う．当委員会において質的研究をテーマにしたワークショップを実施するなど，必ずしも量的研究のみを重視していたわけではないことも附記しておきたい．

実施の課題という点では，2つの論点を挙げておきたい．1つは，ランダム割り付けに関連する課題である．準実験（quasi-experimental）ではない実験的（experimental）デザインを採るには避けて通れない手続きだが，この方法を用いることで，日常の教育場面からかなりかけ離れたセッティングとならざるを得ない．臨床推論の研究においては，今後現場での視点を重視するという方向性が打ち出されている[4]が，今回は現場での観察内容から生み出された研究仮説を証明するという観点でこの方法論を選んだことを改めて強調したい．

もう1つは，施設内の倫理委員会での審査についてである．各大学での対応が様々であったことから，今後本邦で医学教育研究を推進するためには，各施設の倫理委員会に対し，日本医学教育学会側からの周知，対応が必要と考えられた．また，改めて倫理審査において気づかされたこととして，医学教育研究では研究者が教育者側で，研究対象者は学習者であることが多い．その結果，研究対象者は，脆弱集団の立場に該当する場合が多い．臨床研究や疫学研究の研究対象者と同等かそれ以上に，倫理的配慮が必要となると言えるだろう．

これにより，筆者らは医学教育研究における倫理指針が必要であると考えた．各施設内の倫理委員会での一助，研究者に対して学会が示す方針という二つの意味がある．この点に関し，当委員会から日本医学教育学会研究倫理指針（案）を理事会に提出中である．

第15期日本医学教育学会医学教育研究開発小委員会が実施した委員会主体のモデル研究の流れを報告した．本論文が本邦における今後の医学教育研究の遂行を助け論文数の増加に寄与できることを期待する．

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ORIGINAL ARTICLE

Efficacy of computer-aided diagnosis in lung cancer screening with low-dose spiral computed tomography: receiver operating characteristic analysis of radiologists' performance

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Abstract
Purpose. The aim of this study was to evaluate the efficacy of a computer-aided diagnosis (CAD) system we developed that can also respond to subsolid nodules, for lung cancer screening using low-dose spiral computed tomography (LDCT).
Materials and methods. The institutional review board approved this study. A total of 30 positive cases (including 15 lung cancer cases) that needed further examination and 30 negative cases were used for the observer performance study. Three thoracic radiologists, five general radiologists, and three residents participated in this study in which they first read the original CT image on its own and then reassessed the same image with the assistance of CAD. Radiologists' performance was evaluated using receiver operating characteristic (ROC) analysis.
Results. The Az values without and with CAD were 0.872 and 0.910 for the thoracic radiologists, 0.864 and 0.924 for general radiologists, and 0.875 and 0.837 for residents, respectively. The detection accuracy improved significantly for the thoracic and general radiologists with our CAD system; however, no statistically significant difference between without or with CAD was seen for residents.
Conclusion. This CAD system is beneficial in the detection of pulmonary nodules on LDCT when used by experienced radiologists.

Key words Computer-aided diagnosis (CAD) · Lung cancer screening · Low-dose spiral CT (LDCT) · Receiver operating characteristic (ROC) analysis

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Introduction

Lung cancer is the leading cause of cancer deaths in developed countries. In Japan, since 1993, lung cancer has been the leading cause of male cancer deaths. The Minister of Health, Labor and Welfare revealed that there has been a 3.5 fold increase in male and a 2.6 fold increase in female deaths due to lung cancer over the last 40 years.[1] According to the findings of some reports, screening with chest radiography and sputum cytology has not been found to effectively decrease the mortality rate.[2–5] Lung screening CT (LSCT) using low-dose spiral CT (LDCT), the highest sensitivity imaging tool for the detection of pulmonary nodules, has been used by researchers for detection of early lung cancer since the 1990s.[6–14]

LSCT is a powerful tool for earlier detection of thoracic malignancies, although it remains to be seen whether LSCT reduces lung cancer mortality and whether LSCT is actually cost-effective.[13–15] One drawback to LDCT is that the number of CT images that would have to be read per working hour would grow significantly. This could be problematic as it could lead to reduce concentration and rushed judgments. A computerized method for lung nodule detection could help overcome this problem by helping the CT reader concentrate on computer-aided diagnosis (CAD) detected pulmonary lesions. We have developed an automated computer program for the detection of pulmonary nodules. This CAD was made up for detection of nodules which are necessary to discriminate between the lung cancer and others by further examination.

