ARTICLE TITLE: Aortic calcification and aneurysm in Moscow Lung Cancer Screening.

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THESIS:
Objective: assess the prevalence of thoracic aortic calcification and aneurysm in patients in lung cancer screening.
Materials and methods: the retrospective study included randomly selected results of ultra-low-dose computed tomography of 254 patients.
Results: quantitative analysis of aortic calcination by Agatston, Volume, Mass index, as well as qualitative and quantitative analysis of aortic aneurysm occurrence in lung cancer screening was performed.
Conclusion: it is necessary to pay attention to the presence of thoracic aorta calcification and aneurysm in lung cancer screening, as these changes are closely associated with a high risk of cardiovascular diseases leading to death.

KEYWORDS: Aortic calcification, Aortic aneurysm, Ultra-low-dose computed tomography.

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Aortic calcification in Moscow Lung Cancer Screening.

Introduction

Incidental findings are often detected by low-dose computed tomography (LDCT), which is used in lung cancer screening. For example, the National Lung Cancer Screening Trial (NLST) shows a 20% reduction in lung cancer mortality and an overall 6.7% reduction in mortality [1]. LDCT iis an informative method of imaging of the chest, which has an important advantage as low doses compared to standard protocols of computed tomography. In 2017, the project "Moscow lung cancer screening" was launched in Moscow through the use of ultra-low-dose computed tomography (ultra-LDCT), aimed at selective screening of lung cancer in the outpatient link [2]. The project was organized by the Research and Practical Clinical Center of Diagnostics and Telemedicine Technologies, Department of Health Care of Moscow, Russia.

In the protocols of the project "Moscow lung cancer screening" the permissible dose of radiation should be less than 1 mSv (Figure 1), while the image quality allows to evaluate the findings at a reliable level, which is important in the assessment of additional pathological changes.

