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PULMONARY EMBOLISM – ANGIOCT (CTA) ASSESSMENT OF VASCULAR OCCLUSION EXTENT AND LOCALIZATION OF EMBOLI

Pulmonary embolism (PE) is caused by occlusion of the pulmonary artery or its branches. CTA is a 'gold standard' for the diagnosis and extent determination of PE. The etiology of embolic material may influence the extent and localization of embolism. The CTA assessment of influence of PE etiology on extent of vascular occlusion and clot localization. The study group consisted of 24 patients divided into two subgroups (15 patients with deep venous thrombosis - DVT and 9 patients with heart failure/chronic obstructive pulmonary disease - HF/COPD; respectively group A and group B) were taken into consideration. The location of clots and an average percentage of vascular stenosis in CTA were analysed in these two subgroups. The mean percentage of vessel occlusion was 20,49% vs. 14,22% respectively in group A vs. group B. Bilateral occlusion of vessels was more frequent in group A and unilateral in group B. DVT may predispose to bilateral occlusion and more severe vessels obstruction.

1. BACKGROUND

Pulmonary embolism (PE) is caused by occlusion of the pulmonary arteries or its branches. In 90 % the source of blockage material is a blood clot although a bone marrow, fat, air, clumped tumor cells, amniotic fluid or foreign body may also constitute the embolus. PE is often overlooked. Only 10% - 25% of cases are properly diagnosed [1]. Clinical presentation of PE is not specific and the diagnosis is established by combination of validated clinical criteria. There are many imaging methods which are commonly used in daily practice to diagnose PE, e.g.: chest X-ray, pulmonary angiography, ventilation/perfusion scan, transesophageal ultrasonography, MR and CTA. Among them CTA is considered a 'gold standard'

CTA is a noninvasive method, which has almost replaced conventional angiography in pulmonary vessels imaging. Modern CTA using multidetector-row CT (MDCT) provides rapid scanning of vascular pulmonary bed with very narrow collimation and reasonable scan time.

Narrow collimation improves spatial resolution and allows visualization of small (subsegmental) pulmonary arteries. MDCT reduces or eliminates respiratory motion and gives an image of entire lung during a single breath-hold. Sensitivity and specificity of MDCT for pulmonary embolismranges from 90% to 100% and 89% to 94%, respectively [2].

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2. MATERIALS AND METHODS

The study was performed on 97 consecutive patients suspected of having PE from which 26 patients had diagnosed PE. The entry criteria (diagnosed PE – filling contrast defect in vessels and affiliation to DVT-deep venous thrombosis or HF/COPD-heart failure/chronic obstructive pulmonary disease groups) were met in 24 patients (12 women and 12 men) hospitalized in the Pneumonology Department in Katowice from 2004 to 2006. A mean age was 60 years (women: 43-87; men 34-74). Patients were divided into two groups: group A – patients with peripheral impairment of blood flow (patients with DVT) and group B – patients with central impairment of blood flow (patients with HF or COPD) 15 and 9 patients respectively. In CTA an average percentage of vascular occlusion of mediastinal (main and intermediate) and lobar pulmonary arteries and the number of clots located in main, lobar and segmental pulmonary arteries were determined. The study was performed in the Helimed-Diagnostic Imaging and CTA scans were taken using 16-slices GE LightSpeed scanner with 1,25 mm collimation and pitch 1,35:1. Contrast material (1,5 ml/kg) was injected intravenously at 3 ml/sec. with programmable power injector. Contrast injection delay was controlled by Smart Prep programme (semi-automated software). The scanning from apices of lungs to diaphragm proceeded caudally. Every examination was performed during a single breath-hold. The exams were processed on Advantage Windows 4.0 GE workstation. Each image was assessed on transverse, sagittal, coronal and postprocessed reconstructed (multiplanar reconstruction - MPR and maximum intensity projection - MIP) scans. A clot was defined as a filling defect among pulmonary arteries and its branches (Fig.1 B) and on that basis measurements of emboli and width of vessel lumen on the clot level weremade.(Fig.2)

