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Incidence of pulmonary embolism in a chest hospital in Japan and importance of preoperative perfusion lung imaging in the diagnosis of postoperative pulmonary embolism

Toyoharu ISAWA, Takeo TESHIMA, Yoshiki ANAZAWA, Makoto MIKI and Masakichi MOTOMIYA

Department of Medicine, Research Institute for Chest Diseases and Cancer, Tohoku University

The incidence of pulmonary embolism was retrospectively studied in a University Chest Institute and its affiliated hospital in Sendai, Japan, whose annual numbers of discharged patients from chest medical wards and lung operations as a whole are about 600 and 400, respectively. Before 1975 there was no documented patient with pulmonary embolism. Since then 70 patients had been clinically suspected of having pulmonary embolism and 31 of the 70 were diagnosed as having pulmonary embolism; 15 without and 16 with surgical operations in the immediate past. Fourteen of the 31 patients required combined perfusion and aerosol inhalation lung imaging for diagnosis. Twelve postoperative patients could be diagnosed as pulmonary embolism by comparing postoperative perfusion lung images taken at the time of suspicion with preoperative perfusion counterparts.

Although it is said to be rising, the incidence of pulmonary embolism in a chest hospital still seems to remain low compared with that in western countries. For postoperative patients, comparison with preoperative studies was found very useful in diagnosing postoperative pulmonary embolism. The importance of preoperative perfusion lung imaging cannot be overstressed not only as a preoperative lung function test but as a baseline study to be compared with postoperative perfusion images when pulmonary embolism is clinically suspected in postoperative patients.

Key words: aerosol inhalation lung imaging, perfusion lung imaging, postoperative pulmonary embolism, ventilation-perfusion mismatch

INTRODUCTION

THE INCIDENCE of pulmonary embolism in Japan is extremely low compared with that in western countries.[1,2] The reason is not clear. It is reported that there is no significant difference in the incidence of pulmonary embolism between Japanese living in Hawaii and Caucasian patients,[3] but another report states that pulmonary embolism is less common in Japanese living in Hawaii.[4] Because of its rarity the diagnosis of pulmonary embolism itself could pose a problem in Japan. For diagnosing pulmonary embolism, pulmonary angiography is of course a gold standard,[5] but the procedure itself is not without risk and should be done only by experienced hands. Since Taplin initiated ^{131}I-MAA as an agent for perfusion lung imaging,[6] the usefulness of perfusion lung imaging as a noninvasive screening tool for pulmonary embolism has become well defined and widely accepted[7–9] but has also been criticized because of its nonspecificity.[10]

When pulmonary embolism is clinically suspected, if perfusion lung images show perfusion defects un-

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For reprints correspondence should be addressed to: Toyoharu Isawa, M.D., Department of Medicine, Research Institute for Chest Diseases and Cancer, Tohoku University, 4–1 Seiryoumachi, Aoba-ku, Sendai 980, JAPAN.

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explained by chest radiographs and other clinical and laboratory data, inhalation lung imaging should be performed for perfusion-ventilation mismatch.[11,12]

In our hospital, perfusion is usually done first using Technetium-99m (^{99m}Tc)-MAA, and radioaerosol inhalation lung imaging using ^{99m}Tc-albumin aerosol follows 24 hrs later. When Indium-113m (^{113m}In) aerosol or Krypton-81m (^{81m}Kr) gas is used as an isotope for inhalation,[11,13] inhalation studies can be done immediately after perfusion imaging using ^{99m}Tc-MAA. When aerosol inhalation lung imaging using ^{99m}Tc precedes its perfusion counterpart as in one of our previous studies,[14] perfusion lung imaging using more radioactivity can immediately follow inhalation studies.

In postoperative patients we have noted that comparative evaluation of postoperative perfusion lung images with preoperative counterparts seems nearly diagnostic of pulmonary embolism in patients highly suspicious of pulmonary embolism as reported in the following.

