Comparison of computed tomography in relation to ventilation perfusion scan in the diagnosis of pulmonary embolism

Nedžad Paraganlija[1*], Jasmina Bajrović[1,2], Fuad Julardžija[2], Adnan Šehić[2]

[1] Radiology Clinic, Clinical Center of Sarajevo University, Sarajevo, Bosnia and Herzegovina

[2] Department of radiology technologies, Faculty of Health Studies, University of Sarajevo, Sarajevo,Bosnia and Herzegovina

Corresponding author: Nedžad Paraganlija, Radiology Clinic, Clinical Center of Sarajevo University, Bolnička 25, 71 000 Sarajevo, Bosnia and Herzegovina, e-mail: paraganlija.imr@gmail.com.

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ABSTRACT

Introduction: Pulmonary embolism is still a challenge in diagnosis due to its variable and non-specific symptoms. Computed tomography and ventilation/perfusion scanning are the modalities most commonly used in the diagnosis of pulmonary embolism, and both modalities have their advantages and disadvantages. One of the most important factors in the assessment and localization of pulmonary embolism is the diagnostic accuracy of these modalities, which serves to model different diagnostic strategies in the diagnosis of pulmonary embolism.

Material and methods: The research was conducted as a review of professional literature available in scientific research databases. A selection of 20 professional papers was made, based on which an analysis was conducted and a database was formed. Criteria for inclusion in the research were scientific research papers that report on the sensitivity and specificity of diagnostic modalities of CT and V/P scanning as well as the results of diagnostic tests based on which the comparison of data from two modalities determined a diagnostically more accurate modality.

Results: Sensitivity of 91.89% and specificity of 98.86% and diagnostic accuracy of 94.83% were determined in the case of computed tomography. Sensitivity of 90.58% and specificity of 98.33%

and diagnostic accuracy of 96.43% were determined for the ventilation perfusion scanning method. We can conclude that the application of ventilation/perfusion scanning in the diagnosis of pulmonary embolism is a little more accurate compared to computed tomography.

Conclusion: Ventilation/perfusion lung scanning will more accurately identify healthy individuals while on the other hand we can conclude that computed tomography is more accurate in diagnosing embolism in sick individuals. Given that this difference between the two modalities is very small, the question is whether it is statistically significant at all. We can conclude that both diagnostic procedures have a high level of accuracy.

Keywords: CT, V/P, SPECT/CT, CTPA, pulmonary embolism, diagnostic accuracy, contrast media, radiopharmaceuticals.

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Introduction

Pulmonary embolism is the third most common cause of death in the world after a stroke and a heart attack. Most pulmonary embolism originate from DVT of the lower extremities. Pulmonary embolism with a negative D-dimer test can be ruled out in approximately one third of outpatients without additional diagnostic procedures, however, in the case of a positive D-dimer in combination with probability tests, diagnostic tests are necessary. In the diagnosis of pulmonary embolism, two diagnostic modalities are distinguished: ventilation / perfusion scanning of the lungs and computed tomography by the method of pulmonary angiography. For almost 30 years, the method of ventilation / perfusion scanning of the lungs was the number one method of choice as a non-invasive method, but with the development of technology in the late 90's a new, faster, more modern modality for PE detection, computed tomography. With the application of a contrast agent, computed tomography allows a detailed view of the pulmonary arteries and pulmonary blood flow to the smallest detail, which was enough to make this modality the gold standard in the diagnosis of pulmonary embolism in a short time. Today we are witnessing great technological advances in both radiological diagnostics and nuclear medicine that have enabled the development of new modalities. With the advent of SPECT as well as hybrids, the SPECT/CT method of ventilation/ perfusion scanning has gained a new face and computed tomography a new competitor and a potential alternative in the diagnosis of pulmonary embolism. The application of V/P SPECT has showcased an increase in specificity as well as sensitivity and thus the accuracy of this modality, which has attracted the attention of a large number of experts from around the world (1, 2, 3).

Computed tomography is still the number one method of choice in clinics around the world, but what can be noticed is that the comparison of computed tomography and ventilation/ perfusion scanning in the diagnosis of pulmonary embolism, which is also the subject of this paper, is the subject of more scientific papers and discussions.

