pulmonary emphysema using chest CT have been reported.[18,19] The LAA derived from the chest CT scan is correlated with macroscopic and microscopic emphysematous changes in the lungs.[20,21] The severity of emphysema scored subjectively by Goddard was also correlated with the grade of COPD.[12] However, the presence of abnormal findings on chest CT or chest X-ray was not discussed previously as a risk factor in Stage 0 subjects for COPD to keep GOLD guidelines simple to use all over the world. In the present study, some subjects without abnormal spirometry results had evidence of emphysematous changes on chest CT. As demonstrated in the present study, many subjects with emphysematous changes were current smokers or ex-smokers. The proportion of the Stage 0 subjects with a positive visual score was significantly higher than that in normal subjects. In the normal subjects, the proportion of positive visual scores for the normal smoker was significantly higher that that of the normal nonsmoker subjects. In the smoking Stage 0 group, the proportion of positive visual score was significantly higher than that in the nonsmoking Stage 0 group. In this study, cigarette smoking is one of the important factors contributing to the decrease in pulmonary function. Therefore, smoking Stage 0 subjects with emphysematous change show apparent clinical differences as compared with normal subjects. Individuals identified by the combination of smoking history, airflow limitation and emphysematous changes on chest CT findings should be regarded as a different subgroup of Stage 0 subjects.

The most interesting results in this study are shown in the Tables 3 and 4. The proportion of positive visual score showed significant differences between normal nonsmoking and normal smoking subjects. The proportion of positive visual score of the smoking Stage 0 subjects was significantly higher than that of nonsmoking Stage 0 subjects. In Stage 0 subjects, smoking had effects on the abnormality of chest CT findings and the prevalence of men. Stanescu et al. reported that a subset of smokers characterized by a low FEV_1/FVC ratio and a high N2 slope are probably the high-risk subjects with clinically overt COPD.[22] In our present study, as shown in Tables 3 and 4, asymptomatic smokers had early signs of emphysema when visual scores and lung function were compared among normal nonsmokers, normal smokers and Stage 0 subjects. The subjects of this screening study were individuals under 60 years of age without any recognized illness. The results of this study emphasize the need to provide support clinically and educationally for such smoking Stage 0 subjects to prevent further worsening of emphysematous changes.

We did not follow up the subjects over a long period to determine whether Stage 0 actually developed to COPD at some time in the future. These subjects should be followed up to determine the natural history of COPD, and such studies will allow proper assessment of the likelihood of progression of these Stage 0 subjects to more severe stages. Another limitation was that we could not exclude the possibility that chronic cough and sputum were purely expressions of asthma because of the overlap between COPD and asthma. It was not possible to achieve a precise diagnosis or exclude airway hypersensitivity because the information was obtained from self-reported questionnaires. On pulmonary function tests, we did not measure the carbon monoxide diffusing capacity. It was reported previously that subjects with COPD have reduced diffusing capacity for carbon monoxide at an early phase.[23] However, the test, as well as the measurement of forced residual capacity, could not be performed within the limited time of the general health check.

In conclusion, we were able to indicate that asymptomatic smokers have early signs of emphysematous change seen in comparison of pulmonary function tests and the visual score of low-dose chest CT. It is necessary to promote the cessation of smoking as a means of early intervention for smoking subjects.

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Comparison of bronchoscopic diagnosis for peripheral pulmonary nodule under fluoroscopic guidance with CT guidance

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Summary
Background: A new diagnostic procedure has been established for the selection of appropriate therapy for small lung lesions. We compared the sensitivity of real-time multi-slice computed tomography (MSCT) and X-ray television (TV) fluoroscopic guidance for performing bronchoscopy.
Methods: The first author performed and interpreted all bronchoscopies described in this study. The diagnosis of malignancy or benign was based on the results of histopathological examination, as well as clinical and imaging follow-up MSCT. We also compared the diagnostic yields of lesion size between MSCT and X-ray TV fluoroscopic guidance.
Results: Real-time MSCT and X-ray TV fluoroscopic guidance was conducted in 82 and 78 patients, respectively. The lesion size detected by real-time MSCT and X-ray TV fluoroscopic guidance was <10 mm ($n=21$, 14), 11–15 mm ($n=24$, 12), 16–20 mm ($n=19$,14), 21–25 mm ($n=9$, 12) and >26 mm ($n=9$, 26). The sensitivity of real-time MSCT- and X-ray TV fluoroscopic guidance was 62.2% and 52.6%, respectively. The sensitivity of real-time MSCT fluoroscopic guidance for histopathologic diagnosis of lesions less than 15 mm was higher than that of X-ray TV fluoroscopic guidance. While it was difficult to histopathologically diagnose small lung lesions less than 10 mm in diameter, real-time MSCT fluoroscopic guidance offers a better chance of such diagnosis, irrespective of the size of the lesion, compared with X-ray TV fluoroscopic guidance.

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Conclusion: Real-time MSCT fluoroscopic guidance allows the bronchoscopist to accurately determine the location of the instruments in relation to the lesion in real time, thus helping to reduce the number of negative cases.

Introduction

Lung cancer is the primary cause of cancer death. The cure rates have remained low because of the difficulty in detecting early stage disease. Mountain[1] reported that stage IA cancer represented 13% of the total population and that the 5-year survival rate of patients with such tumors was 61%. Surgical treatment is expected to be associated with a fairly high 5-year survival rate for small lung lesions <20 mm without nodal involvement, or even a higher rate for those measuring <15 mm that are often free of nodal involvement.[2,3] Accordingly, a diagnostic technique that can detect cancers at an early stage is needed to reduce the cancer-related mortality.

Bronchoscopy is a minimally invasive alternative to surgical procedures for the diagnosis of peripheral lung nodules. Previous studies on solitary pulmonary nodules have consistently shown that lesion size influences the diagnostic accuracy of bronchoscopy.[4–6] In particular, the yield of bronchoscopy is low in lesions measuring <20 mm located in the outer third of the lung.[7] Thus, other diagnostic procedures or alternative protocols for the diagnosis of small nodules including lung cancers may be preferable in this situation. Of these, CT-guided transthoracic needle biopsy could be considered as a first diagnostic step, especially in very small, peripheral, and easily accessible lesions. However, the techniques carry a high risk of complications, e.g., pneumothorax, and may also be difficult to conduct depending on the exact location of the lesion. Since bronchoscopy is a safe procedure with a low complication rate and allows the examination of the central airways before operation, it is the first diagnostic step in our hospital. In this regard, television (TV) fluoroscopy is limited by the two-dimensional display format that produces the overlap of structures, potentially hindering biopsy of the lung peripheral nodules. On the other hand, the CT scan has been proposed as a useful guidance method to provide a cross-sectional view of the relevant anatomy during the bronchoscopy procedure.[8] Real-time multi-slice CT (rMSCT) fluoroscopy permits real time and precise localization of the bronchoscope tip and needle.[9]

In the present study, we report our experience using rMSCT-guided bronchoscopy, which provides images in real time, and the usefulness and diagnostic accuracy of this procedure for peripheral nodules. We also compared the diagnostic yields of rMSCT fluoroscopic guidance and X-ray TV fluoroscopic guidance for performing bronchoscopy. Specifically, our study was designed to evaluate whether this bronchoscopic procedure offers a possible approach in selected patients.

