ORIGINAL ARTICLE

Perception of the role of scintigraphic imaging in the exploration of pulmonary embolism by cardiologists in French-speaking sub-Saharan Africa

Kokou Adambounou[1], Amegninou Mawuko Yao Adigo[2*], Abalo Mario Bakai[3], Komlan Amoussou[2], Ekoue Edem Fabrice Sodogas[1]

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ABSTRACT

Background: The purpose of this study is to assess the place given to pulmonary scintigraphy in the exploration of pulmonary embolism (PE) by cardiologists in French-speaking sub-Saharan Africa.

Methods: The cross-sectional study, carried out from 1 Feb to 30 May 2017 and included 103 cardiologists working in French-speaking sub-Saharan African countries. Their accessibility, knowledge, and attitudes regarding the use of lung scintigraphy in the exploration of PE were analyzed.

Results: The sample consisted of 103 cardiologists of various nationalities practicing mainly in West Africa (85.4%) and 36.9% of whom had completed a clinical internship in Europe. A nuclear medicine service existed in their country, city, and practice hospital in 56.3%, 48.5%, and 15.5% of cases, respectively. A large majority of cardiologists had never ordered for a pulmonary scintigraphy (79.6%), 15.5% ordered it rarely, and 4.9% often. With equal accessibility, 86.4% would choose Computed tomography (CT) pulmonary angiography as the examination of choice in managing suspected cases of PE, compared to 11.7% for pulmonary scintigraphy. To rule out PE in case of chest pain with normal chest X-ray, only 16.5% would request for a pulmonary scintigraphy, against 80.6% for a CT angiography. However, 61.2% preferred a pulmonary scintigraphy to a CT pulmonary angiography (32%) to diagnose PE in a pregnant woman. More than half (56.3%) said they were unable to recognize a typical scintigraphic image of PE and 28.2% believed that pulmonary scintigraphy was more irradiating than CT pulmonary angiography. Overall, the differences in perception were not statistically significant depending on their country of practice, their professional experience, the completion of a previous internship in Europe.

Conclusion: The place given to pulmonary scintigraphy in the exploration of PE by cardiologists in sub-Saharan Africa is not very satisfactory. It is, therefore, necessary to sensitize clinicians to its diagnostic and prognostic value.

Keywords: Pulmonary scintigraphy, pulmonary embolism, medical imaging, French-speaking sub-Saharan Africa.

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Correspondence to: Amegninou Mawuko Yao Adigo
*Radiology Department, Campus Teaching Hospital, University of Lome, Lome, Togo.
Email: landry05@gmail.com
Full list of author information is available at the end of the article.

Introduction

Pulmonary Embolism (PE) occurs when the trunk of the pulmonary artery or one of its branches is partially or totally obliterated suddenly by a circulating foreign substance, most often a blood clot [1]. It is a frequent, life-threatening, multifactorial pathology, and constitutes a medical emergency [2], which is generally treated by cardiologists. In the absence of pathognomonic clinical sign, the diagnostic approach is based on the evaluation of the clinical probability associated with performing additional tests and imaging [3]. Scintigraphy stands out among the various means of imaging, particularly pulmonary scintigraphy. Scintigraphic imaging regroups diagnostic imaging techniques based on the use of unsealed radioactive sources *in vivo*. It comes under a medical specialty called Nuclear Medicine. Diagnosis, prognosis and therapeutic monitoring of a large number of pathologies are main fields of action of nuclear medicine. Two main types of examinations are used in nuclear medicine: scintigraphies (or Single Photon Emission Computed Tomography) and Positron Emission Tomography [4]. The diagnosis of PE by pulmonary ventilation-perfusion scintigraphy was first described in 1964 [5].

