow) and intraabdominal cyst in lower left quadrant (white arrow).

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<table>
<thead>
<tr>
<th>Localizations of PTE</th>
<th>Patient (percent)</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
<td>Main pulmonary artery and its distal portion</td>
<td>16 (34.8%)</td>
<td></td>
</tr>
<tr>
<td>Segmentary branches and distal to these</td>
<td>25 (54.3%)</td>
<td></td>
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<tr>
<td>Isolated subsegmentary</td>
<td>5 (10.9%)</td>
<td></td>
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<tr>
<td>Total</td>
<td>46</td>
<td></td>
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Table 1: Table 1. PTE localizations in study patients
<table>
<thead>
<tr>
<th>DVT localizations</th>
<th>Patient (percent)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iliac vein, femoral vein, popliteal and crural veins</td>
<td>3 (13.6%)</td>
<td>1</td>
</tr>
<tr>
<td>Femoral, popliteal and crural veins</td>
<td>7 (31.8%)</td>
<td>1</td>
</tr>
<tr>
<td>Femoral and popliteal veins</td>
<td>4 (18.2%)</td>
<td>1</td>
</tr>
<tr>
<td>Femoral vein</td>
<td>1 (4.54%)</td>
<td>1</td>
</tr>
<tr>
<td>Popliteal and crural veins</td>
<td>2 (9.09%)</td>
<td>2</td>
</tr>
<tr>
<td>Popliteal vein</td>
<td>4 (18.2%)</td>
<td>4</td>
</tr>
<tr>
<td>Crural vein</td>
<td>1 (4.54%)</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>22</td>
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**Table 2:** Table 2. DVT localizations in study patients
<table>
<thead>
<tr>
<th>Extra pathologies other than DVT</th>
<th>Patient Number</th>
</tr>
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<tbody>
<tr>
<td>Pelvic free fluid</td>
<td>6</td>
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<tr>
<td>Sacral mass</td>
<td>1</td>
</tr>
<tr>
<td>Intraabdominal cyst in left lower quadrant</td>
<td>1</td>
</tr>
<tr>
<td>Popliteal cyst (detected also with ultrasound)</td>
<td>2</td>
</tr>
<tr>
<td>Right popliteal hematoma (detected also with ultrasound)</td>
<td>1</td>
</tr>
<tr>
<td>Multiple inguinal lymphadenopathies (detected also with ultrasound)</td>
<td>1</td>
</tr>
<tr>
<td>Fat herniation into bilateral inguinal canals</td>
<td>1</td>
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</table>

**Table 3:** Table 3. Pathologic findings other than DVT in indirect CTV

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Conclusions

PTE is still among the three most common reasons for mortality. Annual incidence is between 0.5 and 1 for every 1000 people [8]. In addition to being considered as one of the inexplicable reasons of death among the hospitalized patients, it is the subject of many malpractice suits [9]. Mortality rates in patients who have been diagnosed with the disease and received treatment in time, are reported as 3-8%. If the diagnosis is missed, mortality rate increases by 3-4 folds [10, 11].

VTE trombophlebitis is an entity secondary to DVT and PTE, and it constitutes one of the major reasons for mortality and morbidity. Majority of pulmonary emboli originate from iliac, deep femoral and popliteal veins. Moreover, some studies report that 90% PTE originate from thrombi in the lower extremity veins [12].

It has become a necessity that the search for PTE and DVT are performed with a single investigation since approximately 90% of PTE arise from thrombus in deep veins of the lower extremities and patients with PTE are usually critically ill with severe dyspnea. The so-called "combined CTA-indirect CTV" technique in which use of pulmonary CTA is coupled with indirect CTV to screen leg veins, is the most commonly used method for this purpose [7, 13-14]. Nowadays this investigation can be rapidly performed by means of MDCT whose use is ever becoming more common. Despite ongoing studies in this field, there is not an investigation method upon which a consensus is made. The rationale behind combined CTA-indirect CTV is evaluation of leg veins after pulmonary CTA without a need for extra contrast medium use. The procedure consists of, though studies differ, screening of venous structures from diaphragm to popliteal region with a 1-5 mm slice gaps and 5-10 mm slice thickness after a delay of application of pulmonary CTA. [7, 13].

With an aim to keep the radiation level received by the patient at minimum levels, incremental scanning method was employed in our research and rather than scanning the whole leg, sections were taken from the popliteal region in two parts. The average amount of dose taken by the patient was calculated. According to this, the dose taken by the patient for pulmonary CTA, the popliteal region and the inguinal region were found to be 2.43 mSv, 0.0072 mSv and 0.45 mSv, respectively. When the indirect CTV is added to the average dose of 2.43 mSv given for CTA, the amount of additional dose given is found to be 0.457 mSv. Looking at these results, it is possible to conclude that the additional dose given to the patients is not too high. In the literature it is observed that in some of the studies CTA-CTV is applied on a routine basis in patients with suspected PTE [6,14,15], but in some of the recent studies [16] it is seen that for patients with PTE clinic and a high level of risk [patients with malignity, VTE history or surgical intervention in the preceding 4 weeks, patients with cardiovascular disease], CTA and CTV are applied together in order to avoid extra cost and unnecessary radiation. In a study carried out with a 4
detector MDCT comparing CTV and RDUS the total amount of dose given to the patients has been calculated. The amount of dose given to women is found as 2.31 mSv when only CTA is applied, but the dose has been found to increase to 8.31 mSv when CTA nd CTV were combined. In the present study, CTV protocol was determined as 4X2.5 mm colimation, and the table speed was decided as12.5 mm. Similar findings were found for the men. It was found that when the protocol colimation and masa h#z# are increased to 4X5 and25 mm, respectively, the dose of radiation received by the patient decreases by 11%. We also preferred to apply CTV investigation in patients diagnosed with PTE by CTA only instead of examining all patients.

It is possible to find out some other pathologies in addition to DVT in the indirect BTV investigation carried out to investigate the DVTs in the lower extremities. In our study, in addition to venous thrombosis other pathologies such as pelvic free fluid (n=6), sacral mass (n=1), intraabdominal cyst (n=1), popliteal cyst (n=2), hematoma in the politeal region (n=1), inguinal lymphadenopathy (n=1) and fat tissue herniation into bilateral inguinal canal were also identified.

Although combined CTA-indirect CTV method is a quick study to detect PTE and DVT, the two different components of VTE, in a single session BT investigation, it has still some limitations and drawbacks. The missing point is that although there is research carried out in this field, there are various applications for the investigation protocol and there is not any consensus. Section thickness and interval, scanning method [incremental or helical] are applied in different values in different protocols. It is known that joint prosthesis and metallic artefacts can influence/hinder the evaluation. One of our patients also had metallic artefacts caused by the prosthesis in the popliteal region. However, these artefacts did not preclude DVT evaluation.

In conclusion, the investigation technique called as combined CTA-indirect CTV can help to identify DTV at a high level of sensitivity, although the specificity level is not too high. Moreover, the additional dose of radiation given for indirect CTV is quite low in this protocol. Especially, when it is taken into consideration that the patients with PTE are old with dyspnea, and that early diagnosis is crucial to VTE, this method can be used as an alternative to RDUS. However, additional studies with larger sample sizes are needed to define the most appropriate protocol for the combined CTA-indirect CTV method.

References


4) Taffoni MJ, Ravenel JG, Ackerman SJ. Prospective comparison of indirect CT venography versus venous sonography in ICU patients. AJR 2005; 185:457-462