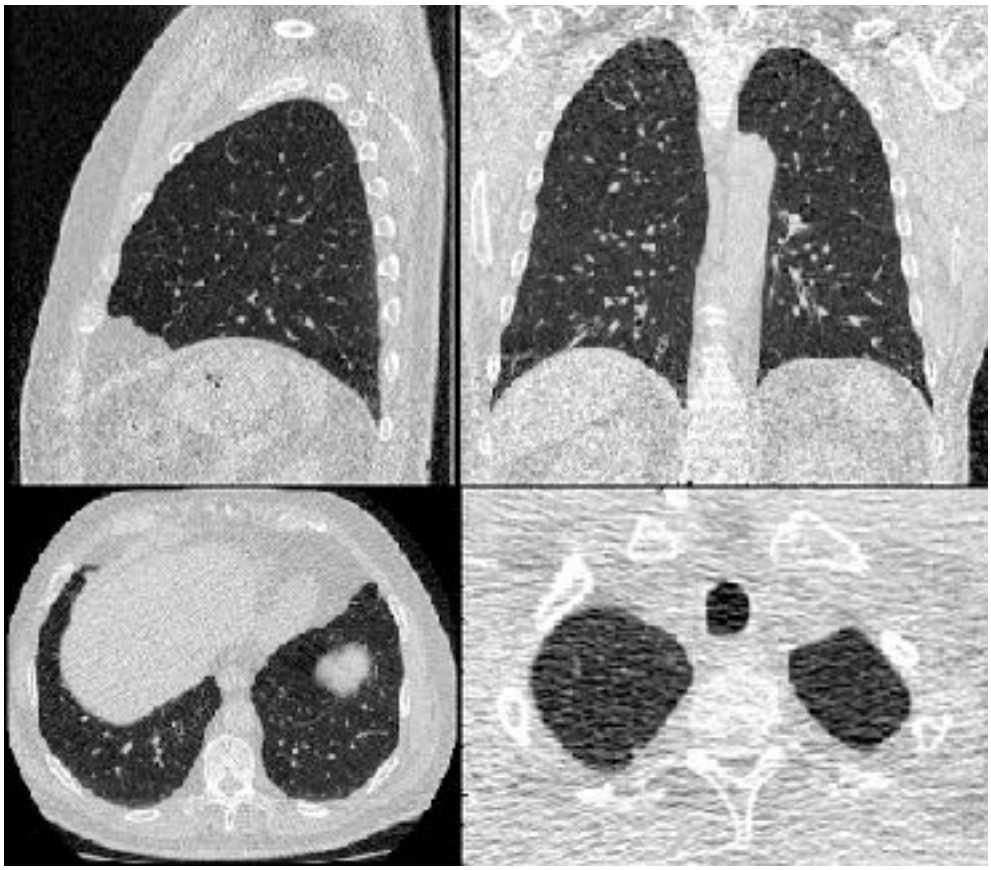


Figure 1. On these images demonstrate quality of LDCT for Moscow lung cancer screening. Please note on the quality in the upper and lower segments of the both lungs.

Ultra-LDCT images are suitable for recognition of obvious and potentially significant incidental findings. In lung cancer screening, early detection of accidental findings can reduce mortality in patients aged 55-75 years [3,4]. Ultra-LDCT screening promotes recognition of significant incidental findings, in particular, early detection of signs of chronic obstructive pulmonary disease and diseases of the cardiovascular system in the smoking population [5]. Established indicator of cardiovascular disease is coronary artery calcification, which is clearly correlated with an increase in the patient's age and the presence of Smoking in the history [6]. In NLST studies, 50% of deaths are associated with cardiovascular disease, as confirmed by observations in other cohorts [7].
Thoracic aorta calcification is associated with risk factors of atherosclerosis, although the pathogenesis and clinical manifestations remain not fully understood.
The native computer tomography (CT) distinguish the following patterns of aorta calcification (Figure 2): circumferential calcification in patients with post-radiation changes of the cardiovascular system, more confluent calcination in patients with inflammation of the walls of history and patchy calcification, which is typical of atherosclerosis [8].

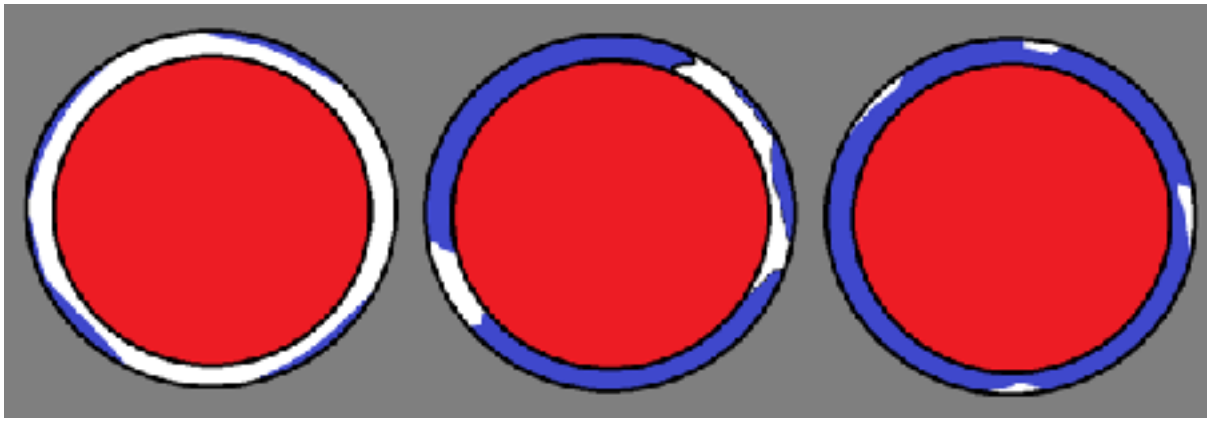


Figure 2. Patterns of aortic wall calcification. On noncontrast-enhanced computed tomography (CT) scans is possible to visualize these patterns of calcification: (right) circumferential calcification in a patient with radiation-associated cardiovascular disease, (middle) more confluent calcification in a patient with a remote history of aortitis and (left) patchy calcification typical of atherosclerosis.