Materials and methods

Bronchoscopist and pathologist

The first author (K.T.) is a pulmonologist with an extensive 10-year experience in bronchoscopy. In this study, K.T. performed and interpreted all bronchoscopies described in this study, including those on patients of Iiyama Red Cross Hospital. On the other hand, the histopathological diagnosis was conducted by the same pathologist (T.H.) at Iiyama Red Cross Hospital and Azumi General Hospital.

Subjects

Chest CT was performed as a part of a CT screening program. Subjects were all patients with well-defined pulmonary nodules identified by chest CT at the Azumi General Hospital, who required final diagnosis by bronchoscopy to select treatments: surgery and administration of antibiotics, which were performed between November 2001 and January 2003. Informed consent was obtained from each patient prior to the bronchoscopy procedure. To compare the diagnostic yields of rMSCT and X-ray TV fluoroscopic guidance for performing bronchoscopy, we also included patients with peripheral pulmonary nodules, as identified by chest CT at the Iiyama Red Cross Hospital, who underwent bronchoscopy to select treatments between September 1999 and September 2001.

Evaluation prior to bronchoscopy

All patients underwent chest radiography and thin-section high-resolution CT images before rMSCT and X-ray TV fluoroscopic guidance for performing bronchoscopy. The CT images were obtained with

a CT fluoroscope (Toshiba Asteion; Tokyo, Japan) with a scan rotation time of 0.75 s, using continuous 1-mm collimation slices. The location of the nodule was determined on the chest CT. The size and presence of bronchus signs of the lesion were determined from the findings of chest CT. The largest dimensions of the lesion parallel and perpendicular to the bronchus were measured. The largest perpendicular dimension was used to define the size of the nodule when calculating the effect of size on the diagnostic yield.

Construction of virtual bronchoscopy

Three-dimensional endoluminal tracheobronchial simulations can be constructed from thin-section high-resolution CT scans, which reproduce the appearances of major endobronchial abnormalities, as confirmed during bronchoscopy. Virtual bronchoscopy was constructed using in software (Navigator; GE Medical Systems, surface rendering method) based on MSCT images. After the construction of virtual bronchoscopy for each patient, we imaged the actual endobronchial findings using virtual bronchoscopy. We selected the nearest bronchus to the peripheral nodules before performing bronchoscopy.

rMSCT fluoroscopy

The rMSCT fluoroscopy (10 mA, 120 kV, 2-mm section thickness, 0.75 s of rotation) was performed with real-time visualization to help confirm the location of the transbronchial brush, needle aspiration and biopsy forceps. For all patients, the use of a 10 mA technique was sufficient to achieve good image quality and to perform bronchoscopy. The patient was placed head first into the scanner, with the bronchoscopist to the head of the MSCT table. The bronchoscope monitor was placed on the same side of the lung lesion. The radiologist operating the MSCT fluoroscopy in the same room stood on the opposite side of the rMSCT fluoroscope monitor. The rMSCT fluoroscope monitor was positioned on the same side as the bronchoscope monitor, such that it was visible to both the bronchoscopist and radiologist. A button on the control panel permitted the release of the MSCT table, so that the position of the table could be adjusted by the radiologists hand in a sliding mode. All physicians who remained in the room during rMSCT fluoroscopic imaging wore lead aprons. The bronchoscopist wore an irradiation monitor on the front of the chest to measure the radiation exposure. Another radiologist operating the rMSCT outside of the rMSCT room could replay the image sequence. An rMSCT fluoroscopic image was obtained to correlate the location of the tip within the target lesions. The brush, aspiration needle or biopsy forceps were inserted through the bronchoscope and implanted in the bronchial wall. The site of implantation was imaged with rMSCT fluoroscopy to ascertain whether the tip was directed properly toward the site of the peripheral lesions. Adjustments were made using rMSCT fluoroscopic images to insure an accurate direction, and the instrument was advanced into the lesion. The biopsy forceps, aspiration needle or brush were directed into the lung segment. Further selection of the appropriate subsegmental region was facilitated with rMSCT fluoroscopic sequences. The location of each instrument, the number of instruments pass and the length of time from the start to end of rMSCT scanning and the amount of overall radiation exposure against patients and bronchoscopist were documented. A final rMSCT fluoroscopic image was obtained to document any complications.

X-ray TV fluoroscopic guidance was performed by bronchoscopy using the above methods under X-ray fluoroscopy, and decided the exact position of the biopsy instrument by changing the patient's body position under X-ray fluoroscopy.

Bronchoscopy procedure

After administration of 1 mg atropine sulfate, 100 μg pethidine hydrochloride and airway anesthesia with 4% lidocaine hydrochloride applied orally, patients lay on the table of the MSCT scanner. Arterial oxygen saturation (SpO_2) and heart rate were continuously measured during bronchoscopy by pulse oximetry. Oxygen was administered via a nasal cannula and the flow was adjusted upward from 1 L/min to maintain SpO_2 above 90%.

A variety of flexible fiberoptic bronchoscopes (Olympus, Tokyo); model BF 3C40 (outer diameter; 3.3 mm, forceps channel; 1.2 mm), and BF P10 (outer diameter; 5.0 mm, forceps channel; 2.0 mm) along with their accessories [brushes (BC-201-c-1006, Olympus), aspiration needles (needle; MAJ-65, sheath; NA-1c-1, Olympus) and biopsy forceps (FB-560-1, Olympus)] were used at Azumi general Hospital and Iiyama Red Cross Hospital. All procedures were performed via the transnasal or transoral route under local anesthesia. After visualization of the vocal cords, additional topical anesthetics were applied as needed. All segments of the bronchial tree were visualized. The presence or absence of endobronchial abnormalities was recorded. The bronchoscope was then advanced

to the lobe and segment known to be the location of the lesion. At first, biopsy forceps using BF 3C40 were advanced into the bronchus under bronchoscope guidance to accurately determine the location of the lesion and performed to obtain at least 2 tissue samples. Next, biopsy using BF P10 was performed to obtain larger 2 tissue samples. After the biopsy forceps, the aspiration needle and brushing were advanced into the lesion, the brushing and aspiration needles were then withdrawn. Specimens obtained by biopsy were placed on glass slides and fixed with 10% formalin. If bacterial or fungal infection was suspected, the brush material was smeared on slides, airdried and processed for Giemsa, acid-fast and PAS staining and was cultured.

Histopathological analysis

Certified cytological technologists blinded to the bronchoscopic findings first confirmed that an adequate sample was collected and then conducted cytological analysis. The diagnosis of malignant disease was based on the results of histopathological analysis of specimens by pathologists also blinded to the bronchoscopic findings. A diagnosis of benign disease was based on results of histopathologic examination, as well as clinical and imaging follow-up MSCTs. Surgical pathological diagnosis was compared with the bronchoscope diagnosis in patients who underwent subsequent resections.