In African countries, Nuclear Medicine is underdeveloped. Only some rare studies have addressed the

utilization of pulmonary scintigraphy in the exploration of PE by cardiologists, particularly in French-speaking sub-Saharan Africa [6]. Regarding this fact, we undertook this work with the general objective of assessing the place of scintigraphic imaging in the exploration of PE by cardiologists in French-speaking sub-Saharan Africa.

Methods

The cross-sectional study conducted from 1 Feb to 30 May 2017, it included 103 graduate cardiologists working in public or private hospitals in French-speaking sub-Saharan Africa (regardless of their nationality), who were willing to complete the survey form. Cardiologists from French-speaking sub-Saharan Africa, practicing in Europe or in a non-French-speaking sub-Saharan African country were not included in this work. The need for ethics approval was waived by a Bioethics Committee for Health Research of the Health Ministry of our country.

The parameters analyzed were:

- Identity of the cardiologists (nationality, country of practice, practicing hospital, country of training in general medicine and medical specialization, internship in Europe, professional experience);
- Accessibility and frequency of order for pulmonary scintigraphies by cardiologists in French-speaking sub-Saharan Africa
- Interest shown to pulmonary scintigraphy examinations in the exploration of PE by cardiologists in French-speaking sub-Saharan Africa.

These parameters were used in the development of the survey sheet, which mainly consisted of multiple-choice questions.

The data were analyzed and processed with the statistical software "Sphinx 5.3.1". Quantitative data was processed with Microsoft Word 2013 and graphs were performed with Microsoft Excel 2013. Results were tested by Chi-Square test. p-value < 0.05 was considered to be significant.

Results

General characteristics of cardiologists

Our sample consisted of 103 cardiologists from various nationalities practicing in 9 different countries of French-speaking sub-Saharan Africa, mainly West Africa (85.4%). The most represented nationality was Senegalese, followed by Togolese and Bukinabe (Table 1).

Eighty-five cardiologists (82.5%) worked in a public hospital and the rest (17.5%) were private. They were 38 doctors (36.9%) to have completed a cardiology clinical internship in Europe. Their professional experience was less than 5 years in 55.3% of cases, between 5 and 10 years in 32.1% of cases and more than 10 years in 12.6% of cases.

Table 1. *Distribution of cardiologists according to their nationality and their country of practice.*

	Nationality		Country of practice	
	Number	%	Number	%
Beninese	11	10.7	11	10.7
Burkinabe	16	15.5	16	15.5
Ivorian	6	5.8	12	11.7
Malian	8	7.8	8	7.8
Nigerian	8	7.8	9	8.7
Senegalese	20	19.4	21	20.4
Chadian	2	1.9	1	1.0
Togolese	19	18.4	18	17.5
Cameroonian	12	11.7	7	6.8
Congolese	1	1.0	0	0.0
Total	103	100.0	103	100.0

p = 0.0001.

Accessibility and frequency of ordering for pulmonary scintigraphies by cardiologists in French-speaking sub-Saharan Africa

Majority of cardiologists had a nuclear medicine department in their country of practice, 48.5% had it in their city of practice and only 15.5% in their practicing health facility (Table 2). The majority of cardiologists had never ordered for a pulmonary scintigraphy (79.6%), 15.5% ordered it rarely, and 4.9% often. Those who ordered it often were cardiologists who had a nuclear medicine department in their country of practice with a statistically significant difference (Table 3).

Interest of nuclear cardiology in the exploration of PEs according to cardiologists

With equal accessibility, 89 cardiologists (86.4%), would order a computed tomography (CT) pulmonary angiography as the examination of choice in managing suspected cases of PE against only 12 (11.7%) for pulmonary scintigraphy and 2 (1.9%) for thoracic angiography. Cardiologists who had nuclear medicine department in their country of practice opted more for a pulmonary scintigraphy with a statistically significant difference (Table 4).

In the case of a patient with a normal chest X-ray, the CT pulmonary angiography was the preferred examination to rule out PE (n = 83; 80.6%) followed by pulmonary scintigraphy (n = 17; 16.5%) and pulmonary angiography (n = 3; 2.9%). The differences observed between the attitude of cardiologists were statistically significant according to professional experience and the existence of a nuclear medicine service in their countries of practice (Table 5).