In a single-center clinical study, which involved 970 patients who applied to the cardiology Department, presented the distribution of the thoracic aorta calcification by segments. Calcifications were most often visualized in the aortic arch and proximal part of the descending aorta, which are not usually included in the scanning field during coronary calcium screening. The data are presented in the study of Cream and co-authors [9], and the results are presented below in figure 3.

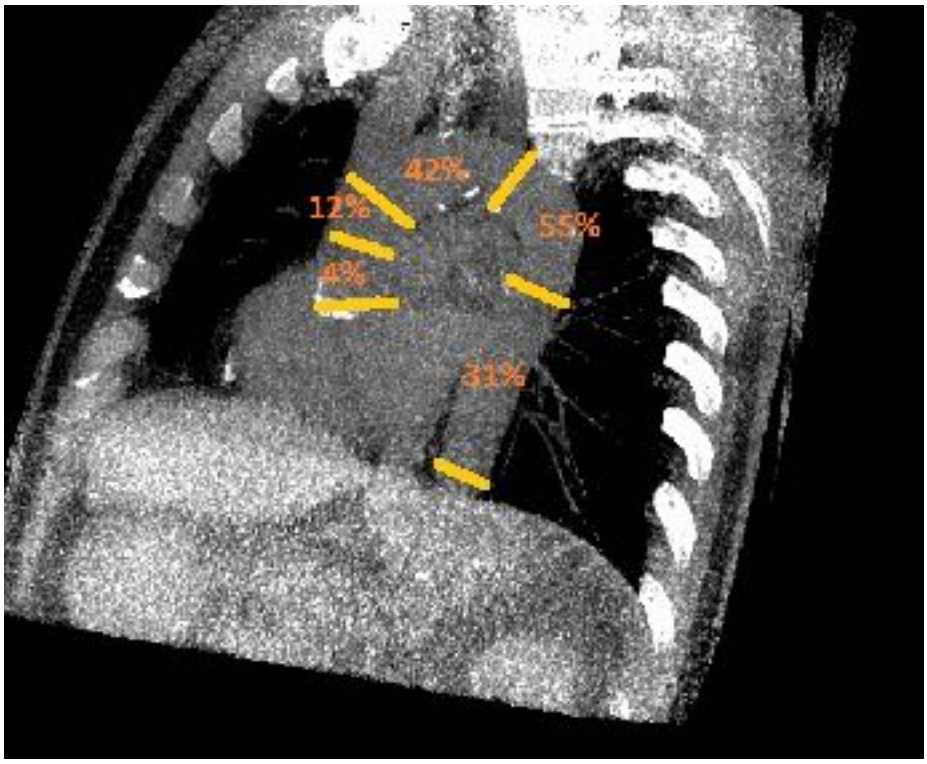


Figure 3. Distribution of thoracic aortic calcification.
In a single-center study of 970 patients referred to a cardiovascular prevention unit, percentages of patients with calcifications at different segments of the thoracic aorta are shown. Calcifications were most commonly visualized in the aortic arch and proximal descending aorta, which are segments not typically included in a CAC scan. Reproduced from data in Craiem et al. [50]

The aim of the study was to assess the prevalence of thoracic aortic calcification and aneurysm in patients of lung cancer screening.

Materials and Methods.

During the primary (baseline) screening round 5,310 ultra-LDCT were conducted in 10 medical organizations providing primary health care to the adult population of Moscow. The studies were carried out on the Toshiba Aquilion 64 computed tomographic scanner using specially developed ultra-low-dose protocols for different patient weight categories with radiation dose up to 1 mSv. 4,762 (89.7% from 5,310 studies,) were performed in individuals who met the criteria for inclusion in the risk group for lung cancer. A certain part of these patients was referred to oncologist, phthisiologist, therapist [10].
In the first part of the study, implying a qualitative assessment of aortic changes, included 254 (4.78%) ultra-LDCT, which were selected using a generator of random number. At the same time, the results of patients who were routed for additional examinations and consultations on the results of ultra-LDCT were not considered. The selected group included