The purpose of this paper is to report our retrospective survey of the incidence and methods used in diagnosing pulmonary embolism in a University Chest Institute in Sendai, Japan and to stress the importance of preoperative perfusion lung imaging in diagnosing pulmonary embolism occurring postoperatively.

MATERIALS AND METHODS

Hospital discharge records of the Hospital of the Research Institute for Chest Diseases and Cancer, Tohoku University (accommodations 100 including Chest Medicine, 40 and Surgery, 30) and Sendai Kohsei Hospital (accommodations 400 including Chest Medicine, 200 and Surgery, 120) that is affiliated to the Research Institute were reviewed from 1941 through the end of August, 1990, and records of perfusion and inhalation lung imaging were surveyed from 1965 through mid-August, 1990.

When a patient was clinically suspected of having pulmonary embolism, he or she underwent perfusion lung imaging with 2–3 mCi (74–111 MBq) of ^{99m}Tc-MAA. Four views, anterior, posterior and right and left laterals were taken. Before 1969 ^{131}I-MAA was an agent for perfusion lung scanning but since 1970 ^{99m}Tc-MAA has been exclusively used.

Perfusion lung images were critically evaluated in conjunction with chest radiographs and clinical and laboratory data including lung function test, electrocardiograms and blood gas analysis. We dismissed the suspicion of pulmonary embolism, if perfusion defects were located in the areas of consolidation, tumor or pleural effusions, if perfusion abnormalities were not localized in lobes or segments but inhomogeneous in distribution, or if other diagnoses such as pneumonia, malignancy, pleural effusions of known causes or obstructive airways disease were more likely or more compatible than pulmonary embolism.

When perfusion abnormalities were compatible with pulmonary embolism, we performed aerosol inhalation lung imaging using ^{99m}Tc-albumin aerosol (activity median aerodynamic diameter (AMAD)= 1.92 micron meter with its geometric standard deviation (σ g)=1.7.[15] Aerosol inhalation was made with tidal breathing with the subject in the same position in which ^{99m}Tc-MAA was injected. When there was a mismatch between perfusion and inhalation lung images,[11,12,16,17] a tentative diagnosis of pulmonary embolism was made. Our criteria were based on mainly to high probability or intermediate probability at most according to Biello and others[16] and PIOPED studies.[17]

In postoperative patients, because all patients had perfusion lung imaging as a preoperative evaluation, postoperative or postprocedural perfusion lung images were compared with preoperative counterparts. If postoperative patients (who were clinically suspected of having pulmonary embolism) showed perfusion defects that were not present preoperatively after excluding the possibility of mucus plugging, atelectasis or pneumonia, a tentative diagnosis of pulmonary embolism was made and was confirmed by pulmonary angiography in selected patients.

RESULTS

1) Patients without Surgery

The number of discharged patients from the chest medicine wards versus the number of patients diagnosed as pulmonary embolism is shown in Table 1.

Table 1 Number of discharge and chest surgery versus pulmonary embolism

YEAR	DISCHARGE	PULM EMB	OPERATION	PULM EMB
1946–1974	16104	0	8714	0
1975	608	1	365	0
1976	599	2	391	0
1977	588	0	349	0
1978	584	0	353	0
1979	566	0	358	0
1980	704	4	374	0
1981	584	1	368	1
1982	618	0	406	0
1983	641	0	386	2
1984	652	0	403	1
1985	662	0	375	0
1986	638	1	399	0
1987	709	2	366	2
1988	679	3	253	5
1989	681	1	393	3
1990	410	0	243	2
TOTAL	26027	15	14496	16

PULM EMB: Pulmonary embolism

We could find absolutely no record of documented pulmonary embolism before 1975.