Sixty- three cardiologists (61.2%) considered that the scintigraphy was the examination of choice in the diagnosis of PE in pregnant women compared to 33 (32%) for CT angiography and 7 (6.8%) for pulmonary angiography.

Table 2. *Distribution of cardiologists according to the availability of a nuclear medicine service in their country, city and hospital.*

	Country of practice		City of practice		Hospital of practice	
	Number	%	Number	%	Number	%
Presence of NMD[a]	58	56.3	50	86.2	16	27.6
No NMD	45	43.7	8	13.8	42	72.4
Total	103	100.0	58	100.0	58	100.0

[a]NMD, Nuclear medicine department.
$p = 0.010$.

Table 3. *Distribution of the frequency of ordering of pulmonary scintigraphy examinations according to professional experience, clinical internship in Europe and the existence of a nuclear medicine service in the country of practice of cardiologists.*

	Never		Seldom		Often		
	Number	%	Number	%	Number	%	*p*
Professional experience in cardiology							
Less than 5 years (*n* = 57)	47	82.4	8	14.1	2	3.5	0.215
5-10 years (*n* = 33)	24	72.7	6	18.2	3	9.1	
More than 10 years (*n* = 13)	11	84.6	2	15.4	0	0.0	
Clinical internship in Europe							
Yes (*n* = 38)	27	71.1	10	26.3	1	2.6	0.199
No (*n* = 65)	55	84.6	6	9.2	4	6.2	
Nuclear medicine department in country of practice							
Yes (*n* = 58)	43	74.1	11	19.0	4	6.9	0.046
No (*n* = 45)	39	86.7	5	11.1	1	2.2	

Table 4. *First-choice examination to be performed in suspected case of pulmonary embolism depending on professional experience, clinical internship in Europe and the existence of a nuclear medicine department in the country of practice of cardiologists.*

	CT pulmonary angiography		Pulmonary scintigraphy		Thoracic angiography		
	Number	%	Number	%	Number	%	*p*
Professional experience in cardiology							
Less than 5 years (*n* = 57)	49	86.0	6	10.5	2	3.5	0.134
5-10 years (*n* = 33)	30	91.0	3	9.0	0	0	
More than 10 years (*n* = 13)	10	77.0	3	23.0	0	0	
Clinical internship in Europe							
Yes (*n* = 38)	30	79.0	8	21.0	0	0.0	0.144
No (*n* = 65)	59	90.8	4	6.2	2	3.0	
Nuclear medicine department in country of practice							
Yes (*n* = 58)	51	88.0	7	12.1	0	0.0	0.032
No (*n* = 45)	38	84.4	5	11.1	2	4.4	

Cardiologists who had completed a hospital internship in Europe opted more for a pulmonary scintigraphy with a statistically significant difference (Table 6).

Twenty-nine (28.2%) of the cardiologists believed that pulmonary scintigraphy was more irradiating than a CT pulmonary angiography. This perception had no statistically significant link with professional experience, the completion of an internship in Europe and the existence of a nuclear medicine service in their country of practice (Table 7).

More than half of cardiologists (n = 58; 56.3%) felt that they were not able to recognize a typical scintigraphic image of PE. Cardiologists with a nuclear medicine department in their country of practice were those who considered themselves the most capable of recognizing a typical scintigraphic image of PE, with a statistically significant difference (Table 8).