Material and methods

The study is designed as a review of the primary professional scientific research literature dealing with this area and refers to the period from 2012 to 2020.In the first phase of the research, a selection of 20 scientific research papers available in relevant databases (Medline, PubMed, Embase, Google Scholar) was selected, on the basis of which an analysis will be conducted and a database of selected papers will be created. After the descriptive analysis for the research of relevant data, the interpretation and comparison of the obtained

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data was done. The extracted data include the general characteristics of the study (authors, year, publications, country, study design) and parameters for determining the accuracy of the modality. The criteria for inclusion in the research were scientific research papers with reports on the sensitivity and specificity of diagnostic modalities of computed tomography and ventilation / perfusion scanning as well as on the results of performed diagnostic procedures and the number: true positive, false negative, true negative and false positive results on the basis of which data were determined diagnostically accurate. Scientific research papers that do not contain the data above, including asymptomatic patients and pregnant women and those who do not deal with this area were not analyzed, which are also criteria for exclusion from the study, and studies published before 2012. and after 2020. To avoid the risk of bias for diagnostic accuracy studies, analysis was performed using the Quality Assessment of Diagnostic Accuracy Studies tool.

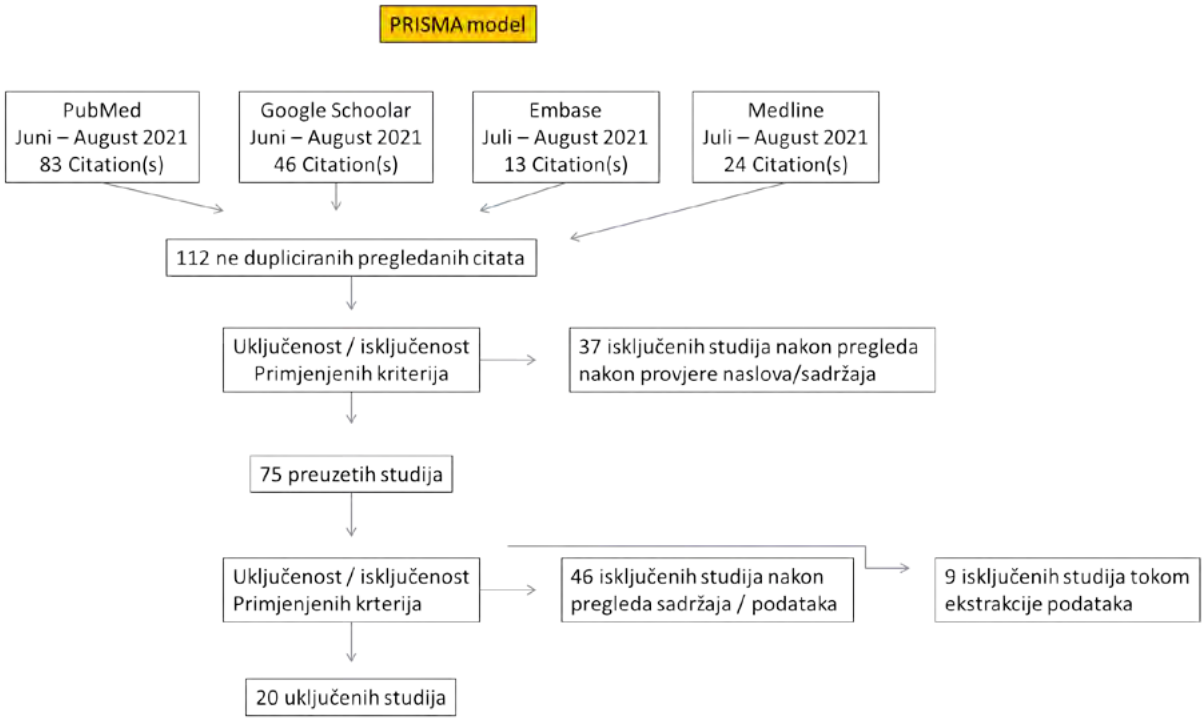

Diagram 1. PRISMA model

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Results

We conducted a bias free assessment for diagnostic test accuracy studies using a revised diagnostic accuracy study quality assessment tool-2. Signal questions are included to help assess the risk of bias (4). The risk of bias is assessed as “low”, “high” or “unclear”.

Table 1. Diagnostic accuracy study quality assessment tool 2 of included V/Q studies.