As shown in Fig. 1, there were 40 patients who were clinically suspected for having pulmonary embolism. They were evaluated by perfusion lung imaging. Pulmonary embolism was diagnosed in 3 because of multiple lobar or segmental perfusion defects without corresponding chest radiographic abnormalities, and it was unlikely in 17 patients. The remaining 20 patients plus 1 of the 3 compatible patients were studied by combined inhalation lung imaging. Thirteen of the 21 showed mismatching between perfusion and inhalation lung images (high probability in 12 and intermediate probability in 1), confirming the clinical suspicion of pulmonary embolism (Fig. 2). A diagnosis of pulmonary embolism was dismissed in the other 8. Thus 15 of the 40 patients were diagnosed as having pulmonary embolism. Eleven patients were from medical wards and 4 from surgical wards. All of the 11 patients from the medical wards were suspected of pulmonary embolism when they first came to the outpatient clinic and there were none who developed pulmonary embolism during hospitalization. Of the 4 patients from the surgical wards, 1 patient with thyroid carcinoma developed pulmonary embolism when he was being evaluated for distant metastases, 1 patient with bronchogenic carcinoma developed pulmonary embolism 1 year after placement of a Greenfield filter

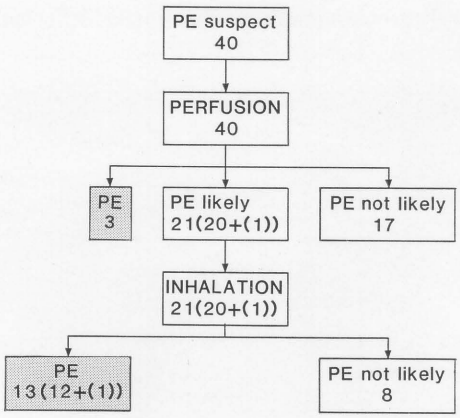

Fig. 1 What has been done in medical patients who are clinically suspected of pulmonary embolism. The number indicates the number of patients studied. (1) indicates one of the 3 patients who were diagnosed as pulmonary embolism simply from perfusion lung imaging. PE stands for pulmonary embolism, PERFUSION, for perfusion lung imaging, and INHALATION, for radioaerosol inhalation lung imaging.

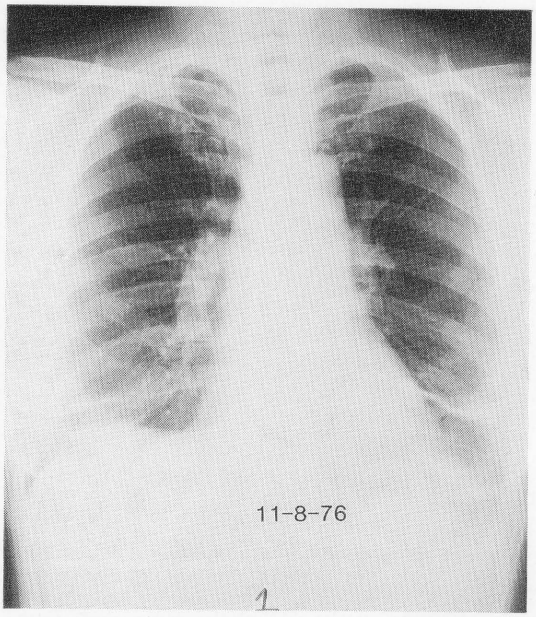

Fig. 2-1 Chest radiograph of a 53 year old female complaining of dyspnea and hemoptysis. Note bilateral basal discoid atelectasis.