Discussion

Our sample consisted of 103 cardiologists from various nationalities practicing in nine different countries in French-speaking sub-Saharan Africa, mainly West Africa (85.4%). This sample, although not including all the

Table 5. *First-choice examination to be performed in case of a normal chest x-ray to rule out PE based on professional experience, clinical internship in Europe and the existence of a nuclear medicine department in the country of practice of the cardiologists.*

	CT pulmonary angiography		Pulmonary scintigraphy		Thoracic angiography		
	Number	%	Number	%	Number	%	*p*
Professional experience in cardiology							
Less than 5 years (*n* = 57)	46	80.7	9	15.8	2	3.5	0.006
5-10 years (*n* = 33)	27	81.9	6	18.1	0	0.0	
More than 10 years (*n* = 13)	10	77.0	2	15.3	1	7.7	
Clinical internship in Europe							
Yes (*n* = 38)	30	79.0	8	21.0	0	0.0	0.094
No (*n* = 65)	53	81.5	9	13.9	3	4.6	
Nuclear medicine department in country of practice							
Yes (*n* = 58)	48	82.7	9	15.5	1	1.8	0.006
No (*n* = 45)	35	77.8	8	17.7	2	4.5	

Table 6. *First-choice examination to be performed for the diagnosis of pulmonary embolism in a pregnant woman according to professional experience, clinical internship in Europe and the existence of a nuclear medicine department in the country of practice of cardiologists.*

	CT pulmonary angiography		Pulmonary scintigraphy		Thoracic angiography		
	Number	%	Number	%	Number	%	*p*
Professional experience in cardiology							
Less than 5 years (*n* = 57)	13	22.8	37	64.9	7	12.3	0.264
5-10 years (*n* = 33)	14	42.4	19	57.6	0	0.0	
More than 10 years (*n* = 13)	6	46.2	7	53.8	0	0.0	
Clinical internship in Europe							
Yes (*n* = 38)	12	31.6	25	65.8	1	2.6	0.007
No (*n* = 65)	21	32.3	38	58.5	6	9.2	
Nuclear medicine department in country of practice							
Yes (*n* = 58)	22	37.9	33	56.9	3	5.2	0.263
No (*n* = 45)	11	24.4	30	66.7	4	8.9	

Table 7. *Distribution of cardiologists based the choice of the most irradiating examination according to professional experience, clinical internship in Europe and the existence of a nuclear medicine department in their country of practice.*

	Pulmonary scintigraphy		CT pulmonary angiography		
	Number	%	Number	%	*p*
Professional experience in cardiology					
Less than 5 years (*n* = 57)	15	26.3	42	73.7	2.361
5-10 years (*n* = 33)	9	27.3	24	72.7	
More than 10 years (*n* = 13)	5	38.5	8	61.5	
Clinical internship in Europe					
Yes (*n* = 38)	12	31.6	26	68.4	0.265
No (*n* = 65)	17	26.2	48	73.8	
Nuclear medicine department in country of practice					
Yes (*n* = 58)	18	31.0	40	69.0	0.182
No (*n* = 45)	11	24.4	34	75.6	

countries of French-speaking sub-Saharan Africa, is representative of French-speaking sub-Saharan African cardiologists since it includes the majority of these countries with French as the only official language.

Table 8. *Ability to recognize typical pulmonary embolism images on scintigraphic imaging by cardiologists according to professional experience, clinical internship in Europe and the existence of a nuclear medicine department in the cardiologists' country of practice.*

	Able		Not able		
	Number	%	Number	%	*p*
Professional experience in cardiology					0.338
Less than 5 years (*n* = 57)	24	42.1	33	57.9	
5-10 years (*n* = 33)	13	39.4	20	60.6	
More than 10 years (*n* = 13)	8	61.5	5	38.5	
Clinical internship in Europe					0.389
Yes (*n* = 38)	17	44.7	21	55.3	
No (*n* = 65)	28	43.1	37	56.9	
Nuclear medicine department in country of practice					<0.001
Yes (*n* = 58)	31	53.4	27	46.6	
No (*n* = 45)	14	31.1	31	68.9	

In our study, Senegal was the first country of origin and practice for the cardiologists. This situation can be explained by the fact that Senegal, one of the great countries in Africa, is home to the oldest faculty of medicine in French-speaking West Africa and one of the most developed in French-speaking Africa in terms of specialized medical training. Our work reveals a low frequency of ordering of pulmonary scintigraphy, with a large majority of cardiologists having never ordered it. This situation is somewhat regrettable when we know that PE is a frequent and life-threatening pathology, and that pulmonary scintigraphy plays an important role in its management [2,7,8].