Studija	RIZIK OD PRISTRASNOSTI				PRIMJENJIVOST		
	SELEKCIJA PACIJENATA	INDEX TEST	REFERENTNI STANDARD	FLOW AND TIMING	SELEKCIJA PACIJENATA	INDEX TEST	REFERENTNI STANDARD
BAJC	☺	☺	☺	☺	☺	☺	☺
BHATIA	☺	☺	☺	☺	☺	☺	☺
GRUNING	☺	☺	☺	☺	☺	☺	☺
HUISMANN	☺	?	☺	☺	☺	?	☺
LING	☺	☺	☺	☺	☺	☺	☺
LE-DUC PEN	☺	☺	☺	☺	☺	☺	☺
MASY	?	☺	☺	☺	☺	☺	☺
SKARLOVIK	☺	☺	☺	☺	☺	☺	☺
THIEME	☺	☹	☺	☺	☺	?	☺
WEINMANN	☺	☺	?	☺	☺	☺	☺

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Table 2. Diagnostic accuracy study quality assessment tool 2 of included CT studies.

Studija	RISK OD PRISTRASNOSTI				PRIMJENJIVOST		
	SELEKCIJA PACIJENATA	INDEX TEST	REFERENTNI STANDARD	FLOW AND TIMING	SELEKCIJA PACIJENATA	INDEX TEST	REFERENTNI STANDARD
HE	☺	☺	☺	☺	☺	☺	☺
KOENIG	?	☺	☺	☺	☺	☺	☺
MOORES	☺	☺	☺	☺	☺	☺	☺
MEGYRI	☺	☺	☹	☺	☺	☺	☺
MIURA	☺	?	☺	☺	☺	☺	☺
NAZERIAN	☺	☺	☺	☺	☺	☺	☺
RIGIHII	☺	☺	☺	☺	☺	☺	☺
VAN DER H.	☺	☺	☺	☺	☺	☺	☺
ZHANG	☺	☺	☺	☺	☺	☺	☺
ZSOLT	?	☺	☺	☺	☺	☺	☺

☹ - high ?- unclear ☺ - low

Data from 10 relevant studies according to the table below were used to analyze the sensitivity and specificity of computed tomography in the diagnosis of pulmonary embolism. The table lists the names of the studies and the reliability estimates for each of the studies where sensitivity and specificity were tested (with a 95% C.I.):

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Table 2. Sensitivity of individual CT studies used in the research

STUDIES	ESTIMATION (95% C.I)
1. MOORES	0,98 (0,97, - 0,99)
2. MEGYRI	0,94 (0,81, - 0,98)
3. RIGIHII	0,99 (0,96, - 0,99)
4. ZHANG	0,89 (0,76, - 0,96)
5. MIURA	0,86 (0,42, - 1,00)
6. VAN DER HULLE	0,92 (0,86, - 0,95)
7. HE	0,81 (0,62, - 0,92)
8. NAZERIAN	0,90 (0,83, - 0,95)
9. KOENIG	0,17 (0,02, - 0,48)
10. ZSOLT SZUCS FARKAS	0.97 (0.87. – 0.99)

Table 3. Specificity of individual CT studies used in the research

STUDIES	ESTIMATION (95% C.I)
1. MOORES	0,99 (0,92, - 1,00)
2. MEGYRI	0,97 (0,94, - 0,99)
3. RIGIHII	0,99 (0,96, - 1,00)
4. ZHANG	0,75 (0,19, - 0,99)
5. MIURA	1,00 (0,54, - 1,00)
6. VAN DER HULLE	0,99 (0,98, - 1,00)
7. HE	0,99 (0,89, - 1,00)
8. NAZERIAN	0,86 (0,81, - 0,95)
9. KOENIG	1,00 (0,96, - 1,00)
10. ZSOLT SZUCS FARKAS	0.98 (0.95. – 0.99)

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For each of these studies, we obtained data on truly positive and negative patients, and false positive and negative patients, which allows us to further analyze the sensitivity and specificity of computed tomography and calculate the necessary parameters (table below).

Table 4. Results of analysis of CT studies in the diagnosis of PE

TRUE POSITIVE	FALSE NEGATIVE	TRUE NEGATIVE	FALSE POSITIVE
1. 364	4	95	0
2. 36	2	184	4
3. 181	1	243	0
4. 41	5	3	1
5. 7	0	6	0
6. 115	9	522	0
7. 259	58	197	14
8. 99	11	213	34
9. 2	10	84	0
10. 41	1	209	4
1145	**101**	**1756**	**57**

Table 5. Sensitivity and specificity of CT in the diagnosis of PE

TRUE POSITIVE	1145
FALSE NEGATIVE	101
TRUE NEGATIVE	1756
FALSE POSITIVE	57
CTA SENSITIVITY	**91.89%**
CTA SPECIFICITY	**96.86%**

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Sensitivity represents the likelihood that a person will be classified by the model as ill if she really is. If the sensitivity were 100%, the model would be correctly classified by all patients, which would mean that the model in terms of sensitivity is set ideally. In our case, the sensitivity is 91.89%, which means that computed tomography in the diagnosis of pulmonary embolism per 100 people we know to have 91.89 (≈92) will make the correct diagnosis.

