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Single photon emission computed tomography in pulmonary embolism – estimation of selected, scintigraphic regions of interests

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Summary

Background:

Pulmonary embolism is considered dangerous form of thrombo-embolic venous disease contracted by 25000 people annually with around 30% deaths. Accurate diagnosis of the disease and treatment could reduce mortality rate by several per cent.

Discernment of ailment is obstructed by variety of clinical picture. Suspicion of pulmonary embolism is verified by diagnostic patterns, among which SPECT is used as well.

Aim of this study was to prove perfusion scintigraphy with use of SPECT evaluated together with radiological examinations of chest could be efficient method of pulmonary embolism diagnosis.

Material/Methods:

SPECT of lungs was performed in 92 patients, examinations were compared to X-ray scans of chest and in 13 cases to computer tomography. Regions of interest in symmetric zones of chest were also traced in order to evaluate differences radiotracer accumulation.

Results:

Pulmonary embolism was diagnosed by means of SPECT in 59 patients (64.1%). Radiological examinations allowed to exclude other causes of decreased pulmonary perfusion.

Conclusions:

Difference over 10% in radiotracer accumulation in symmetric zones among patients with pulmonary embolism was stated in 42 patients, 5–10% – in 15, under 5% – in 2.

Drawing symmetric regions of interest all over lungs indicates essential points of decreased perfusion whereas difference in radiotracer accumulation is greater than 10%.

Key words:

pulmonary embolism • SPECT

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Background

Pulmonary embolism is one kind of thromboembolic venous disease. It is estimated that pulmonary embolism affect around 25000 people in Poland annually. Unrecognized ailment leads to decrease in 30% of cases [1]. Accurate diagnosis of disease enables undertaking right treatment aiming to prevent decease in short term, but in long term implementation of preventive procedures in

order not to have any more embolic incidents, together with cleaning pulmonary bed from clots and preventing thromboembolic pulmonary hypertension to develop [2].

Suspected pulmonary embolism enables using various pattern procedures differing mainly in sequences of examinations in following stages of diagnostics [3,4]. Ventilatory and perfusion scintigraphy hold strong position among other imaging examinations [5–12].

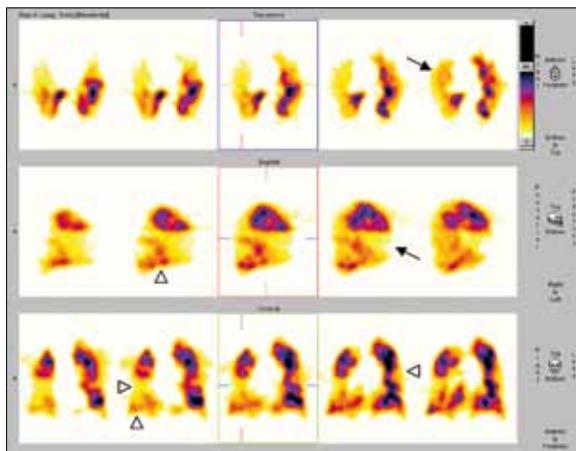


Figure 1. Patient aged 80, hospitalized of respiratory failure in course of chronic obstructive disease of lungs and suspected pulmonary embolism. Angio-CT was performed with no changes visible. SPECT of lungs – no pulmonary perfusion in segments 4 and 5 (arrows), and hypoperfusion in segments of lower lobe of right lung, and 4 and 5 of left lung (spears).

Authors applied SPECT in diagnostics of pulmonary embolism and drew regions of interests (ROI) in order to evaluate accumulation of radiotraced albumin macroaggregates (^{99m}Tc -MAA). Results were compared to X-ray scans of chest and, in some cases, CT examinations.

Aim of the study was to prove pulmonary perfusion scintigraphy with use of single photon emission computed tomography (SPECT) evaluated with radiological examinations of chest could be efficient method of pulmonary embolism diagnosis.

Material and Methods

SPECT examination of lungs was performed in 92 people (46 females and 46 males), at ages of 23 to 85 years (average: 59 years). Diagnosis was set on the basis of clinical examination. Patients most frequently reported shortness of breath (65 people) and some pain in chest (46 people). Symptoms of thrombosis of lower limbs were found in 26 patients, paroxysmal atrial fibrillation in 6, shortness of breath after finished antithrombosis treatment in 5, during course of neoplastic disease in 5, after operations in 7, including one patient after cesarean procedure. Moreover, in 6 cases pulmonary embolism was suspected during echocardiography, in 4 – during CT scanning and in 1 case in histopathological procedure after partial lung resection because of oedematous blisters. Each patient had previous X-ray of chest and 14 patients CT of chest with spiral, 4-slices CT (angio – CT: 11 patients, HRCT: 3 patients). D-dimers were marked in 44 patients and in 12 cases results were within normal range (50–228 micrograms/l), in others results were increased (417–1000 micrograms/l).