With equal accessibility, the vast majority of cardiologists (86.4%) in our study would choose CT angiography in a suspected case of PE compared to only 11.7% for pulmonary scintigraphy. This result is highly debatable and can be interpreted as the expression of insufficient knowledge of the cardiologists of this study on the importance of pulmonary scintigraphy in the diagnostic strategies of PE [3]. In fact, the diagnosis of PE is not based on a single examination, but on the application of diagnostic strategies or algorithms associating different explorations in a sequential manner [3]. The currently validated strategies either use pulmonary CT angiography, lung planar ventilation-perfusion scintigraphy or pulmonary ventilation-perfusion tomoscintigraphy as cornerstone. Several diagnostic algorithms using scintigraphy as cornerstone have thus been developed [9-11]. The safety of a strategy using planar ventilation-perfusion scintigraphy or better tomoscintigraphy to rule out PE is now clearly established. They may also have the advantage of not over diagnosing PE compared to strategies using CT pulmonary angiography [10,12]. They also have the advantage of not requiring an injection of iodinated contrast agents and therefore of being able to be performed in almost all patients. Pulmonary scintigraphy also shows favorable dosimetry. The effective dose of a pulmonary scintigraphy performed with a radiolabeled macroaggregated albumin corresponds to approximately 30% of the dose received with a pulmonary CT angiography and only 3% of the dose in the mammary gland [13]. These dosimetric considerations mean that scintigraphy is probably more suitable for follow-up, given the frequency of suspected recurrence in a patient having presented a first thromboembolic event [14].

In the presence of chest pain with normal chest X-ray, normal pulmonary scintigraphy rules out a PE at almost 100% [15-17]. The preference of CT pulmonary angiography to pulmonary scintigraphy by the vast majority of cardiologists in our study in managing cases of chest pain in a patient with a normal chest X-ray to rule out PE is therefore regrettable. This reflects their ignorance of the very high negative predictive value of pulmonary scintigraphy to rule out PE in a patient with a normal chest X-ray. Normal chest X-ray increases the specificity of pulmonary scintigraphy as it excludes other diagnoses (pneumonia, pneumothorax, and pulmonary edema) [18] which may be confused with PE on a pulmonary scintigraphy.

PE is common during pregnancy and postpartum and is one of the leading causes of maternal mortality [5,19]. In fact, the risk of thromboembolic disease is four to five times greater during pregnancy, due to the physiological changes occurring during pregnancy [20]. Faced with the poor symptomatology of PE, it is difficult to differentiate between the usual so-called "normal" signs related to pregnancy and signs of PE. As the clinical signs and labs are limiting, the choice of adequate imaging for diagnosis is essential, especially since these examinations are not without any harm for both fetus and mother. Several algorithms were thus proposed on the choice between pulmonary scintigraphy and CT pulmonary angiography. It is a fact that recommendations reported in the literature regarding the imaging technique to be used as first intention between scintigraphy and CT angiography [21] are sometimes controversial. However, it is more judicious to prefer

pulmonary scintigraphy to CT angiography in the diagnosis of PE in pregnant women. Actually, the hyperdynamic state and hemodilution as well as the dilution of the contrast agent by unopacified venous blood from the inferior vena cava [22] in pregnant women, are weak points to CT angiography. The poor opacification of the pulmonary arteries, more frequent in pregnant women, is the cause of inconclusive examinations (estimated between 27.5% and 35.7%) [23,24]. In addition, the use of iodinated contrast agent may cause depression of thyroid function in the fetus [25]; hence, the recommendation to monitor thyroid function in the newborn, during the first week of life, if a CT angiography has been performed during pregnancy [25].