Outcome

We divided the final diagnosis into three groups: Incompletion, Negative and Positive. Incompletion as a final diagnosis was the case in which rMSCT fluoroscopic guidance for performing bronchoscopy could not apparently reach the nodules. Negatives were cases in which the surgical diagnosis differed from the bronchoscopy diagnosis although the biopsy forceps, aspiration needle or brush instruments could apparently reach the nodule(s) under rMSCT. Positives were cases in which the surgical diagnosis was similar to that established using bronchoscopy, or histopathological diagnosis by bronchoscopy that showed granuloma or an inflammatory change, and these findings decreased or disappeared on follow-up CTs.

Statistical analysis

All values described in the text and tables are the group mean$\pm$standard deviation. One-way analysis of variance, Student's unpaired *t*-test and Fisher's exact probability test for independence were used for comparisons between the groups. A *P*-value less than 0.05 was considered statistically significant.

Results

Eighty-two patients were enrolled in the rMSCT fluoroscopic guidance for performing the bronchoscopy arm of this study (Table 1). The patient population consisted of 43 males and 39 females with a mean age of 65.9$\pm$12.3 years (range, 20–95 years), and 24 were current or ex-smokers. Of the 82 procedures in which rMSCT fluoroscopy was used along with bronchoscopy, 82 were directed toward abnormalities in the peripheral lung fields. Table 2 shows the final diagnosis based on bronchoscopy, operation, clinical follow-up or follow-up MSCTs. The final diagnosis was established using bronchoscope samples in 51 patients (62.2%). Histological diagnosis showed 27 adenocarcinoma, 1 small cell carcinoma, 1 large cell carcinoma, 3 atypical adenomatous hyperplasia, and 1 lymphoangioma. In 31 patients, bronchoscopy could not assist in establishing the diagnosis. Thirty-two positive

Table 1 Lesion characteristics.

Lesion size (mm)	rMSCT fluoroscopic guidance	X-ray TV fluoroscopic guidance
<10	21 (1) [3]	14 (1) [4]
11–15	24 (5) [4]	12 (4) [6]
16–20	19 (8) [12]	14 (6) [11]
21–25	9 (4) [2]	12 (8) [12]
>25	9 (6) [7]	26 (20) [26]
Total	82 (24) [28]	78 (39) [59]

Data in parentheses are nodules with a positive bronchial sign.
Numbers in square brackets represent cases visible under X-ray fluoroscopy.
rMSCT: real-time multi-slice computed tomography; TV: television; BF: bronchoscopy.

Table 2 Final clinical diagnosis of patients under rMSCT fluoroscopic guidance.

	Bronchoscopy	Operation	Follow-up CTs	Therapy
Lung cancer	29	21	2	1
AAH	3	0	0	0
Benign tumor	6	1	0	0
Inflammation	13	0	6	0
Total	51	22	8	1

rMSCT: real-time multislice computed tomography; CT: computed tomography; AAH: adenomatous atypical hyperplasia.

Table 3 Final bronchoscopic results of peripheral lesions under rMSCT fluoroscopic guidance.

Lesion size (mm)	Positive	Incompletion	Negative
<10	9 (1) [2]	10 [1]	2
11–15	13 (5) [3]	6 [1]	5
16–20	12 (4) [8]	5 (2) [2]	2 (2) [2]
21–25	8 (4) [1]	0	1 [1]
>25	9 (6) [7]	0	0
Total	51 (20) [21]	21 (2) [4]	10 (2) [3]

rMSCT: real-time multislice computed tomography; data in parentheses are nodules with a positive bronchial sign. Numbers in square brackets represent cases visible under X-ray fluoroscopy.

cases were diagnosed as malignancy and 19 were diagnosed as benign. In 8 of these 31 patients, diagnosis was established by subsequent CTs. The remaining 22 patients underwent lung lobectomy or video-assisted thoracic surgery. One patient was treated with chemotherapy after diagnosis of a post-operative recurrent lung cancer (Table 2). Nine of 10 negative cases were diagnosed as adenocarcinoma and one was a fibrotic change by surgery. The diagnostic yields that was considered suspicious for malignancy and benign lesions by radiologists based on the chest CT findings were 59.3% (32 of 54) and 64.3% (18 of 28), respectively. The diagnostic yield of bronchoscopy correlated significantly with the lesion size ($P<0.05$).

The mean diameter of 82 peripheral lung lesions was 16.7 mm (range: 5–51 mm). Twenty-eight of 82 (34.1%) lesions could be detected by X-ray TV-fluoroscopy. A bronchus transiting the lesion (bronchus sign) was detected in 24 patients, and 20 of these 24 (83.3%) lesions were diagnosed by bronchoscopy (Table 3). Positive diagnosis was made in 51 patients, negative diagnosis in 10 patients and incompletion diagnosis in 21 patients. Twenty-one of 31 patients who underwent a nondiagnostic rMSCT CT fluoroscopic guidance were confirmed to have lung cancer at surgery, and 1 patient was confirmed to have a benign at surgery. The location of the nodular lesions was 7 in the left upper, 37 in the right upper lobes, 1 in the lingual lobe, 12 in the middle lobe, 9 in the left lower and 16 in the right lower lobe. The morphological data regarding their nodules were 25 solid nodules, 52 ground glass nodules with high density (mixed nodular pattern) and 5 pure ground glass nodules (non-solid nodular pattern) on chest CT scan. In all patients, re-adjustment using rMSCT fluoroscopy was required before biopsy, aspiration or brushing. Table 3 shows the diagnostic yield according to lesion size: <10 mm in diameter, 9 of 21 patients (42.9%); 11–15 mm, 13 of 24 patients (54.2%); 16–20 mm, 12 of 19 patients (57.9%); 21–25 mm; 8 of 9 patients (88.9%) and >25 mm in diameter, 9 of 9 patients (100%). The visualization and localization of the peripheral lesions under rMSCT fluoroscopy were good and each sampling method (brushing, aspiration and biopsy) was performed. In 21 of 82 patients, adequate bronchoscopy could not be performed because we could not accurately localize the correct bronchial subsegment associated with the lesion ($n = 14$) with MSCT fluoroscopy, or accurately slide the sampling instrument along the sides of the lesion or through the lesion ($n = 5$). In two patients, the ground-glass opacity could be detected under rMSCT. In 8 patients in whom the lesion could not be diagnosed and who had underwent rMSCT fluoroscopic guidance, the lesion resolved spontaneously, as demonstrated on follow-up CTs.[12] In 6 of 8 patients, the nodules or ground glass opacity disappeared on sequential CTs

Table 4 Diagnostic yield of bronchoscopy under rMSCT fluoroscopic guidance.