Specificity is the probability that a model will not classify a person as ill if he or she is not really ill. If the specificity were 100% it would mean that the model 'recognized' all those who were not sick and classified them correctly. In our case, the specificity is 96.86%, which would mean that in 96.89% (≈97) cases, computed tomography in the diagnosis of pulmonary embolism declares healthy patients healthy, which is a very good result in the diagnosis.

Since the specificity is higher than the sensitivity, it can be concluded that this model is better in the diagnosis of pulmonary embolism in recognizing and classifying those who are not ill.

Data from 10 other relevant studies according to the table below was used to analyze the sensitivity and specificity of ventilation / perfusion scanning in the diagnosis of pulmonary embolism. The table lists the names of the studies and the reliability estimates for each of the studies where sensitivity and specificity were tested (with a 95% C.I.).

Table 6. Sensitivity of individual V/Q studies used in the research

STUDIES	ESTIMATION (95 % C.I)
1. LE DUC-PENNEC	1,00 (0,83-0,99)
2. WEINMANN	0,79 (0,68-0,88)
3. LING	0,93 (0,58-0,95)
4. HUISMANN	0,68 (0,90-0,76)
5. SKARLOVNIK	1,00 (0,70–1,00)
6. GRUNING	0,96 (0,93-0,97)
7. BHATIA	1,00 (0,77-1,00)
8. BAJC	0,90 (0,70-0,95)
9. MASY	0,97 (0,85-0,99)
10. THIEME	0,86 (0,83-0,87)

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Table 7. Specificity of individual V/Q studies used in research

STUDIES	ESTIMATION (95 % C.I)
1. LE DUC-PENNEC	0,98 (0,95-0,99)
2. WEINMANN	0,83 (0,63-0,95)
3. LING	1,00 (0,85-0,99)
4. HUISMANN	0,99 (0,97-0,99)
5. SKARLOVNIK	0, 98 (0,87-1,00)
6. GRUNING	0,99 (0,98-0,99)
7. BHATIA	0,94 (0,87-0,98)
8. BAJC	0,95 (0,90- 0,98)
9. MASY	0,86 (0,73-0,93)
10. THIEME	0,88 (0,75 – 0,94)

For each of the studies, we obtained data on truly positive and negative persons, and false positive and negative persons, which allows us to further analyze the sensitivity and specificity of venous perfusion scanning and calculate the necessary parameters (table below).

Table 8. The result of V/Q scan analysis in PE diagnostics

TRUE POSITIVE	FALSE NEGATIVE	TRUE NEGATIVE	FALSE POSITIVE
1. 45	3	191	4
2. 56	15	20	4
3. 28	1	78	0
4. 73	32	599	2
5. 9	0	39	1
6. 442	20	1386	20
7. 13	0	84	6
8. 53	6	88	5
9. 35	1	44	0
10. 6	1	7	1
760	**79**	**2536**	**43**

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Table 9. Sensitivity and specificity of V/Q scanning in PE diagnosis

TRUE POSITIVE	760
FALSE NEGATIVE	79
TRUE NEGATIVE	2536
FALSE POSITIVE	43
V/Q SENSITIVITY	**90.58%**
V/Q SPECIFICITY	**98.33%**

The sensitivity in ventilation / perfusion scanning in the diagnosis of pulmonary embolism is 90.58%, which is again a very high sensitivity, although slightly lower than in computed tomography. This would mean that a ventilatory / perfusion scan in the diagnosis of pulmonary embolism per 100 people we know to have 90.58 (≈91) will correctly diagnose.

The specificity of ventilation / perfusion scanning in the diagnosis of pulmonary embolism is 98.33%, which is the highest measure of diagnostic accuracy in this study. Again, specificity is greater than sensitivity, which means that even in ventilation / perfusion scanning in the diagnosis of pulmonary embolism, the model is more likely to recognize and correctly classify healthy people than sick ones.