In addition, the weak point of pulmonary scintigraphy in the general population, namely, the high proportion of inconclusive examinations classified with an intermediate probability (26.5%), is lower in pregnant women (19%) [26] probably because of the young age of pregnant patients. In the light of the above, we can say that the attitude of the majority of French-speaking African cardiologists to favor scintigraphy to CT angiography in the exploration of PE in pregnant women is encouraging. In our study, cardiologists who had completed a hospital internship in Europe opted more for a pulmonary scintigraphy in the diagnosis of PE in pregnant women with a statistically significant difference. This result shows that internships in Europe have a positive influence on cardiologists' perception of the important role of stratigraphic imaging in the exploration of PE. Indeed, nuclear medicine is more developed and more accessible in Europe than in African countries.

In addition to its diagnostic performance, pulmonary scintigraphy is less irradiating than CT angiography as we mentioned above and it is comforting to note that 71.8% of the cardiologists in our study knew this. In fact, the CT pulmonary angiography delivers an average dose of 15mSv compared to 1mSv for pulmonary scintigraphy [27]. The low dose of irradiation of the pulmonary scintigraphy compared to the CT angiography is one more reason to order it as first-line in pregnant women in the diagnosis of PE. Authors such as Sellem et al. [20] also recommend this in their study on the diagnosis of PE in 116 pregnant women in Tunisia.

Nuclear medicine is a specialty that is less known and not much accessible in French-speaking sub-Saharan Africa, where many doctors, like in Togo, have never seen performed a scintigraphic examination [28]. Hence it is not much surprising to find that in our study the majority of cardiologists, especially those who had not a nuclear medicine department in their country of practice, were unable to recognize a typical image of PE. It is therefore up to nuclear physicians in French-speaking African countries to educate clinicians on the real diagnostic and prognostic interest of nuclear medicine examinations in the exploration of cardiovascular pathologies such as PE. By doing so, scintigraphic imaging can occupy the essential place which it holds alongside other medical imaging techniques in French-speaking sub-Saharan Africa.

Conclusion

The medical management of PE is based on diagnostic strategies that revolve around medical imaging, among which, scintigraphic imaging occupies an important place. This study enabled us to realize that the place given to pulmonary scintigraphy in the management of PE by cardiologists in French-speaking sub-Saharan Africa is unsatisfactory. Raising awareness among cardiologists in particular and clinicians in general of the real diagnostic and prognostic interest of pulmonary scintigraphy is, therefore, necessary for scintigraphic imaging to occupy the genuine place it deserves alongside other imaging techniques in French-speaking sub-Saharan Africa.

List of Abbreviations

CT	Computed tomography
PE	Pulmonary embolism

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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None.

Consent to participate

The voluntary decision of cardiologists to participate in this study served as informed consent.

Ethical approval

The need for ethics approval was waived by a Bioethics Committee for Health Research of the Health Ministry of our country. The study did not involve the use of animals.

Author details

Kokou Adambounou[1], Amegninou Mawuko Yao Adigo[2], Abalo Mario Bakai[3], Komlan Amoussou[2], Ekoue Edem Fabrice Sodogas[1]

1. Biophysic and Nuclear Medicine Departments, Campus Teaching Hospital, University of Lome, Lome, Togo
2. Radiology Department, Campus Teaching Hospital, University of Lome, Lome, Togo
3. Cardiology Department, Lome Teaching Hospital, University of Lome, Lome, Togo

References

1. Cohen A, Estem. Embolie pulmonaire. In: Cardiologie et pathologies cardiovasculaires. Paris, France: Estem; 1997. pp 775–816.
2. Robert-Ebadi H, Righini M. [Diagnosis of pulmonary embolism]. Rev Mal Respir. 2011;28(6):790–9. https://doi.org/10.1016/j.rmr.2010.10.039
3. Le Roux PY, Rousset J, Le Gal G, Salaun PY. Diagnostic strategies for suspected acute pulmonary embolism: current status and future perspectives of pulmonary ventilation-perfusion scintigraphy. Med Nucl. 2014;38:275–82.
4. Société Française de Médecine Nucléaire et d'imagerie moléculaire (SFMN). Livre Blanc de la médecine nucléaire.