Lesion size (mm)	Peripheral lung lesions		
	rMSCT (diagnosed number/total number)	X-ray TV (diagnosed number/total number)	Significance
<10	9/21 (42.9%)	1/14 (7.7%)	$P = 0.028$
11–15	13/24 (54.2%)	2 /12 (20%)	$P = 0.039$
16–20	12/19 (63.2%)	9/14 (64.3%)	NS
21–25	8/9 (88.9%)	9/12 (75%)	NS
>25	9/9 (100%)	20/26 (76.9%)	NS
All lesions	51/82 (62.2%)	41/78 (52.6%)	NS

Data are numbers and (percentages) of correctly diagnosed cases.
rMSCT: real-time multi-slice computed tomography; TV: television; NS: not significant.

Table 5 Radiation exposure.

Lesion size (mm)	Patients		Bronchoscopist
	Exposure time (s)		Radiation exposure (μSv)
< 10	330.3±170	925±476	93.5±67
10–15	343.7±203	962±567	65.1±47
16–20	387.3±144	1084±404	94.8±47
21–25	253.5±83.1	710±233	43.9±28
>25	210.4±138	589±386	75.1±45
Conventional CT	12	474	
Conventional with thin-section CT	22	869	

Data are mean±standard deviation.
CT: computed tomography.

after the administration of broad-spectrum antibiotic therapy after rMSCT fluoroscopic guidance.

Comparison of X-ray TV and rMSCT CT fluoroscopic guidance for performing bronchoscopy

Seventy-eight patients were enrolled in the X-ray TV fluoroscopic guidance for performing the bronchoscopy arm of this study. At the Iiyama Red Cross Hospital, the diagnostic yield of X-ray TV fluoroscopic guidance in all lesions was 52.6% (41 of 78 patients). The proportions of cases with accurate final diagnoses by X-ray TV fluoroscopic guidance and rMSCT fluoroscopic guidance for performing bronchoscopy were not significantly different. The diagnostic yields of X-ray TV fluoroscopic guidance and rMSCT fluoroscopic guidance for lung lesions were: for lesions <10 mm in diameter, 7.7% and 43%; 11–15 mm, 20% and 54%; 16–20 mm, 64% and 63%; 21–25 mm, 75% and 89%; >26 mm in diameter, 77% and 100%, respectively. These results indicate that the diagnostic yield of rMSCT fluoroscopic guidance for performing bronchoscopy was significantly superior to that of X-ray TV fluoroscopic guidance for lesions measuring <15 mm ($P<0.001$) (Table 4).

Radiation exposure

Patients and the bronchoscopist were exposed to a mean radiation dose of 912.2 μSv (range, 138–2313 μSv) and 75.2 μSv (range, 16–208 μSv), respectively. The mean time of the rMSCT fluoroscopic procedure was 325.8 s (range, 49.3–826 s). Table 5 shows the radiation dose and time of bronchoscopy according to lesion size.

Complications

No significant bleeding occurred during the procedures and no dyspnea or ventilatory compromise was noted. None of the procedures resulted in pneumothorax, pneumomediastinum or bacteremia.

Discussion

This study is the first to compare the diagnostic yields of X-ray TV fluoroscopic guidance and rMSCT fluoroscopic guidance for performing bronchoscopy, although it is a historical comparison between the two techniques. However, this study does not serve as a control study unless the nodules are truly matched in terms of their size and location density, although we assessed the diagnostic yield of rMSCT fluoroscopic guidance for peripheral nodules, and compared these results with those of X-ray TV fluoroscopic guidance conducted by a single physician (K.T.). However, the present data can show the use of rMSCT fluoroscopic guidance in patients with peripheral lung lesions. Compared with CT-guided percutaneous thoracic needle biopsy, bronchoscopy has low sensitivity and false negative results. CT-guided percutaneous thoracic needle biopsy may be considered as the first diagnostic step, especially for very small, peripheral and easily accessible lesions. We did not perform CT-guided biopsy for peripheral lesions, although the frequency of pleural dissemination was low. Surgical excision was also performed for the final diagnosis of lung cancer. However, some patients were anxious or refused surgery, or hoped a final diagnosis of the pulmonary lesion could be made before surgery. Moreover, some studies showed that CT-guided bronchoscopy for transbronchial needle aspiration is a safe and efficient tool for providing diagnostic material from mediastinal lymph nodes and peripheral nodules.[8,9,11] Therefore, we performed rMSCT fluoroscopic guidance for the diagnosis of pulmonary lesions and to compare its diagnostic accuracy with that of X-ray TV fluoroscopic guidance. However, the selected approach depends on the location and extent of lesions, as well as other considerations such as referral patterns, expertise and preferences, in addition to the availability of the necessary equipment.

In our study, diagnosis was confirmed by biopsy in 51 of 82 patients. This compares favorably with recent studies in which the overall rate of accurate diagnosis was 50–70% for lesions of various sizes.[7] The sensitivity was markedly better than that of fiberoptic bronchoscopy conducted by Baaklini et al.[7] who reported a positive bronchial wash in 71 of 177 cases (40%). Our conventional diagnostic procedures of bronchoscopy included needle aspiration, brush and transbronchial biopsy. Transbronchial biopsy is the only bronchoscopic method that allows obtaining a biopsy specimen, hence allowing diagnosis of benign lesions. Although transbronchial biopsy is associated with a higher risk of bleeding and pneumothorax than transbronchial needle aspiration,[12] we performed endobronchial biopsy as one of the bronchoscopic procedures when possible. Consequently, it is possible to provide a histological diagnosis by the transbronchial biopsy. Our results showed certain benefits of rMSCT fluoroscopic guidance for performing bronchoscopy. The diagnostic procedure enabled the detection of small lesions, which could not be detected by X-ray TV fluoroscopic guidance. It is important to accurately determine the location of lesions when planning the biopsy and needle aspiration, especially for small peripheral lesions and the lymph nodes adjacent to the major blood vessels. Transbronchial needle aspiration under the rMSCT fluoroscopic guidance can visualize the needle and select an optimal site for needle penetration and can confirm the depth and angle of the needle in real time during the procedure. Although no complications occurred in our study, we performed a CT sequence immediately upon completion of the procedure, which would have permitted immediate detection of and intervention for pneumothorax or hemorrhage.

The most important drawback of rMSCT fluoroscopic guidance for performing bronchoscopy is the radiation exposure of patients, bronchoscopist and assistants (Table 5). The potential concern related to this technique is the use of several minutes of fluoroscopy. Conventional X-ray TV fluoroscopic guidance dose parameters are approximately 90 kV and 4 mA per second. In comparison, these parameters are 120 kV and 150 mA per second in the conventional CT fluoroscopy but only 120 kV and 10 mA per second in our MSCT fluoroscopy. The dose used in MSCT fluoroscopy was at least double that used for conventional X-ray TV-guided fluoroscopy. In conventional CT, exposure of the entire lung requires movement of the sliding table in about 12 s, resulting in a maximum skin dose level of approximately 395 μSv. This time was as much as ~22 s, making the maximum skin dose level of ~869 μSv in conventional CT combined with thin-section CT. As shown in Table 5, this radiation exposure is almost the same as that of rMSCT fluoroscopic bronchoscopy (mean maximum skin dose level; 852 μSv, mean bronchoscope procedure time; 304 s). The bronchoscopist was exposed to a mean maximum radiation dose of 69.5 μSv. Unlike conventional fluoroscopy MSCT fluoroscopy employs a tightly collimated beam (2 mm) that confines to a narrow area. The radiation dose is further dissipated because the sliding table method used in this procedure limits exposure to any particular region. Moreover, we reconstructed the virtual bronchoscopy and selected the precise bronchus with the nodule before performing bronchoscopy.