Scintigraphic examinations were performed with one-head gammacamera. Technical parameters of equipment: rectangular crystal glass, spectrum of detector: 39×53 mm, diagonal of detector: 65 mm, number of printers: 59.

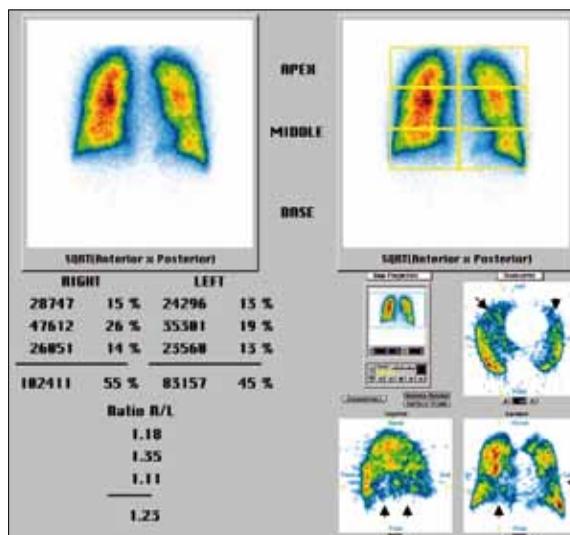


Figure 2. Patient aged 50, hospitalized of suspected pulmonary embolism. Angio-CT was performed showing decrease of filling partially filling ID in right pulmonary artery. SPECT of lungs was performed. Comparing symmetrical regions of interests, difference in radiotracer accumulation in lung middle areas (7%) is visible. In emission tomography scattered subsegmental foci of hypoperfusion in lower lobes of lungs were shown (arrows).

Low-energetic collimator of high resolution was applied. Patient's position during SPECT examination: horizontally lying. SPECT of chest was carried out after 5 min. post intravenous injection of 150 MBq ^{99m}Tc -MAA (64 projections, head rotation of 360 degrees). Acquisition was made in matrix of 128×128 pixels.

Programs "e. soft" and "icon" were used for tomographic scans analysis (SPECT) (Figure 1). Symmetric regions of interest (ROI) were drawn at the level of upper, middle and lower pulmonary fields with use of "icon" program, which enabled to average counts of front and back projections (Figure 2).

Results

Lack of perfusion or impaired pulmonary perfusion of various degree of intensity were diagnosed in 71 patients (77.2%) among 92 examined patients. Area of perfusion disorders covered from 1 to 12 pleural segments in 35 cases (38%). In 27 patients (29.3%) scattered, subsegmental changes were identified, including 2 cases of bullous emphysema and 1 scleroderma in HRCT examination. Comparing scintigraphic examinations to X-ray scans, pulmonary embolism was excluded in 9 patients (9.8%), in suspected areas of fibrocreative changes after past tuberculosis infection.

Finally pulmonary embolism was diagnosed in 59 patients (64.1%), after analysis of scintigraphic and radiological images. Disorders of pulmonary perfusion were not confirmed in 21 cases (22.8%) with use of emission tomography. SPECT examination proved impaired pulmonary perfusion in 9 cases of negative CT examinations, including 3 cases of segments with fibrocreative changes of

Table 1. In this table, radioactivity expansion (percentage of counts) in symmetrical regions of interests in lungs (ROI) in all patients was introduced.

ROI	Upper left	Upper right	Middle left	Middle right	Lower left	Lower right
Average (%)	12.5	13.37	25.67	21.2	16.18	11.21
SD	3.47	2.44	3.81	4.29	4.62	3.55
n	92	92	92	92	92	92
p	<0.001		<0.001		<0.001	

ROI – regions of interest.

Table 2. Radioactivity expansion (percentage of counts) in symmetrical regions of interests (ROI) in patients with pulmonary embolism.

ROI	Upper left	Upper right	Middle left	Middle right	Lower left	Lower right
Average (%)	12.47	13.73	25.1	21.53	15.71	11.33
SD	3.61	2.54	4.45	4.85	5.05	3.38
n	59	59	59	59	59	59
p	<0.01		<0.001		<0.001	

ROI – regions of interest.