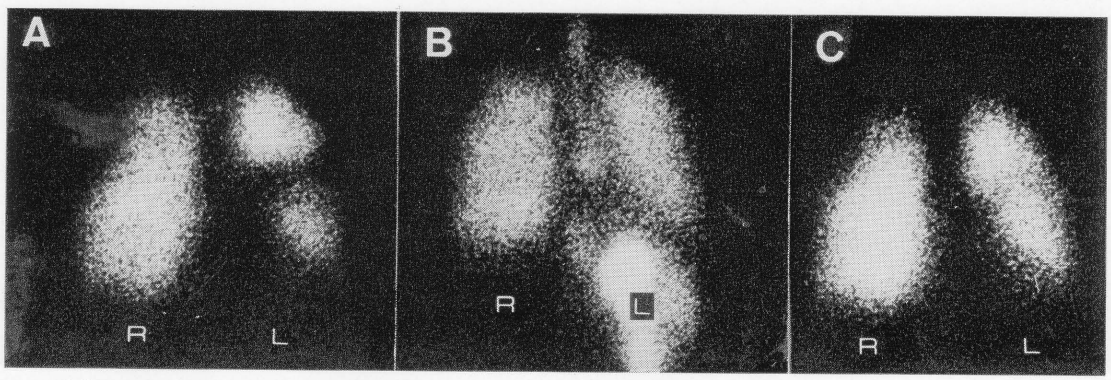

Fig. 2-2 A: Perfusion lung image (anterior) on admission indicating bilateral perfusion defects. Pulmonary embolism was suspected and anticoagulation therapy was started. B: Aerosol inhalation lung image (anterior) on the following day confirmed the diagnosis. Much radioactivity was swallowed into the stomach but still a ventilation-perfusion mismatch was evident. Anticoagulation therapy was continued. C: Perfusion lung image (anterior) 5 weeks later, revealing fairly good recovery of perfusion in the right and left lungs. R: Right, L: Left

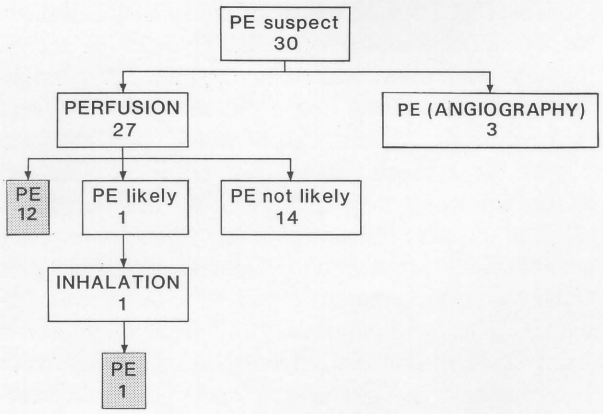

Fig. 3 What has been done in postoperative patients who are clinically suspected of pulmonary embolism. The number indicates the number of patients studied. PE stands for pulmonary embolism, PERFUSION, for perfusion lung imaging, and INHALATION, for radioaerosol inhalation lung imaging.

for venous thrombosis, 1 developed pulmonary embolism while a surgical intervention was being contemplated for venous thrombosis, and the remaining 1 had recurrent femoral thrombophlebitis for the previous 10 months.

2) Postoperative Patients

As shown in Fig. 3, there were 30 patients who were suspected of having pulmonary embolism following surgical operations or procedures in the immediate past. In 14 of them pulmonary embolism was thought to be unlikely on the basis of a comparison of postoperative perfusion lung images at the time of suspicion with preoperative counterparts. Thirteen patients were interpreted as compatible with pulmonary embolism (Fig. 4). One of the 13 required combined inhalation lung imaging to evaluate regional perfusion and ventilation mismatch. The

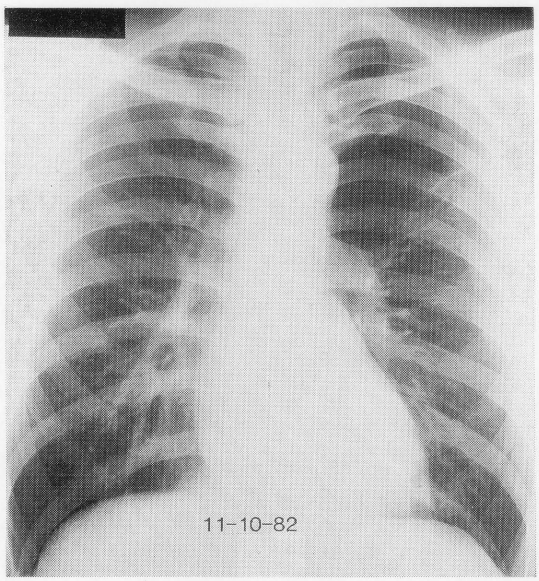

Fig. 4-1 Preoperative chest radiograph (11-10-82). Note bilateral apical bullae.