McAdams et al.[13] reported the use of virtual bronchoscopy for guidance during the transbronchial biopsy procedures. Their results suggested that imaging guidance might improve the diagnostic sensitivity for malignant nodule. Although virtual bronchoscopy provides a "road map" that could be viewed by the bronchoscopist before performing bronchoscopy, it does not provide direct guidance during the procedure. The usefulness of virtual bronchoscopy is unfortunately limited because it cannot confirm the correct location of the peripheral bronchus, due to its limited success in reconstructing the peripheral bronchi in detail. However, we believe that virtual bronchoscopy is beneficial as it shortens the procedure of MSCT fluoroscopy since the virtual images could correctly detect fourth-order bronchi under 1-mm collimation high-resolution CT.

rMSCT-fluoroscopic guidance, as well as X-ray TV fluoroscopy are associated with other risk factors. The minute specimens obtained by the BF 3C40 procedure make it difficult to establish a definitive histopathological diagnosis, especially ground-glass opacity with Noguchi type A and type B or adenomatous atypical hyperplasia. Lesions detected by chest CT screening mostly appears as small-diameter lesions. A large proportion of small nodules do not invade the neighboring bronchus. Therefore, even with the brush instrument placed in the center of the lesions, it is difficult to obtain sufficient material from alveolar-lining tumors. Specimens obtained by bronchoscopy are only tiny parts compared with the specimens obtained by operations, and are unsuitable to assess the histological grade of the whole lesion apparent on MSCT. Moreover, it is often difficult to maneuver the biopsy instruments to reach the site of the peripheral lesion, due to the limited flexion inherent in such instruments, compared with brush instruments. In some cases, the peripheral nodules could not be accessed by biopsy forceps but could be reached by the brush instrument. In this study, it was difficult to make a definitive diagnosis for small nodules measuring < 10 mm without bronchial signs, using rMSCT fluoroscopic guidance. To obtain samples correctly from nodules < 10 mm in diameter, it is necessary to place the bronchoscope at a bronchus adjacent to the nodules, and to perform transbronchial biopsy. In four small nodules measuring < 10 mm, diagnosis could not be established using 3C40 bronchoscopy. Instead, we used ultrathin-bronchoscopy (Olympus BF XP 40, outer diameter: 2.8 mm, forceps channel: 1.2 mm) to improve the approach to the small nodules. That bronchoscopy allowed the approach of the deep part of the second-order bronchus better than 3C40 bronchoscopy, although no firm diagnosis could be made in any of these cases. For small nodules < 10 mm in diameter, rMSCT fluoroscopic guidance showed clearly superior accuracy compared with X-ray TV fluoroscopic guidance, although the diagnostic accuracy of the former procedure is not yet ideal.

The endoscopic ultrasound-guided bronchoscopy has been adapted for the central mass and peripheral nodules. Kikuchi or Kurimoto et al. reported that even when restricted to peripheral small nodules < 20 mm in diameter, the diagnostic sensitivity of endobronchial ultrasonography with guide sheath-guided transbronchial biopsy was 53% or 66%, respectively.[14,15] However, US cannot detect the nodules without solid component less than 15 mm in diameter although the data was not shown on our hospital. Therefore, the bronchoscopy under MSCT is more useful to reach a diagnosis than that under EBUS for the nodules without solid components less than 15 mm in diameter.

The final problem is the cost-utility of this technique. We calculated the cost of rMSCT fluoroscopic guidance for the performance bronchoscopy to be more expensive by $40 compared with X-ray TV fluoroscopic guidance. The screening cost for lung cancer by chest CT per person was $50, based on our 3-year CT screening program (Asakura et al., Japanese publication, 1999). Surgical excision was also performed for a final diagnosis of lung cancer. However, some patients may be anxious or refuse surgery, or hope a final diagnosis of the pulmonary nodule could be made before surgery. We commonly used to follow small nodules by performing serial CTs because its interval growth would be an indication for surgery. However, the cost of more than 2 follow-up CTs was more expensive than that of rMSCT fluoroscopic guidance. To establish a diagnosis at the time of first identification may could be more cost-effective compared with the cost of serial follow-up CTs.

Conclusions

Nodules of different sizes could be assessed using one or more diagnostic procedure. In bronchoscopic procedures for peripheral nodules, small nodules less than 10 mm should be diagnosed based on CT morphologic and density characteristics and the presence or absence of tumor growth tendencies as determined by serial follow-up CTs because of low diagnostic sensitivity of rMSCT fluoroscopic guidance for performing bronchoscopy. For lung

nodules of 10–15 mm in diameter and nodules of 16–20 mm not clearly visible on X-ray TV, rMSCT fluoroscopic guidance is a useful procedure based on the diagnostic sensitivity determined in our study. For nodules more than 20 mm in diameter, rMSCT- or X-ray fluoroscopic guidance for performing bronchoscopy could be selected.

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特集 増え続ける肺癌ー治療成績を向上させるために

肺癌検診の現状

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特集 増え続ける肺癌－治療成績を向上させるために

肺癌検診の現状

Current situation of screening for lung cancer

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肺がんは，がん死亡の第1原因である．罹患数の多さのみならず，その救命率の極端な低さによる．治療成績の向上には早期発見が不可欠である．肺野型肺がんの早期発見には胸部X線写真は非力である．低X線曝射方式のCT検診によりこれが可能になり肺がんの治療成績は飛躍的に向上するであろう．その普及には，受診者数を増加するための検診コストへの配慮と検診実施態勢，精度管理体制の確立が望まれる．

はじめに

平成16年度のわが国における肺がん死亡数は59,910名(男性43,910名，女性16,000名)，人口10万人対死亡率は47.5(男性71.3，女性24.8)で，がん死亡の第1位であった．罹患数と死亡数の差，すなわち救命数(率)が低い点でも肺がんはすい臓がんとともに特異であり，難治がんと目される状況にある．肺がんの5年生存率は米国でもおよそ14%でありわが国と同様に低い[1]．早期肺がんの手術成績は，病理学的病期IAでは約80%と報告されているにもかかわらず[2]，肺がんの85%以上が進行がん状態で発見されるために，全体としてはこのような低治癒率を示している[3]．肺がん対策を唱えるからには，早期発見と治療の実現，そのために有効な検診法の導入に目を向けるべきであり，現実には，肺がんの早期発見に役立つ低X線CT検診の有用性の理解と具体化に向けた動きが必要である．