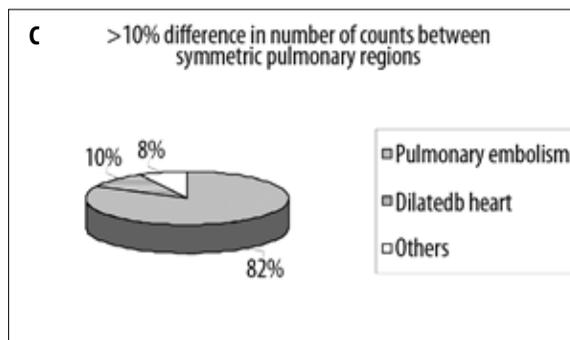
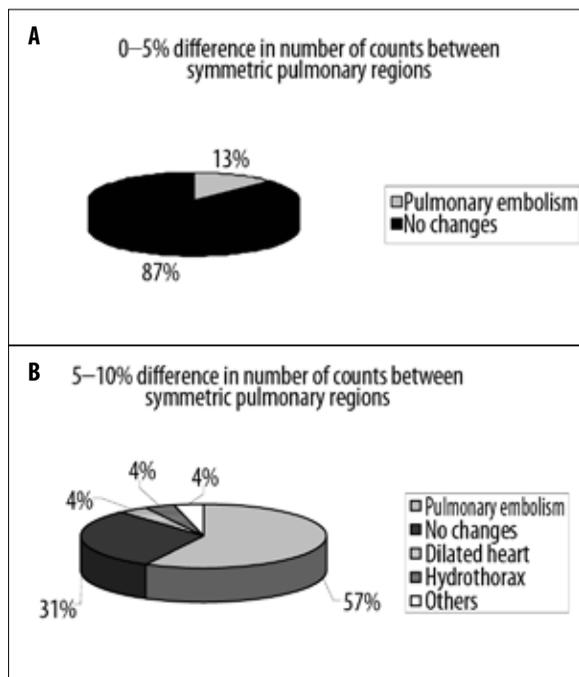


Figure 3. Comparison of radiotracer accumulation in symmetrical regions of interests (ROI) with causes of pulmonary perfusion disorders recognized in imaging examinations (SPECT, CT, X-ray of chest).

tuberculosis. Analysis of regions of interest proved the most frequent impairment of pulmonary perfusion concerned right lower pulmonary field (Tables 1,2). It was also confirmed that only over 10% difference in number of counts among symmetric regions allows to suspect pulmonary embolism (Figure 3A-C).

Discussion

Pulmonary embolism (PE) belongs to severe conditions of threatening life. It is one form of thromboembolic venous diseases which frequency in population takes out about 100 cases/100 000 people per year [13]. Diagnosis of pulmonary embolism is difficult regarding variety of clinical

picture features. Rapid revision of suspected pulmonary embolism, with use of suitable diagnostic methods, enables undertaking antithrombotic treatment or its relinquishment. Preliminary procedures of diagnosis with suspected PE are still being increased [3,4]. They are based on analysis of risk factors, subject and object examinations, that including quantity evaluation of D-dimmer concentration allow us to direct further proceeding [14]. In our study D-dimmer concentration was marked in 44 patients and in 30 cases pulmonary embolism was confirmed in SPECT examination.

Evaluation model of clinical probability of PE, connected with ventilation-perfusion scintigraphy of lungs and ultrasonography of lower limbs venous system was proposed by Wells et al. in 1998 [15]. In 2000 aforementioned authors presented simplified point scale, that was called Wells' scale [16]. One can distinguished two groups of embolism probability: not high (<4 points) and high (>4 points). In case of not high clinical probability of embolism and negative result of D-dimmer, one can withdraw from performing any further diagnostic examinations, according to this

scale [17]. Disadvantage of this scale is subjective element of evaluation regard – doctor is obliged to decide if PE is less, either equally, or more probable than optional diagnosis and score, or not, as many as 3 points.

In 2001 Wicki et al. introduced scale of PE evaluation probability based on objective, standardized criteria. It is, so called, genevian scale. One has to consider not only risk factors, subject and object symptoms, but also, among others, gasometry of arterial blood and X-ray of lungs in this scale [18]. Genevian scale was modified in 2006 – it now includes standardized, objective criteria, without results of additional examinations in evaluation [19].

Comparative research indicates Wells' and Geneva scales have similar predictive quality, as far as PE is concerned, among patients of general departments [20]. Despite aforementioned scales are well-known and should be used, probability evaluation of PE, even at emergency departments, is often not based on factual data [2].

Recently, in some departments was applied the pulmonary embolism severity index (PESI) suggested by Aujesky et al. In this scale points were given as follows: age, sex, heart rate, cancer, heart failure, chronic lung disease, systolic pressure, respiratory rate, body temperature and mental state – similar to Genevian scale, without results of additional examinations in evaluation [21,22].