the results of ultra-LDCT 142 (56.0%) men and 112 (44.0%) women; the average age was 61 years. The exact age distribution of the surveyed: 55-59 years – 25.2% (64), 60-64 years – 25.2% (64), 65-69 years – 24.8% (63), 70-74 years – 24.8% (63).
In the second part of the study, implying a quantitative assessment of aortic calcification, included 25 (0.471%) ultra-LDCT, which were selected using a random number generator. At the same time, the results of patients who were routed for additional examinations and consultations on the results of ultra-LDCT were not considered. The selected group included the results of ultra-LDCT of 10 (40.0%) men and 15 (60.0%) women in the age group of 70-74 years.
A retrospective review of the results (images and reports of chest ultra-LDCT performed within the framework of the project "Moscow screening of lung cancer" in 2017) for a preliminary assessment of the prevalence of thoracic aortic calcification was carried out. The review was carried out by two independent experts with more than 7 years of experience in thoracic radiology, followed by a panel discussion.
Medical data has been depersonalized in accordance with applicable personal data protection legislation. The image analysis in DICOM 3.0 standard was carried out using the software "AGFA Agility Enterprise 8.0" and "OsiriX MD (V. 5.5.1 64-bit)". Quantitative data were obtained and analyzed. Quantitative analysis of aortic calcination by The Agatston, Volume, Mass index was carried out using the standard scanning technique during screening using ultra-LDCT with a thickness of slice in 1 mm. Aortic calcification was evaluated semi-automatically, as shown in the image below (Figure 4). The protocols of the description searched for all pathological findings related to the calcification of the thoracic aorta.

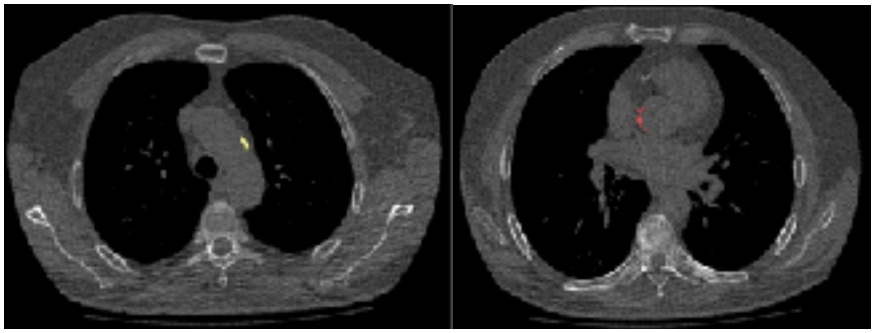
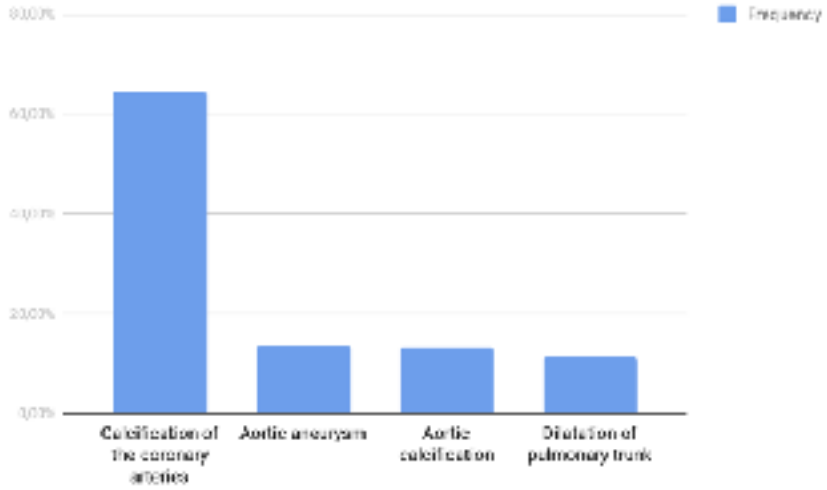


Figure 4.
On these images it demonstrates semiautomatic segmentation of thoracic aorta calcification with Osirix software.