The purpose of this study is to determine whether the CAD system developed is effective in the initial detection of pulmonary nodules and to determine if that lead to an increase in CT reader assessment accuracy.

Materials and methods

Case selection

The institutional review board of our facility approved this study and the informed consent was obtained from the patients. Questionnaires about respiratory symptoms and smoking history were also attained from all participants prior to CT screening. Between 1998 and 2000, we conducted a total of 13 524 CT screenings for lung cancer, consisting of 7 956 individuals (6 313 men and 1637 women aged 50 years and older) as baseline.

In this study, a single detector spiral CT scanner was used and scanning parameters were 120 kVp, 50 mAs and 10 mm collimated acquisition with a 2 to 1 pitch, an X-ray tube rotation speed of 1 second, 20 mm/second table speed, 10-mm-thick sections were reconstructed. In total, 64 patients underwent additional examinations consisting of serum tumor marker, bronchoscopy, and biopsy. Thoracic surgery or video-assisted thoracic biopsy was performed on 51 patients. Of these 51 patients, 36 cases were histologically confirmed to have primary lung cancer. The primary tumors were unifocal in 35 patients and multifocal in one patient.

One thoracic and one general radiologist chose the subjects for this study from our center's database. The former had 5 years of LSCT experience using LDCT and the latter had 2 years experience on the same. They did not participate in the observer performance study. All nodules were identified and diagnosed by them. After considering the balance of degree of their confidence level, they chose the nodules, which were used in the following observation study, not to cluster one side of the degree of difficulty. Finally, they selected 60 cases, including 30 positive and 30 negative for the observer performance study. Interpretation time and degree of difficulty were taken into consideration. The positive cases were those who needed thin-section CT for further examination. They were defined as non-calcified nodules of 5 mm or more in maximum diameter. Final diagnoses of this positive group using biopsy resulted in: 13 adenocarcinomas, two atypical adenomatous hyperplasias, and 15 benign nodules that include granulomas, inflammatory changes, tuberculomas, and intrapulmonary lymph nodes. On thin-section CT of positive nodules, 7 nodules were 5–10 mm in maximum diameter, 15 nodules were 11–20 mm, and 8 nodules were 21–30 mm. Using Henschke et al. CT-screening-lung-nodule-classification, thirty positive cases were classified into 25 subsolid nodules (11 part-solid nodule and 14 non-solid nodules) and five solid nodules.[16] Solid nodule was defined as a nodule that completely obscures the entire lung parenchyma within it whereas the subsolid nodule does not. A subsolid nodule was further classified as either part-solid (nodule with patches of parenchyma that are completely obscured) or non-solid (nodule with no such areas). Negative cases were defined as those that went unchanged over a 2-year period and were either a clear lung or a lung with a nodule less than 5 mm in maximum diameter, an interstitial change, or scarring.

Computerized scheme for automated detection of pulmonary nodules

Our CT nodule detection method is outlined in Fig. 1. There are various stages in detecting pulmonary nodules using this CAD system. First the system enhances input images through binary processing so that structures with higher attenuation than pulmonary parenchyma are selected. Second, to exclude regular intrapulmonary structures such as bronchi, vessels and pleura, the high attenuation structures are processed with cutting and localization processing algorithms. As a result, nodular opacities are separated from the regular intrapulmonary