I. 肺がん検診

一般にがん検診が有効に働く要件として，対象がんの罹患率が高く社会的関心や影響が大きいこと，現状では救命率(罹患率と死亡率の差が少ない)が低いが，早期発見できるテスト法があって，これによる発見と診断確定後に効果的治療が実施可能なこと，そして当該のテスト法が一般に普及可能な内容，すなわち安全性や侵襲性，利便性に問題のないことなどがあげられる[4]．今日，肺がんはまさにこのような条件に合致しており，がん検診の対象疾患として最適である．

従来は，胸部疾患一般の検診に胸部X線単純写真が利用され，上述の要求を満たすと考えられていたであろう．1987年来，老人保健事業における肺がん検診の胸部検査法として，痰の細胞診断法とともに定着している．しかし肺がんではこれ

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は正しくなく，死亡率低減の観点からは，胸部X線写真は余り役立たない[5]．小さい肺がんに対する感度，発見能に問題がある．真に有効な肺がん検診を実施するためには，テスト法の見直し，CT検診への転換が必要である．

II. 肺がん検診の有効性

胸部X線写真を用いた肺がん検診の死亡減少効果をみるための無作為比較対照試験，RCT(randomized controlled trial of screening)は1960年台に英国で行われ，胸部X線写真による頻回の検診では，より多くの肺癌が発見されるが死亡低減に働かなかった[6]．胸部X線写真により発見される肺がんはすでに進行がんであることが多く，これに続く当時の治療法では効果が得られなかったのであろう．

胸部X線写真と痰の細胞診断を用いた検診のRCTは，1970年台に米国がん医療の一大プロジェクトとして3つのサイトで行われたが，検診による死亡率低減効果は認められなかった．痰の細胞診断を加えることによる効果も証明されなかった[6]．胸部X線写真については，すでに行われていた英国での検討と同じテスト法であり，追試的役割を果たしたに過ぎないであろう．痰の細胞診断は主に肺門型肺がんに関連するのでここでは触れない．

わが国での成績として，Sodaらが，すでに1993年に報告している．30万人強の受診者から約200名の肺がんを発見，うち約100名が病期I期であった．検診の問題点として，病期I期肺がんの発見が少ないことと急速進展例における発見の遅れが指摘された．小さい肺がんでは前年のX線写真を見直すと見えることが多く，急速進展がんは中間期がん(interval cancer，前回の検診で陰性の判定，しかし次の検診前に発症するもの)として発見されることが多いなど，胸部X線写真による検診の困難性が明確に示された[7]．

Sagawaらはわが国で1990年台に行われた肺がん検診についての症例対照試験(case-control study)のまとめを報告した．過去1年間に従来法による検診を受けたかについて，肺がんによる死亡者とその対照群を比較した．オッズ比(ある事例の起こる確率をpとする．起こらない確率qは1－pである．両者の比，p/qをオッズという．ここで具体的にいうなら，症例群，肺がん死亡者群，のオッズは，その中で検診を受けていたものと受けていなかったものの比率である．対照群，すなわち肺がん死亡者とマッチして定められた対照群のオッズは同様に，その中で検診を受けていたものと受けていなかったものの比率である．これら二種類の比率の比がここでいうオッズ比である．オッズ比が1以下なら，検診に死亡抑制効果があるとみられる)は，4研究班のまとめでは0.40～0.68の範囲にあった．信頼区間をみても，1研究班を除いて，1以下におさまり統計学的有意差を示した．検診受診による肺がん死亡リスクの減少，32%から60%までを示した[8]．しかし臨床医の立場では，この論文の考察部で紹介されている5年生存率に関心が向く．発見肺がんの5年生存率は48～61%であり，従来法で達成し得る最高値に近いのであろうが，一般人が望むがんの治療成績からはかけ離れており低すぎる．従来方式の検診法の限界が示されたとみる．

肺野型肺がんについては，その後，登場した低X線CT撮影による検診が，小さい病巣の発見を容易にし，これにより治療効果の向上が期待される[6)9)-11)]．ここでの懸案事項は，CT検診で発見される小さい病巣への対処法である．オーバーダイアグノーシスの懸念に対する説明あるいは対処法ならびにCT検診の経済的運用ならびに精度管理の方策などの具体的事項の検討が重要であろう．

III. 肺がん検診の目標

肺がん検診は，従来から「肺がんの早期発見に役立つ検診を受けましょう」と受診を勧誘しているが，これを単なる謳い文句でなく，実質的なものにするには，良好な治療成績を期待できる肺が

んとは如何なるものかを明確にし，この目標にそって検診が実施されることが必要である．そして今後は，どのような具体的成果があげられているかの情報開示が求められそうである．

過去には，肺野型肺がんについては，手術可能のもの，病期Ⅰ期(T1N0M0，すなわち肺野型では，腫瘍の最大径が3 cm 以下で肺内あるいは臓側胸膜内に腫瘍が存在し，リンパ節転移や血行転移のないもの．あるいはT2N0M0，すなわち肺野型では，最大径が3 cm を越えるか臓側胸膜浸潤があるが，リンパ節転移や血行転移のないもの)および病期Ⅱ期(T1N1M0とT2N1M0，すなわちⅠ期にN1が加わったもの．N1：縦隔胸膜より遠位にある同側の肺門，気管支周囲リンパ節転移のあるもの)を早期と称したが，治療成績は満足できるものではなかった．腫瘍の大きさが予後を左右することや所属リンパ節転移が予後を劣化させる重要因子であることなどが明らかにされ，T2とN1例は早期から除外して，病期ⅠA(T1N0M0)を早期と考え，さらに腫瘍が小さいものほど，良好な予後につながることから，T1の腫瘍の大きさ「3 cm 以下」を細分類することが検討されている．境界を1 cm，1.5 cm，2 cm などにとる研究では，何れにおいても予後に差が認められている．わが国では従来，大きさ2 cm 以下の肺野型肺がんを早期としていた．腫瘍の大きさが1 cm 以下であれば，リンパ節転移は低頻度であり，当面の到達目標としてよさそうであるが，逆にこのように小さいものが今の検診でよく発見されているかに疑問が生じ，実用的内容でないとも考えられる[3)12)]．1.5 cm を当面の目標と定め，しかし1 cm 以上の大きさの腫瘍においては，診断確定や治療開始に時間を長く取られないよう留意することが適当であろう．腫瘍の密度や組織型によっても変わってくる．野口分類のA，Bで，腫瘤影の50%以上をGGO 成分が占める例は早期と考えるという一つのまとめがある．この場合に，手術的に高リスク者であれば縮小手術が容認される[3)]．野口分類A，B以外については今後のデータ集積による検証が必要である．とくに小細胞がんや大細胞がんでは別の考察が必要であろう．