Results.
The localization of incidental findings was as follows: lungs and bronchi – 68.3% (174) of cases, pleura – 2.75% (7), cardiovascular system – 75.4% (192), mediastinum – 2.75% (7), some organs of the abdominal cavity and retroperitoneal space – 4.2% (10), endocrine system organs – 2.7% (7), mammary glands – 0.8% of cases.

A total of 58.4% (148/254) of random findings were not described in the initial reports of ultra-LDCT.

In the primary description of ultra-LDCT, radiologists most often did not indicate changes in the adrenal glands in the reports (in 3 cases, all 100.0% are not indicated), expansion of the pulmonary trunk (19 – 100.0%), expansion of the ascending and descending aorta (159 -82.3%), and the presence of coronary calcium (64 -33.0%).
All incidental findings of the cardiovascular system revealed at 76.4% (169/221) cases. In the primary reports of ultra-LDCT 67,0% (113) were specified, thus any recommendations (for example, consultation of the cardiologist) were not given. The structure of the most frequent incidental findings of the cardiovascular system is shown in figure 1.
In most cases (64,5%; 124/169) incidental finding was calcification of the coronary arteries, but despite this, the aneurysm and calcification of the aorta together comprise almost a quarter (26,7%; 45/169).



Graph №1. The structure of the most frequent random findings of the cardiovascular system in Moscow Lung Cancer Screening.

In the reports of ultra-LDCT, radiologists did not indicate the presence of coronary calcium in 33%, aortic calcification in 25%, ascending and descending aorta dilation in 82.3% of cases, and pulmonary trunk dilation in 100%. Thus, in those opinions, which marked the presence of the above changes of the cardiovascular system, all reports were absent recommendation part. In CT images, coronary calcium was found in 64.5% of cases, ascending and descending aorta dilation in 13.7% and 11.4% of cases, respectively, and pulmonary trunk dilation in 11.4% of cases. The average morphometry of the ascending and descending aorta and pulmonary trunk was 35.3+/-4.5 cm, 26.5+/-3.5 cm, 25.3+/-3.8 cm, respectively (see table 1).
Table 1. Qualitative and quantitative analysis of aortic aneurysm occurrence.

Value	N	Arithmetic mean	% of normal	Average square deviation	Average error	Cs
The diameter of the ascending aorta	254	35,33	85.4%	4,51	2,22	0,063
The diameter of the descending aorta	254	26,51	88.4%	3,50	1,663	0,063

Retrospectively, 25 patients were evaluated for aortic calcification by Agatston, Volume, Mass, the corresponding results are presented in table 2 below.

Table 2. Assessment of aortic calcification by Agatston, Volume, Mass.

	Total calcification of the aorta (Agatston)	Total aortic calcification (Volume)	Total aortic calcification (Mass)
N	25	25	25
Arithmetic mean	7000,40	2277,64	4095,80
Average square deviation	7833,33	2426,15	4717,88
Maximal value	24953	7897	13917
Minimal value	342	107	147

Discussion.

Based on the results of the analysis of the data obtained during the NLST screening program, the clinical significance of coronary artery calcification in lung cancer screening with LDCT was proved [11]. However, as and some other incidental findings [2].

Evaluation of coronary calcium contributes to earlier treatment administration, while most of the examined persons are already candidates for therapy only on the basis of two indicators (age and time of smoking) [11].

One of the frequent findings was an aortic aneurysm (more than 4.1 cm in diameter), rarely indicated in the primary reporting. In such a situation, it is justified to refer patients for re-examination after 6 months due to the circumstances specified below.

Surgical intervention in aortic aneurysm is indicated [12]:

- with a growth rate of more than 0.5 cm per year;
- the initial diameter of the thoracic aorta is more than 5.5 cm (in the initial study);

- the initial diameter of the thoracic aorta is more than 4.4-5.0 cm against the background of systemic connective tissue disease or in the presence of symptoms.