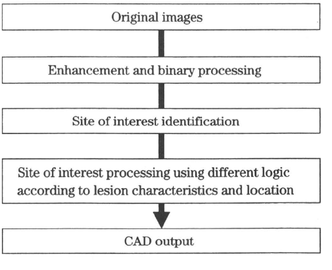

Fig. 1. Flow chart of computer-aided diagnosis (*CAD*) system for detection, processing, and identification

structures. Third, sites of interest that are greater than 5 mm in maximum diameter are recognized. Each site of interest is then processed several times by CAD. Each time, different logic is used at the site of interest to determine the presence or absence of ground-glass opacities, discontinuous high attenuation areas different from vessels, bronchial wall or pleural thickening. Sites with suspected nodules were then processed according to lesion characteristics such as area, center, shape, and density. Again, different CAD logic is used to differentiate between a hazy opacity and a solid opacity nodule. Furthermore, nodules located at the periphery of parenchymas were analyzed using different assessment logic than that used for centrally located nodules. The resulting output image is then displayed on the monitor for assisting the diagnosis. One of the advantages of this system in detecting nodules is that it can detect subsolid nodules such as atypical adenomatous hyperplasias as well as well-differentiated adenocarcinomas. This CAD system was first preliminarily applied to a database consisting of the 64 CTs with 65 actionable lung cancers with further necessary examination (e.g., bronchoscopy, biopsy, etc.). Using this database, we achieved a detection sensitivity of 81.5% with an average of 15.1 false-positive detections per case.

Figure 2 shows examples of CAD output. In each case the system encircles a candidate nodule. Three adenocarcinomas in Fig. 2 were correctly identified by the CAD system. Two false-positive nodules (Fig. 2C) corresponding to the azygos vein and overlapping pulmonary vessels were also identified. This CAD system was able to detect subsolid nodules reliably, which appeared as hazy opacities (ground-glass attenuation) on LDCT. Twenty of the 25 subsolid nodules and four of five solid nodules were identified by the CAD system correctly.

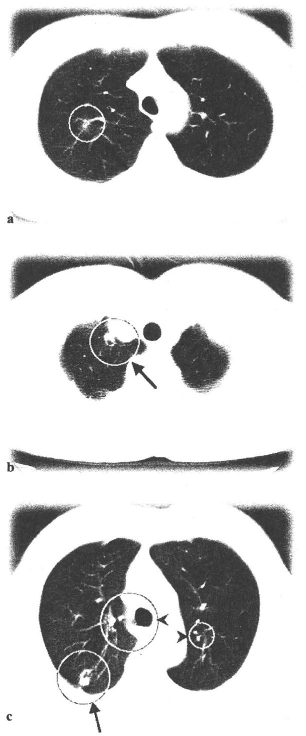

Fig. 2. CAD system output. Each suspect site on the image was established by placing a circle. **A** A 50-year-old man with well-differentiated adenocarcinoma (*arrow*). An adenocarcinoma is correctly identified by the CAD system. **B** A 62-year-old man with moderately differentiated adenocarcinoma (*arrow*). An adenocarcinoma is correctly identified by the CAD system. **C** A 63-year-old man with well-differentiated adenocarcinoma (*arrow*). An adenocarcinoma is correctly identified by the CAD system. Two false-positive nodules (*arrowheads*) corresponding to an azygos vein and overlapping pulmonary vessels are apparent

Observer performance study

Eleven radiologists (three thoracic radiologists, five general radiologists, and three radiology residents) took part in the observer performance study. The three thoracic radiologists had over 10 years of experience and the five general radiologists had between 5 to 10 years of experience. Prior to participating in the study, observers were trained on the CAD system using ten training cases (5 positive and 5 negative) to learn the rating method and also to learn how to operate the CAD system. The degree of difficulty for the 10 training cases was adjusted to be at the same level as the 60 cases that were to be used in the observation study. The training cases were separate from the 60 cases used in the observer performance study. Prior to performance testing, observers were provided with each patient's sex, age and smoking habits. In addition, they were informed that half of the cases to be assessed were in fact positive, and nodules measured from 5 mm in maximum diameter to 30 mm on thin-section CT. Some cases had more than one inflammatory nodule. However cases with multifocal cancers were excluded from this study.