Ⅳ．肺がん検診に関する行政的指針

「がん検診の有効性評価に関する研究」(平成8年度)[13)]は，わが国でのがん検診の方向付けに重要な役割をはたしている．ここでの勧告は「肺がんの生存率は一般に極めて低い，しかし，肺がん検診を逐年受診することの有効性は示唆されている．ただし，現行の方法による検診の効果はあっても小さいことは事実である．中略．個別検診の一般化にあたっては厳重な精度管理を前提とする必要がある．また，集団検診へのCT の導入など一層早期の発見の研究が必要である」とされた．これを補充するかたちで次に行われた「がんの原因となる微生物等を発見する検診の有効性に関する研究についての文献学的調査」(平成10年度)における肺がんに対するCT 検診の検討部分では「前略，低X 線曝射によるCT 検診では，治療効果の高いとみられる5 mm から2 cm までの肺がんが多数発見され，本法の利用が最も現実的で効果的な肺がん対策法であろう，後略」とされた[14)]．次の「がん検診の適正化に関する調査研究事業－新たながん検診手法の有効性の評価」(平成12年度)では「肺がんの生存率は一般に極めて低い．しかし現行の肺がん検診は，適切に行うならば，死亡率減少に寄与する可能性が高く，継続して実施する相応の根拠がある」「らせんCT によって全肺スキャンを行えば，より小さい肺がんを発見することが知られている．しかしながら，この装置が検診の分野で普及し始めたのは，わが国においても，極く最近のことであり，肺がん死亡減少効果を測定する研究は，現在，着手されようとするところである．したがって，その結果が判明するまで評価を留保する」[15)]であった．平成12年度の報告書の記載は平成8年度のものに比べて，CT 検診に対して抑制的，胸部X 線写真による現行法の効果を強調した文章になっている．学問的には文句のない記載であるが，従来からの研究

の詳細や経緯を熟知してはいないかも知れない地方自治体の保健予防担当者にはCT検診は時期尚早と理解されるであろう。そして今般，平成17年4月1日付，厚生労働省老健局老人保健課布告の「がん予防重点健康教育及びがん検診実施のための指針」の一部改定においては，肺がん検診における検査法として「従来からの胸部エックス線写真を用いてこれを実施する」という内容にとどまっている。このような現在の行政的見解は，地域における保健予防担当者に肺がんに対するCT検診の推進を躊躇させ，先送りの口実を与えている。肺がんの死亡率低減をはかるために，現在唯一，非常に有効なCT検診にブレーキがかけられた。さいわい，関係諸学会協働で作成された「低線量CTによる肺癌検診の手引き」は専門学会から提示された権威ある文書として，地域における担当者にCT検診推進のための唯一の拠りどころとなっている[16]。

V. 肺がん検診における胸部X線写真の限界

従来，肺がんが早期発見されなかった原因は，その診断に用いられた胸部X線写真の感度不足にあった。肺がんにおいては感度不足であるが，このことが軽視され，その経済性と普遍性のみが強調されている。胸部単純写真の感度不足は，肺の広い範囲が盲点になることと，盲点以外の肺に発生した肺がんについても，これが腺がんのように密度が低いものではわれわれが肉眼的に認識できるほどの濃度，まわりの肺とのコントラストを形成しないことからきている。胸部正面写真の盲点とは，心臓や縦隔大血管，横隔膜に重なる肺部分であり，肺全体の約26%を占める。したがって胸部単純写真を用いて肺がん検診を行う限り，少なくとも約1/4の肺がんについての診断の遅れは覚悟しなければならない[17]。検診受診者にこのことを告げておくべきである。側面写真を追加してもこの事情はほとんど変わらない。最近のオルソ系感光システム(X線フイルムと希土類増感紙の組み合わせで，これが最近は一般化され通常のものになっている)や最近普及しているCR(computed radiography)システムを使用すれば，このような肺がんの検出能が多少とも向上しないかとの素朴な質問もあるが，この事情はほとんど変わらない。要点的には，小さい肺がん病巣を発見するには，CTのような断層画像法を用いることが必須であり，これにデジタル画像法の特長である高コントラスト機能を加えることによりわれわれの病巣発見能が高められ，小さい病巣の発見が容易になる。腺がんのように密度が低いものは，通常のX線写真上では，われわれが肉眼的に認識できるほどの濃度，周囲の肺とのコントラストを形成しないために医師が肉眼的に指摘できないことが多かった。発見された肺がんについて，過去のX線写真を見直せば，かすかに見えることはよく経験されている。

VI. 肺癌に対する低X線曝射CT検診の成績[6)9)-11)17)]

東京から肺がんをなくす会(Anti-Lung Cancer Association)での発見肺がんについての報告によると，従来法とCT検診導入後を比較して，病期IAが42%対81%であり，5年生存率は48%から82%に向上した。われわれの長野県におけるCT検診発見肺がんでは病期IAが88%，5年生存率が90%強(未発表)であった。

ここでは，われわれが平成8年から10年までの3年間に行ったCT検診の結果を簡単に示す。40歳から74歳までの受診者については，延べ13,786件のCT検診から手術確定肺がん60名を発見した。延べCT検診数の0.44%，肺がん関連で精密検査が必要と判定された人の10%であった。発見される肺がんは小さいもの，治癒する可能性が高いものが多かった。患者の年令をみると40歳代前半にはなく，45歳以上にみられ，55歳以上で多くなった。女性や非喫煙者にも，喫煙者に劣らず，多くの肺がんが発見された。喫煙者の肺がんは一般に早く増大した。低X線曝射によるCT検診において精密検査が必要とされた人の約10%が最

終的に肺がんを有していた。残りの約90%の人は，精密検査で肺がん以外の病気であることがわかった。

低X線曝射CT検診では，結節性病巣の有無をスクリーンするものであり，病巣の有無についての擬陽性はほとんどない。この後の鑑別診断で肺がん以外と確定診断されるものは少なくない。低X線曝射CT検査は，肺がんを含めた肺病巣の有無をみるための第一次テストとみるべきである。ここでの陽性者について肺がんかどうかの絞り込みを，第二次テスト，通常のCT検査で行うと考えるのが適当であろう。元来，低X線CT検診では鑑別診断を行えるほどに十分な画像情報は得られていないのであり，ここでの陽性者のうち非癌と最終診断されるものが多いことをとらえて，低X線CT検診には疑陽性が多いと問題視するのは見当違いであろう。

VII. 肺がん検診における胸部X線写真と低X線CTの比較

従来の胸部X線写真法による肺がん検診のデータでは，わが国で年間，肺がん検診受診者は約670万人，うち要精検者は約17万人，すなわち検診受診者の2.5%，肺がんと診断されるもの3,144人，すなわち検診受診者の約0.05%，要精検者の約2%であった[13]。一方，昭和56年から58年までの全国がん登録に10,325例の肺がんが登録され，そのうち腫瘍の大きさが3 cm以下，肺門リンパ節転移を認めない群，すなわちステージIAと分類されるものが2,412例(約23%)であった[15]。この比率を上のデータにそのまま適用すると，わが国での1年間の肺がん検診，受診者約670万人からおよそ720人のIA期肺がんが発見されたことになる。

低線量CT検診のデータは上記のとおりである。CT検診受診者13,786件，うち要精検者が588件(検診受診者の4.3%)，CTで発見され手術で確認された肺がん56人(検診受診者の約0.4%，要精検者の約10%)，手術で直りやすい2 cm以下のものが約95%であった。わが国での1年間の肺がん検診の受診者約670万人全員にCT検診を実施すれば，初回検診では約26,000人のIA期肺がんが発見されると推定される。上記の通常検診における推定値，約720人と格段に異なる[9)17)]。