Quantify the calcification of the aorta is not yet developed scale with the recommendation part (by analogy with the conventional scale of Agatston), which is a promising topic for future research. The intensive development of automatic segmentation and artificial intelligence should facilitate the approach to solving this problem, and it will allow to obtain more information about the patient in lung cancer screening.
Early detection of clinically significant changes in the cardiovascular system, such as thoracic aorta aneurysm and calcification, is possible with ultra-LDCT in lung cancer screening, which will help to reduce mortality rates in general population.

Conclusion

Upon detection of changes in the cardiovascular system with ultra-HDCT in lung cancer screening, it is necessary to carefully evaluate these changes of the aorta such as its diameter and the presence of calcification. In the reporting is important to note the presence of the thoracic aorta calcification, as well as be sure to send the patient to the consultation of a cardiologist, because these changes are associated with a high risk of cardiovascular diseases that lead to death.

Disclosures

The authors declare that there is no conflict of interest

References:

1. National Lung Screening Trial Research Team, Aberle DR, Adams AM, et al: Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening. N Engl J Med 365:395-409, 2011

2. Gombolevskiy V.A., Kharlamov K.A., Pyatnitskiy I.A., Kim S.Yu., Morozov S.P. Shablony protokolov opisaniy issledovaniy po spetsialnosti rentgenologiya. Kompyuternaya tomografiya. [Protocol templates for description of X-ray examinations. Computed tomography]. GBUZ Goroda Moskvy Nauchno-Prakticheskiy Tsentr Meditsinskoy Radiologii Departamenta Zdravookhraneniya Goroda Moskvy Publ.

3. National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health: The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General [Internet]. Atlanta (GA): Centers for Disease Control and Prevention (US), 2014. [cited 2017 Aug 24]. (Reports of the Surgeon General). Available from: http://www.ncbi.nlm.nih.gov/books/NBK179276/

4. Final Update Summary: Lung Cancer: Screening - US Preventive Services Task Force [Internet]. [cited 2017 Aug 22]. Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFi nal/lung-cancer-screening.

5. Incidental Findings on Lung Cancer Screening: Significance and Management Emily B. Tsai, MD, Caroline Chiles, MD, Brett W. Carter, MD, Myrna C.B. Godoy, MD, PhD, Girish S. Shroff, MD, Reginald F. Munden, MD, DMD, MBA, Mylene T. Truong, MD, and Carol C. Wu, MD

6. Oei HH, Vliegenthart R, Hofman A, et al. Risk factors for coronary calcification in older subjects. The Rotterdam Coronary Calcification Study. Eur Heart J 2004;25:48–55.

7. Chiles C, Duan F, Gladish GW, et al. Association of coronary artery calcification and mortality in the national lung screening trial: a comparison of three scoring methods. Radiology 2015;276:82–90.

8. JACC Cardiovasc Imaging. 2018 Jul;11(7):1012-1026. doi: 10.1016/j.jcmg.2018.03.023. Thoracic Aortic Calcification: Diagnostic, Prognostic, and Management Considerations. Desai MY1, Cremer PC2, Schoenhagen P3.

9. Craiem D, Chironi G, Casciaro ME, Graf S, Simon A. Calcifications of the thoracic aorta on extended non-contrast-enhanced cardiac CT. PLoS One 2014;9:e109584.

10. Gombolevskiy V.A., Barchuk A.A., Laypan A.Sh., Vetsheva N.N. et al. Organization and efficiency of screening for malignant lung tumors by low-dose computed tomography. Radiologiya. Praktika. 2018, no. 1 (67), pp. 28-36. (In Russ.)

11. Chiles C., Duan F., Gladish G. W. et al. Association of coronary artery calcification and mortality in the National Lung Screening Trial: a comparison of three scoring methods // Radiology. – 2015. – Vol. 276. – P. 82-90.

12. National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health. The Health Consequences of Smoking – 50 Years of Progress: A Report of the Surgeon General. Atlanta (GA), Centers for Disease Control and Prevention (US), 2014. Available from: http://www.ncbi.nlm.nih.gov/books/NBK179276/