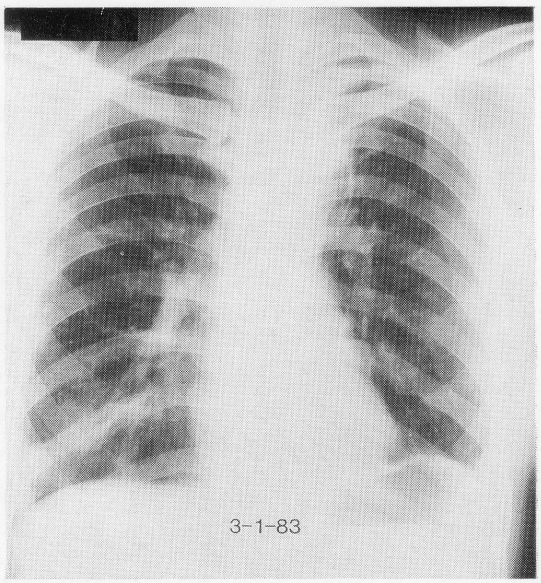

Fig. 4-2 Postoperative chest radiograph (3-1-83).

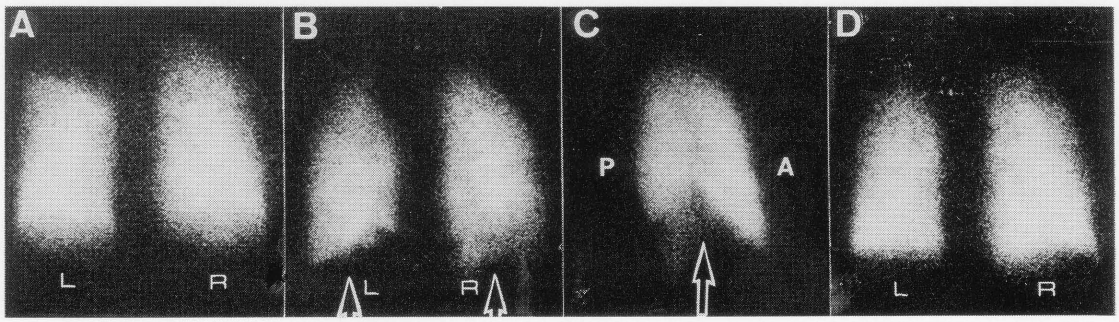

Fig. 4-3 A: Preoperative perfusion lung image (posterior) of a 35 year old male with giant bullae in the left lung apex. B and C: Perfusion lung images, posterior and right lateral, respectively, 10 days after bullectomy when the patient began to complain of dyspnea. Perfusion defects were in the bilateral bases (arrows). Anticoagulation therapy was started. D: Perfusion lung image (posterior) 2 weeks after treatment, indicating nearly complete perfusion recovery. R: Right, L: Left, A: Anterior, P: posterior.

remaining 3 underwent only pulmonary angiography to diagnose pulmonary embolism.

Table 1 shows the yearly number of major lung operations and the number of patients who developed postoperative pulmonary embolism. Ten of the 16 patients developed it within 4 days, 4 within 10 days and 2 within 3 weeks postoperatively or postprocedurally. Surgical operations and procedures included lobectomy in 7 (right upper lobectomy in 2, right lower lobectomy in 2, and left upper lobectomy in 3), pneumonectomy in 1, exploratory thoracotomy in 1, unilateral pulmonary artery occlusion (UPAO) test to determine surgical feasibility in 2, removal of the drainage tube for pleural effusion in 1, and pulmonary angiography (PAG) in 1, all having bronchogenic carcinoma, right lower lobectomy for aspergillosis in 1, bullectomy for giant bullae in 1 and extirpation of mediastinal neurofibroma in 1. The patients with UPAO, PAG and drainage tube withdrawal were not postoperative in the strict sense of the word but were included here because the procedures involved minor surgery and because they were all candidates for lung surgery, having preoperative lung perfusion images to be compared with.