Fig.1. Contrast-enhanced CT pulmonary angiography: A) demonstrates 'clear' left pulmonary artery (arrow), B) left pulmonary artery filled in distal segment with embolus (arrowhead)
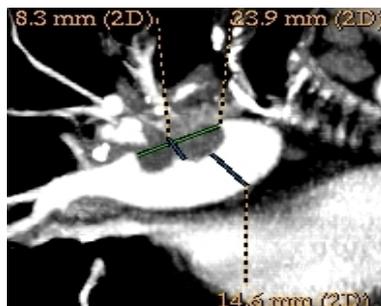

Fig.2. Right pulmonary artery: clot measurements and width of the vessel facilitate calculation of artery percentage occlusion

The percentage of occlusion (obstruction index) of the pulmonary artery circulation was calculated using 'Mastora' score (the CT severity score). This scale was used to calculate central score (mediastinal and lobar pulmonary arteries occlusion). Each of 10 analysed arteries was scored for the degree of vessel obliteration on a scale from 0 to 5 (0 = 0%, 1 = 1-24%, 2 = 25-49%, 3 = 50-74%, 4 = 75-99%, 5 = 100%). So the maximum CT obstruction score for those arteries is 50. The percentage of vessel occlusion is calculated by dividing patient's score by the maximum total score and multiplying the results by 100 (range, 0-100%) [3]. The resulting means were statistically assessed using t-Student test and ANOVA for the mean percentage occlusion of central pulmonary vessels, whereas chi-square test was used to assess a distribution of clots in the pulmonary arteries.

3. RESULTS

Every occluded artery of pulmonary vascular bed did not have more than one clot. Total number of clots in all diagnosed patients was 129 from which 93 (72,10%) clots were found in group A and 36 (27,90%) clots in group B. Within the main pulmonary arteries there were 12 clots (9,3% of all in 24 patients) from which 9 clots in group A (9,67% of all in group A) and 3 in group B (8,33% of all in group B). Lobar arteries had 57 emboli (44,18%) from which 39 (41,9%) in group A and 18 (50%) in group B whereas in segmental arteries there were 60 (46,52%) from which 45 (48,43%) in group A and 15 (41,67%) in group B. Clots per patient ratio was estimated at 6,2 for group A and 4,0 for group B. The mean percentage of vessel occlusion (the pulmonary arterial obstruction index) in group A was 20,49% (range, 0-56%) and in group B 14,22% (range, 4-32%). The resulting means were not statistically significant (p>0,05). (Fig.3).
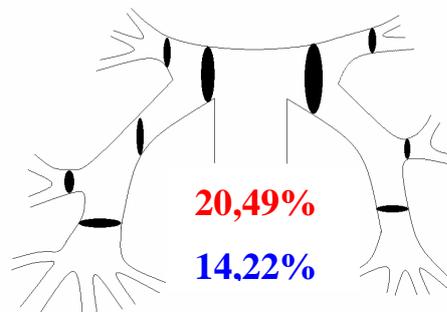

Fig.3. Mean percentage of central vessels occlusion (red colour – group A, blue colour – group B)

Table 1 shows the distribution of clots in big pulmonary branches. As it is demonstrated pulmonary arteries were clotted unilaterally in the same percentage in both groups (group A: 33,3% vs. group B: 33,3%) in contrast to bilateral occlusion where group B shows no case (group A: 13,3% vs. 0%). Distribution of clots in lobar arteries was diverse (see table 1). Analysing unpaired arteries (intermediate artery, middle lobe artery and lingular branch) in both groups it was observed that in group A and group B clots occurred respectively (group A: 33,3% vs. group B: 11,1% ; group A: 40% vs. group B: 22,2% ; group A: 13,3% vs. group B: 0%). Segmental arteries presented almost the same distribution of clots according to unilateral and bilateral location (Table 2). Upper and lower lobe

segmental arteries were occluded unilaterally respectively - group A: 20% vs. group B: 22,2% ; group A: 26,7% vs. group B: 44,4%. The situation was reversed when considered bilateral distribution. And so segmental arteries of upper and lower lobe were clotted respectively – group A: 40% vs. group B: 11,1% ; group A: 66,7% vs. group B: 33,3%). Middle lobe segmental artery was occluded in 40% patients of group A in contrary to 11,1% patients of group B. Assessing unilateral and bilateral distribution of clots in both groups the differences are not statistically significant ($chi^2=1,6$; $p=0,21$). Furthermore DVT and HF/COPD does not show predilection to the localization of emboli in upper, middle or lower lobe segmental arteries ($chi^2=0,71$; $p=0,7$).