Table 10. Accuracy of CTA and V/Q scans in the diagnosis of PE

CTA ACCURACY	**94.83%**
V/Q ACCURACY	**96.43%**

The accuracy of the diagnostic procedure gives us the answer to the question of how well this test distinguishes two conditions or traits (in our case, sick people from healthy people). For the calculation, we use truly positive and negative patients in relation to the total sample.

In our study, we calculated the accuracy for both diagnostic procedures. The calculated accuracy in computed tomography in the diagnosis of pulmonary embolism is 94.83%, while the accuracy in ventilation / perfusion scanning is 96.43%.

From the above we can conclude that the use of ventilation / perfusion scanning in the diagnosis of pulmonary embolism is more accurate than computed tomography with an accuracy greater than 1.6% in favor of ventilation / perfusion scanning. Since this difference is very small (1.6%), we can conclude that both diagnostic modalities have a high level of accuracy in the diagnosis of pulmonary embolism.

We found that both diagnostic procedures had a high level of accuracy. Also, for both models we can conclude that they will better recognize and correctly classify healthy people than sick ones (higher specificity in relation to sensitivity), with this percentage being higher in ventilation / perfusion scanning in the diagnosis of pulmonary embolism (98.33% in relation to at 96.86%). According to the obtained results, computed tomography is a slightly more precise procedure in the diagnosis of pulmonary embolism in sick people (91.89% of them will make the correct diagnosis, while the percentage of ventilation / perfusion scan is 90.58%).

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Disscusion

The review paper included 20 professional articles, 10 professional articles in the field of radiodiagnostics or computed tomography of the lungs in the diagnosis of pulmonary embolism and 10 professional articles in the field of nuclear medicine or methods of ventilation-perfusion scanning of the lungs in the diagnosis of pulmonary embolism. The main goal of this paper was to determine which of the two methods is a more accurate method in the diagnosis of diseases that still pose a challenge in the diagnosis. In this paper, sensitivity of 91.89% and specificity of 98.86% and diagnostic accuracy of 94.83% were determined in the case of computed tomography. Sensitivity of 90.58% and specificity of 98.33% and diagnostic accuracy of 96.43% were determined for the ventilation perfusion scanning method. A 2020 study by Patel et al., Through a meta-analysis on the accuracy of tests in the diagnosis of pulmonary embolism involving the use of computed tomography and ventilatory perfusion lung scanning, found a specificity of 0.98 (95% CI, 0.97-0.99) and 0.98 (95% CI, 0.96–0.99), respectively (5). Computed tomography is the gold standard in the diagnosis of pulmonary embolism with high accuracy, which was established in the work of Moore et al. I cannot receive a contrast agent. In this paper, a sensitivity of 83% was determined in relation to the specificity of 96% in the case of computed tomography, while in the case of ventilatory perfusion scanning a sensitivity of 85% was determined in relation to the specificity of 93% (6). The difference in diagnostic inferiority of these two modalities in most cases is not large deviations, which was found in the work of Anderson et al. In 2007 in a study of 1400 patients, but most pulmonary embolism was diagnosed using computed tomography (7). As the two most common diagnostic methods in the diagnosis of pulmonary embolism, CT angiography of the lungs and V / P lung scanning are the subject of many scientific papers, including Hesse et al. Published in 2016 in the form of a review and meta-analysis comparing the two modalities. at the same time a topic and our studies. In this paper, the diagnostic accuracy was determined to be 96.5% versus 88.6% in favor of ventilatory perfusion scanning versus computed tomography with a sensitivity of 97.6% versus 82.0% and a specificity of 95.9% versus 93.8% also in favor ventilatory perfusion scanning (8). In a study conducted in 2013 by Jing-Jing Meng on 111 patients, sensitivity and specificity were found to be 85% and 93% in the case of ventilatory perfusion lung scan, while computed tomography of the lungs was found to be 85% sensitive and 90% specific. The results of this study indicate that ventilatory perfusion scanning is slightly superior to computed tomography with an established accuracy of 88% compared to 86% in the diagnosis of pulmonary embolism (9). According to the obtained results of the research, as well as the observed researches of other authors, ventilation / perfusion scanning in the diagnosis of pulmonary embolism has a slightly

higher percentage of accuracy compared to the use of computed tomography. But as the difference between the diagnostic modalities in both this study and the above is very small, we can say with certainty that both modalities have high diagnostic accuracy.

Conclusion

Ventilation/perfusion lung scanning will better identify healthy individuals while on the other hand we can conclude that computed tomography is more accurate in diagnosing embolism in sick individuals. We can conclude that both diagnostic procedures have a high level of accuracy.

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