In all the 16 patients pulmonary embolism occurred in the contralateral lung. Six of the 13 whose postoperative perfusion lung imaging was performed showed evidence of possible pulmonary embolism also in the ipsilateral lung.

Ten of the 13 patients underwent pulmonary angiography and the scan diagnosis of pulmonary embolism was confirmed.

The 31 patients, 16 with and 15 without surgery in the immediate past, respectively, were followed up with perfusion lung imaging at least once a week for the first several weeks and then at longer intervals until perfusion recovery was confirmed. By demonstrating the recovery of perfusion we could be further confident of our diagnosis of pulmonary embolism.

3) Symptoms and Signs

The initial symptoms and signs of the 31 patients diagnosed as pulmonary embolism were dyspnea in 23 (74.2%), chest pain in 13 (41.9%), hypotension and arrhythmia or tachycardia in 4 (12.9%), respectively, hemoptysis and loss of consciousness in 2 (6.5%), respectively and one case each of hyperventilation, diaphoresis, leg swelling and dizziness (3.2%). These symptoms and signs initially caused the attending physicians and surgeons to suspect of pulmonary embolism.

DISCUSSION

The incidence of pulmonary embolism in our hospital was very low as shown in Table 1, supporting its low incidence in Japan in general as reported by other authors.[1,2] The number of patients clinically suspected of having pulmonary embolism, 70 in total, was also very small as compared to the number of patients we treat and operate on in our hospital as shown in Table 1 as well as the number of perfusion lung imagings performed; the number had already reached 10,000 by mid-August, 1990 since 1965. The first documented case of pulmonary embolism in our hospital was encountered in 1975. He was a 69 year old man who was referred for increasing dyspnea and chest pain. Perfusion lung imaging on admission revealed multiple perfusion defects compatible with pulmonary embolism with the so-called S1Q3T3 pattern on the electrocardiogram.[18] He died in 3 hours and autopsy confirmed pulmonary embolism. Since then only 31 patients including this case have been diagnosed as pulmonary embolism. This number is extremely low compared with that in the western countries.[1] The reason why pulmonary embolism is so infrequent in Japan remains to be elucidated.

In our present study 21 patients without prior surgical procedures were performed combined inhalation lung imaging to see evidence of ventilation-perfusion mismatch, and 13 of the 20 who showed either high probability or intermediate probability[16,17] were diagnosed as pulmonary embolism, 12 as high probability and 1 as intermediate probability. The latter one was included here as pulmonary embolism because the patient showed a steady recovery in perfusion abnormalities with anticoagulant therapy.

One of the postoperative patients required combined inhalation lung imaging, but in the majority of postoperative patients we could diagnose pulmonary embolism without it by comparing postoperative perfusion lung images with preoperative ones. Despite the statement that generally aerosol inhalation lung imaging is an easy procedure, actual application of the procedure to immediately postoperative patients is not easy because of patients' postoperative pain and dyspnea. In this sense preoperative perfusion lung images as a "control" study seem very helpful. As far as diagnostic sensitivity is concerned, 10 of the 13 patients who were diagnosed as pulmonary embolism underwent pulmonary angiography and all of the 10 were confirmed as having pulmonary embolism by it. Thus diagnostic sensitivity could be calculated as 100%.

We have performed perfusion lung imaging on all candidates for lung surgery since 1971 as one of the essential preoperative examinations. This practice has turned out to be useful as a control study for diagnosing postoperative pulmonary embolism. The

primary reason why we perform preoperative perfusion lung imaging is to learn not only the perfusion ratios of the right and left lungs as a substitute for differential bronchospirometry[19] but also regional perfusion distribution itself, because the correlation between the oxygen uptake ratios of the right and left lungs measured by bronchospirometry using Carlens catheter and the perfusion ratios of the respective lungs measured by perfusion lung scans was found to be excellent[20,21] and we often find unexpected regional perfusion abnormality.