Méd Nucl. 2012;36:700–16. https://doi.org/10.1016/j.mednuc.2012.10.002
5. Wagner HN, Sabiston DC, McAfee JG, Tow D, Stern HS. Diagnosis of massive pulmonary embolism in man by radioisotope scanning. N Engl J Med. 1964;271:377–84. https://doi.org/10.1056/NEJM196408202710801
6. Adigo AMY, Adjenou KV, Sonhaye L, Adambounou K, Agoda-Kousséma LK, Djagnikpo O, et al. Comment faisons-nous le diagnostic en imagerie de l'embolie pulmonaire (EP) à Lomé? Rev. Cames Sante. 2014;2(2):52–6.
7. Goldhaber SZ. Pulmonary embolism. Lancet. 2004;363 (9417):1295–305. https://doi.org/10.1016/S0140-6736 (04)16004-2
8. Heit JA, Silverstein MD, Mohr DN, Petterson TM, Lohse CM, O'Fallon WM, et al. The epidemiology of venous thromboembolism in the community. Thromb Haemost. 2001;86(1):452–63. https://doi.org/10.1055/s-0037-1616243
9. Wells PS, DR Anderson, M Rodger, Stiell I, Dreyer JF, Barnes D, et al. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. Ann Intern Med. 2001;135:98–107. https://doi.org/10.7326/0003-4819-135-2-200107170-00010
10. Anderson DR, Kahn SR, Rodger MA, Kovacs MJ, Morris T, Hirsch A, et al. Computed tomographic pulmonary angiography vs ventilation-perfusion lung scanning in patients with suspected pulmonary embolism: a randomized controlled trial. JAMA. 2007;298:2743–53. https://doi.org/10.1001/jama.298.23.2743
11. Salaun PY, Couturaud F, Le Duc-Pennec A, Lacut K, Le Roux PY, Guillo P, et al. Noninvasive diagnosis of pulmonary embolism. Chest. 2011;139:1294–8. https://doi.org/10.1378/chest.10-1209
12. Anderson DR, Kahn SR, Rodger MA, Kovacs MJ, Morris T, Hirsch A, et al. Computed tomographic pulmonary angiography vs ventilation-perfusion lung scanning in patients with suspected pulmonary embolism: a randomized controlled trial. JAMA. 2007;298:2743–53. https://doi.org/10.1001/jama.298.23.2743
13. Bajc M, Neilly JB, Miniati M, Schuemichen C, Meignan M, Jonson B. EANM guidelines for ventilation/perfusion scintigraphy: Part 2. Algorithms and clinical considerations for diagnosis of pulmonary emboli with V/P (SPECT) and MDCT. Eur J Nucl Med Mol Imaging. 2009;36:1528–38. https://doi.org/10.1007/s00259-009-1169-y
14. Le Gal G, Kovacs MJ, Carrier M, Do K, Kahn SR, Wells PS, et al. Validation of a diagnostic approach to exclude recurrent venous thromboembolism. J Thromb Haemost. 2009;7:752–9. https://doi.org/10.1111/j.1538-7836.2009.03324.x
15. Sostman HD, Stein PD, Gottschalk A, Matta F, Hull R, Goodman L. Acute pulmonary embolism: sensitivity and specificity of ventilation-perfusion scintigraphy in PIOPED II study. Radiology. 2008;246:941–6. https://doi.org/10.1148/radiol.2463070270
16. Kruip MJ, Leclercq MG, van der Heul C, Prins MH, Büller HR. Diagnostic strategies for excluding pulmonary embolism in clinical outcome studies. A systematic review. Ann Intern Med. 2003;138:941–51. https://doi.org/10.7326/0003-4819-138-12-200306170-00005