従来法では要精検者は検診受診者の2.5%とCT検診における4.3%より少ないがこの差以上に見落とし(偽陰性)が非常に多い。すなわち肺がんの発見率が0.05%対0.4%とCT検診の約1/10と劣っていて，CTで発見される肺がんの10例中9例を見落としている(感度が非常に低い)。逆に，肺がんでないものを肺がんの疑いと分類する，いわゆる読み過ぎ(擬陽性)も従来法では多い。要精検者のうち肺がんと最終診断されるのは，胸部X線写真法では約2%，CT検診では約10%である。発見される肺がんの内容も大いに異なる[9)17)]。胸部X線写真法では治癒しやすい1.5 cmから2 cmまでの大きさの肺がんが発見されることは少なかった。CT検診ではこのような小さい肺がんが良く見え，高率に発見される。CT検診は格段に精度が高く，とくに治る肺がんを発見するためのテストとしてすぐれ，コスト的にも有利といえる。

VIII. 肺がんのCT検診実施について

低線量CTによる肺癌検診の手引き[16]にも記述があるが，ここではわれわれの長野県でのデータを述べる[9)17)]。

1．適当な対象群

長野県でわれわれの行った管電流25 mAによる低線量CT検診における利益対リスク比(早期発見による余命延長という利益と放射線被曝による発がんによる余命短縮という不利益，リスクの関係)は40～44歳男性で6.6，女性で1.8，これ以上の年齢層ではさらに大きくなり，利益が大幅に上回るという結果であった。長野県の一般住民，40～74歳を対象とした集計では，初回CT検診による肺がん発見率は10万人対で435人であり，男女あるいは喫煙歴による差はほとんどなかった。

初回検診受診群はこのように高率に肺がんを有するので，経費面での効果は絶大である．経年検診群では減少する．対象の年齢層や喫煙歴の有無で異なってくる．要約すると，40歳代後半にCT検診を1度念のために受け始めるのが良い．時に肺がんが発見される．この年齢層では，定期的に毎年CT検診を受ける必要はない．50歳代後半から定期的に受けるのが良い．55歳から60歳頃から肺がんの発見率は高くなる．

2．適当な検診回数

治る肺がん，すなわちリンパ節転移が少ない，大きさ15 mm以下の肺がんの発見を目標として検診を実施したい．この場合は以下のようにプランできよう．すなわち，低線量CT検診で発見される肺がんの大きさは通常3 mm以上である．したがって，腫瘍の大きさが3 mmから15 mmの間で肺がんを発見するようCT検診の間隔，すなわち回数を設定するとよい．腫瘍の増大速度に関する従来のデータ(腫瘍容積倍増時間)を用いた計算では[17]，喫煙者は年1回，非喫煙者は3～4年に1回の検診でこのような目標がほぼ達成される．喫煙者の肺がんは早く進行するので，1年に1回の継年的受診が必要である．たとえば，45歳頃に受診を始め，以後は2年に1回程度，55歳以降は毎年受診するなどが適当と思われる．

しかし例外もある．喫煙者には，例外的に非常に早く大きくなるか，早期に転移を起こす小細胞がんや大細胞がんが発生することがある．おそらく，全体の5％以下と予測される．この場合は，毎年1回のCT検診では不十分と思われる．これをさけるためには，1年に2回のCT検診が必要になるが一般化できる内容ではない．このような特殊群については，喫煙歴以外の危険要素が今後明らかにされ，特定検診対象群として取り扱われることが望ましい．

逆に，徐々にしか増大しない低悪性度肺腫瘍(異型腺腫様過形成や高分化腺がん)が低濃度のすりガラス濃度結節(pure ground-glass opacity nodule, pure GGOあるいは肺がんCT検診ではnon-solid noduleとも表現する)として主に非喫煙者に発見される．肺腫瘍類似の限局性炎症性変化がpure GGO結節としてCT検診で発見されることもある．いずれも非常に淡い，増大傾向に乏しい腫瘤影を呈する．鑑別診断が困難であるが，その進め方や適切な医学的取扱い法については今後さらなる検討が必要である．

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胸部ＣＴ画像読影の能率と精度および学習効果の評価法に関する研究
―１外国人研修医を対象にして

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原著

胸部CT画像読影の能率と精度および学習効果の評価法に関する研究—1外国人研修医を対象にして

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要旨

研修目的で来院した1外国人医師を対象に、研修によるCT画像読影の精度の向上を評価する方法論を検討した。CT画像136例を読影する実験の結果、ROC曲線下面積Azで表した異常所見検出能は、研修前0.892から研修後0.979に上昇し、正常、良性、癌を鑑別する正答率は研修前それぞれ95.7%, 24.3%, 45.8%（確定診断との一致率κ=0.284）であったが研修後は91.3%, 60.0%, 75.6%（κ=0.614）へと変化した。これらの結果より、本法によるCT画像読影の研修は有用であったと結論された。

キーワード：CT画像、画像読影精度、診断正確度、トレーニング効果、ROC

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はじめに

医療技術革新の代表ともいうべきCT装置が胸部疾患診断の能率や精度の向上に寄与していることは疑問の余地がないように思われる。しかし、せっかくの技術もこれを活用する医師の読影技術が未熟であれば、その恩恵はX線被曝のリスクに比し不十分なものとなる。

最近の研修医制度の導入とも関連して、CT検査の安全と質を一層高めるため、研修医が医療現場で日常業務をこなしつつ、CT画像読影技術をいかに習得し、その効果のほどをいかに確認するか、CT画像診断の能率と精度を的確に評価できる方法論の確立が重要課題[1)-3)]となっている。

このような現状に鑑み本報では、安曇総合病院に研修目的で来院した一外国人医師を対象に、CT画像読影の能率と精度を評価する方法を検討、それを胸部CT画像読影の修練を目的にした読影実験に応用し学習効果を評価した。その結果、興味ある知見が得られたので報告する。

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1．材料および方法

胸部CT画像読影の学習効果を評価するために考案した方法論とそれを用いて行った読影実験の手順および材料を以下に示す。

1）実験-1

研修目的で中国（上海）から安曇総合病院に来院した医師1名が勤務に入る直前に確定診断付き胸部CT画像データベースを読影、存在診断を行う読影実験-1を行った。画像データベースは1症例中の1スライスを延べ270例分集めたものからなる[4)]。胸部CT画像データベースの疾患の内訳は、肺癌131例、肺癌以外の疾患70例、正常69例、従って、異常所見有りは201例、異常所見無しは69例であった。異常所見有り例では1画像中、重要な所見1個のみが定義された。以上の疾患分布および異常所見有無の分布の情報は読影者に公開されなかった。

実験-1で研修医が読影したCT画像は270例であった。異常所見が複数個あると判断した時は、最も重要と思った所見を1個のみ回