Aim of PE diagnostics is not only to confirm or deny this disease, but also to get quantitative data on degree and area of pulmonary changes [23]. Massive clogs should be treated with thrombolysis, moderate ones require hospitalization, and in minor one can propose posthospital treatment [23–25]. Planar scintigraphy of PE, not only perfusion, but also ventilation, was considered as efficient diagnostic method not so long ago, for its non-invasive character, simplicity, low cost and risk of radiation [5,10,23]. But only 50–80% of PE cases can be recognized with this method [6]. Scintigraphic examinations are most frequently performed in horizontal position of patients that makes difficult to evaluate pulmonary perfusion for physiological movement of functional blood to higher levels of lungs, extension of heart shape, higher position of phrenic domes, difficulty with breathing etc. Also aforementioned differences in examinations technique should be concerned comparing chest X-ray scans with planar scintigrams. We proved evaluation of planar examinations to be delusive, regarding even 10% difference, by drawing symmetrical regions of interests after averaging counts of front and back projections (Figure 3A–C). With difference of counts under 5% only in 2 for 13 patients showed PE, among 5–10% PE was affirmed in 8 cases for 25. Finally differences in radiotracer accumulation over 10% indicated PE in 42 cases for 51. We assume, similarly to Reinartz et al., planar methods of imaging should not be used any more [12].

PE diagnostics can be improved by SPECT [6,25]. In our research 59 patients (64.1%) were diagnosed with PE. In 35 cases (38%) area of perfusion disorders covered at least 1 segment, in 24 (36.1%) – subsegmental changes were found. Comparing SPECT images to chest X-ray scans let

us exclude cases of perfusion disorders caused by fibrocreative changes of tuberculosis (9 patients), then HRCT examination enabled to recognize bullous emphysema in 2 and scleroderma in 1 patients. In aforementioned material PE was not detected in 21 patients (22.8%) despite increased D-dimmers (417–451 micrograms/l) were seen. One must not exclude that in individual cases slight, subsegmental perfusion decreases were not detected. Many authors recognize comparison of perfusion to ventilation pulmonary emission tomography (V/Q SPECT) as standard [5,9,11,23,25,26]. However, comparing these methods, we must remember that scintigraphic decreases of “mismatch” type can be of different origin than congestion [7,11]. In order to improve diagnostic efficiency one proposes automatic algorithms with use of computers using inversion, subtraction and fusion of images, or acquisition of images gated by breathing (respiratory-gated SPECT) [11,27]. Magnetic Resonance Imaging (MRI) qualities are also taken into account for imaging pulmonary perfusion disorders in patients with suspected pulmonary embolism. Kluge et al. proved high compatibility of MRI and SPECT examinations according to subsegmental disorders of pulmonary perfusion detection [28]. Promising method of pulmonary perfusion and ventilation evaluation is use of nitrogen isotope ($^{13}\text{N}_2$) in positron emission tomography (PET) [29].

In recent years one has been able to see some “competition” between angio-CT and V/Q SPECT in evaluation of pulmonary embolism [7,8,11,12]. Although V/Q SPECT is accepted and frequently performed procedure in PE diagnostics, there have appeared more and more controversies according to its efficacy regarding increasing competition with more and more efficient MSCT [12]. Diagnosis of embolism in case of recognizing “mismatch” decreases in V/Q SPECT examination is well-founded, for similar decreases in for example lung tumor, lymphadenopathy, radiotherapy results, blood vessels inflammation seldom occur and can be easily excluded with use of interview or X-ray of lungs [7]. Howarth et al. think that embolism should be recognized in cases of “mismatch” decreases of half segment or more size. Doing so, they established sensitivity of 0.98 and peculiarity of 0.96 in group of 924 people. These data are impressive and stressing out diagnostic abilities of pulmonary scintigraphy [30]. According to subsegmental embolisms higher sensitivity of V/Q SPECT is stated, however, MSCT is more specific method [12]. Radiological and scintigraphic methods can be reconciled performing fusions of angio-CT and V/Q SPECT images [8,12]. As scintigraphic decreases of “mismatch” type of different origin than embolism can be more thoroughly analyzed and cleared differently for example artifacts of “partial volume” type in CT [7]. In our material angio-CT was performed in 11 patients showing in only 2 cases embolism in large pulmonary vessels. In SPECT examination lack of pulmonary perfusion was confirmed in these patients and moreover 6 scintigraphic features of PE were displayed, in 3 cases perfusion disorders were connected with segments where either in X-ray scan, or CT examination fibrocreative changes of tuberculosis were visible. Examinations were performed by means of 4-slices CT that does not guarantee suitable diagnostic efficacy in PE detection.

Conclusions

1. Pulmonary embolism was recognized in 59 patients (64.1%) comparing SPECT of lungs to radiological examinations, after excluding other causes of asthenic pulmonary perfusion.

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