17. Ten Wolde M, Hagen PJ, Macgillavry MR, Pollen IJ, Mairuhu ATA, Koopman MMW, et al. Non-invasive diagnostic work-up of patients with clinically suspected pulmonary embolism; results of a management study. J Thromb Haemost. 2004;2:1110–7. https://doi.org/10.1111/j.1538-7836.2004.00769.x
18. Perrier A, Desmarais S, Miron MJ, de Moerloose P, Lepage R, Slosman D, et al. Non-invasive diagnosis of venous thromboembolism in outpatients. Lancet. 1999; 353(9148):190–5. https://doi.org/10.1016/S0140-6736 (98)05248-9
19. Bourjeily G, Paidas M, Khalil H, Rosene-Montella K, Rodger M. Pulmonary embolism in pregnancy. Lancet. 2010;375:500–12. https://doi.org/10.1016/S0140-6736(09)60996-X
20. Sellem A, Elajmi W, Mahjoub Y, Hammami H. Diagnostic de l'embolie pulmonaire chez la femme enceinte: apport de la scintigraphie. Étude rétrospective à propos de 116 cas. Méd Nucl. 2013;37:432–8. https://doi.org/10.1016/j.mednuc.2013.09.030
21. Shahir K, Goodman LR, Tali A, Thorsen KM, Hellman RS. Pulmonary embolism in pregnancy: CT pulmonary angiography versus perfusion scanning. AJR Am J Roentgenol. 2010;195:214–20. https://doi.org/10.2214/AJR.09.3506
22. Schaefer-Prokop C, Prokop M. CTPA for the diagnosis of acute pulmonary embolism during pregnancy. Eur Radiol. 2008;18:2705–8. https://doi.org/10.1007/s00330-008-1158-8
23. U-King-Im JM, Freeman SJ, Boylan T, Cheow HK. Quality of CT pulmonary angiography for suspected pulmonary embolus in pregnancy. Eur Radiol. 2008;18:2709–15. https://doi.org/10.1007/s00330-008-1100-0
24. Ridge CA, McDermott S, Freyne BJ, Brennan DJ, Collins CD, Skehan SJ. Pulmonary embolism in pregnancy: comparison of pulmonary CT angiography and lung scintigraphy. AJR Am J Roentgenol. 2009;193:1223–7. https://doi.org/10.2214/AJR.09.2360
25. Webb JA, Thomsen HS, Morcos SK, Members of contrast media safety committee of European Society of Urogenital Radiology (ESUR). The use of iodinated an gadolinium contrast media during pregnancy and lactation. Eur Radiol. 2005;15:1234–40. https://doi.org/10.1007/s00330-004-2583-y
26. Chan WS, Ray JG, Murray S, Coady GE, Coates G, Ginsberg JS. Suspected pulmonary embolism in pregnancy: clinical presentation, results of lung scanning, and subsequent maternal an pediatric outcomes. Arch Intern Med. 2002;162:1170–5. https://doi.org/10.1001/archinte.162.10.1170
27. de Broucker T, Pontana F, Santangelo T, Faivre JB, Tacelli N, Delannoy-Deken et al. Single- and dual-source chest CT protocols: levels of radiation dose in routine clinical practice. Diagn Interv Imaging. 2012;93:852–8. https://doi.org/10.1016/j.diii.2012.07.009
28. Adambounou K, Adjenou KV, Achy OB, Mossi KE, Gbande P, Adigo AMY, et al. Connaissances et perception de la médecine nucléaire par les médecins togolais. Med Nucl. 2015;39:15–20. https://doi.org/10.1016/j.mednuc.2014.10.003