Table 1. Distribution and number of clots in big pulmonary branches

	Group A	Group B
Pulmonary arteries		
- unilaterally	**5 (33,30%)**	**3 (33,30%)**
- bilaterally	**2 (13,30%)**	**0%**
Intermediate artery	**5 (33,30%)**	**1 (11,10%)**
Lobar arteries		
Upper lobe artery		
- unilaterally	**5 (33,30%)**	**4 (44,40%)**
- bilaterally	**2 (13,30%)**	**1 (11,10%)**
Middle lobe artery	**6 (40%)**	**2 (22,20%)**
Lower lobe artery		
- unilaterally	**3 (20%)**	**3 (33,30%)**
- bilaterally	**7 (46,70%)**	**3 (33,30%)**
Lingular branch	**2 (13,30%)**	**0%**

Table 2. Distribution and number of clots in segmental arteries

Segmental arteries	Group A	Group B
Upper lobe arteries		
- unilaterally	**3 (20%)**	**2 (22,20%)**
- bilaterally	**6 (40%)**	**1 (11,10%)**
Middle lobe arteries	**6 (40%)**	**1 (11,10%)**
Lower lobe arteries		
- unilaterally	**4 (26,70%)**	**4 (44,40%)**
- bilaterally	**10 (66,70%)**	**3 (33,30%)**

4. DISCUSSION

The prevalence of PE was 26,8% (26 of 97 patients). De Monyé at al [4] reports also 27% prevalence (130 of 487 patients).

In 24 analysed patients in present study 129 clots were diagnosed: 93 emboli in group A (clots per patient ratio – 6,2) and 36 in group B (clots per patient ratio – 4,0). There were no emboli in pulmonary trunk, 12 clots (9,3%) in main pulmonary arteries, 57 emboli (44,18%) in lobar arteries and 60 clots (46,52%) in segmental arteries. Subsegmental

arteries were free from clots. De Monyé at al results were respectively: the main pulmonary trunk had 10 (7,7%) emboli, main pulmonary branches 19 (14,6%), the lobar arteries 37 (28,5%), the segmental arteries 35 (26,9%), and isolated clots in subsegmental arteries 29 (22,3%). Observed differences in distribution probably result from different patient prequalification and possibly different technology used. Total number of diagnosed clots was almost the same (130 emboli diagnosed in de Monyé at al study vs. 129 clots in my study). The absence of emboli in subsegmental arteries in my study is the most important difference. Subsegmental emboli constituted 22,3% clots observed by de Monyé at al. Low sensitivity of MDCT in diagnosing subsegmental clots – approximately 60% has been also reported [5]. The presence of isolated subsegmental emboli is estimated at 6-30% [6].

In this study there was no significant difference in anatomic distribution of clots in particular groups of patients (group A vs. group B), respectively: main pulmonary arteries (9,67% vs. 8,33%), lobar arteries (44,18 vs. 41,9%), segmental arteries (46,52 vs. 48,43%) also the difference in unilateral and bilateral vessels occlusion in these both groups was not statistically significant. DVT does not predispose to bilateral obstruction of pulmonary vascular bed more often than HF/COPD. However, such predisposition might be possible in case of study on larger group of patients.

Analysing the pulmonary arterial obstruction index by using Mastora score mean percentage of central vessel occlusion for all 24 patients was 18,14% (range, 0-56%). Wu et al [7] reported a mean percentage of total pulmonary arterial obstruction of 22% (range, 2,5-92,5%) and Qanadli at al [8] reported 29%. This lower value of 18,14% results from analysing only central vessels and omitting segmental arteries. There was no significant difference of the mean percentage occlusion between group A and B (group A: 20,49% vs. group B: 14,22%).

5. CONCLUSION

DVT as a peripheral impairment of blood flow does not cause more disperse and serious embolization of pulmonary vessels. Moreover DVT does not result in bilateral occlusion of arteries in comparison to HF/COPD (central impairment of blood flow). However, clots per patient ratio is higher in DVT group. A study of more numerous group would be needed to verify these observations.

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