Interestingly the contralateral lung was generally affected by pulmonary embolism following surgical procedures. This characteristic has made it easier to recognize newly developed postoperative perfusion defects by comparison with the preoperative perfusion images, because the postoperative perfusion distribution in the contralateral lung should remain similar to the postoperative counterpart unless something new occurs. Blood clots seem to be carried more easily to the contralateral lung. The reason is not clear but vascular resistance could be less in the contralateral lung than in the operated lung. Two patients who underwent UPAO test developed bilateral pulmonary embolism.

One important fact that should be borne in mind in interpreting postoperative perfusion lung imaging is that regional perfusion could be decreased or absent if regional ventilation is disturbed.[22,23] In fact postoperatively regional ventilation can often be adversely affected by mucous accumulation in the airways.[14] Any mucous deposits on the airways are imaged as "hot spots" by aerosol inhalation lung imaging and these "hot spots" mostly occurred in the operated lung.[14] Postoperative perfusion defects compatible with pulmonary embolism, however, tend to occur in the contralateral lung as found in the present study. We think that this characteristic of contralateral occurrence of pulmonary embolism in postoperative patients has virtually obviated the need for combined inhalation lung imaging following lung surgery. This statement, however, requires further investigation and confirmation.

We are aware of the criticism that inhalation lung imaging 24 hrs after perfusion imaging is too late. Ideally both perfusion and inhalation or ventilation studies should be done simultaneously. But for technical reasons related to the use of the same isotope ^{99m}Tc as a tracer for both perfusion and inhalation lung imaging and because perfusion lung imaging is usually done first preceding inhalation studies, simultaneous examination is not possible, although it is ideal. Because of the low incidence of pulmonary embolism, inhalation lung imaging preceding the perfusion counterpart would not be practical, either. Although we know that the perfusion distribution in pulmonary embolism could vary in a short period,[24] we are of the opinion that inhalation lung imaging 24 hrs after perfusion imaging is still informative, when pulmonary embolism is suspected.

The importance of preoperative perfusion lung scans has been stressed in high risk patients who are going to undergo surgery for implantation of total hip or total knee prostheses.[25,26] Our data also show the importance of preoperative perfusion lung images in patients with lung surgery or lung related surgical procedures. A similar risk of developing pulmonary embolism should also be expected in postoperative patients who were operated on other organs.

In Japan, where the incidence of pulmonary embolism is low,[1,2] pulmonary embolism itself may not be suspected by the physicians. We are afraid that we ourselves might be overlooking patients with pulmonary embolism because the diagnosis of pulmonary embolism has been limited to those patients whose scan findings were generally equivalent to high probability or at most intermediate probability.[16,17] Those patients with low probability or asymptomatic patients could well elude our diagnostic acuity. Pulmonary embolism itself, however, must indeed occur infrequently in Japan.[1,2] As shown in Table 1, the number of patients diagnosed as having pulmonary embolism has been increased in our hospital since 1975, coinciding with the increase as indicated in autopsy reports.[1,2] One possible reason for the increasing incidence could be changes in the patients' population we are dealing with. Fifty years ago our hospital started as s tuberculosis hospital, and before 1970 more than 80 per cent of the patients were actually tuberculous patients, and less than 10% of them those with a malignancy. The situation at present is completely reversed; more than 70% are those with malignant diseases and less than 5 percent with tuberculosis. Some patients indeed develop thrombophlebitis during an intravenous infusion therapy through indwelling catheters, but none has culminated in pulmonary embolism in our hospital. This is also different from western countries where thrombophlebitis due to intravenous tubing is very frequent. Another factor would be a more westernized way of life including food habit.

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