Each observer recorded his confidence level regarding the presence or absence of a nodule using a line-marking method, on a continuous rating scale, to see if further examination was needed. A chest CT image was first interpreted without CAD, and the confidence level was indicated by marking a slash across a 5-cm long rating scale line in black.[16] Then the observer viewed the same image after being processed by the CAD system and then this second confidence level was indicated in red on the same rating scale line. Study cases were presented in random order to each reader. Although reading time was not limited, readers were asked to assess the images at the rate they would assess during a normal working day. For each reader, the time to complete the study was recorded. For all results, the distance from the start of the scale to the point where the reader put a slash mark on the scale was measured and interpolated on a scale of 0 to 100.

Statistical analysis

Receiver operating characteristic (ROC) analysis (LABROC5 program by Metz et al, University of Chicago, IL, USA) was used for comparing the observer performance in discriminating between positive and negative cases without and with CAD. The accuracy of the detection was quantified by using the area under the ROC curve (A_z value). We used "ROCKIT" and "corresponding two-tailed paired t test" for analyzing significant difference. A beneficial or detrimental effect due to the use of CAD was evaluated in terms of the difference between the first and second rating score.[17,18] We assumed that the computer output had had an effect on an observer's diagnosis when there was a difference in the rating score of 30% or more between the first and second ratings. The statistical significance of the difference between the average number of cases affected beneficially and those affected detrimentally was evaluated with a nonparametric two-tailed test for paired data. P values of less than 0.05 were considered to indicate a significant difference.

Table 1. Values for each radiologist for interpretations without and with CAD

	Az value	
Observer	Without CAD	With CAD
Thoracic radiologists		
A	0.764	0.817
B	0.906	0.960
C	0.947	0.953
Mean	0.872	0.910
General radiologists		
D	0.835	0.894
E	0.883	0.932
F	0.890	0.922
G	0.947	0.956
H	0.767	0.914
Mean	0.864	0.924
Residents		
I	0.768	0.747
J	0.928	0.922
K	0.911	0.842
Mean	0.875	0.837
All	0.871	0.890

CAD, computer-aided diagnosis; A_z value, area under the receiver operating characteristic (ROC) curve

Results

In this study, the sensitivity of the CAD system was 80% for the 30 significant pulmonary nodule cases (100% for the 15 neoplasms) and showed 15 false positives for each case. This CAD system was able to detect subsolid nodules, which appeared as hazy opacities (ground-glass attenuation) on LDCT.

The A_z values for each observer in detecting all pulmonary nodules without and with CAD output are summarized in Table 1. The A_z values for all radiologists significantly increased from 0.871 without CAD to 0.891 with CAD ($P < 0.05$) (Fig. 3). The A_z values also showed significant improvement ($P < 0.05$) for thoracic and general radiologists: for thoracic radiologists from 0.872 without to 0.910 with CAD, and for general radiologists from 0.864 without to 0.924 with CAD. For residents, however, the A_z value decreased from 0.875 without CAD to 0.834 with CAD, although a statistical significant difference could not be seen.

For positive cases, the average number of cases affected beneficially was 1.64 and was significantly larger than that affected detrimentally (average number was 0.36). The beneficial cases included one solid nodule (a total of two readings by two observers), one part-solid nodule (a total of two readings by two observers), and 10 non-solid nodules (a total of 14 readings by seven observers). The beneficial cases with neoplasms included one solid and one part-solid adenocarcinoma, located on the pleura and which mimicked non-significant pleural changes, and five non-solid nodules, two of them were atypical adenomatous hyperplasias and three were adenocarcinomas (one of which was obscured by the central bronchovascular bundle). These beneficial cases demonstrated that the observers could correct their oversight when the CAD pointed out irregularities.

For negative cases, a significant statistical difference was not seen.

The average time to complete the study was one hour 47 minutes for all 60 cases (thoracic radiologists, one hour 19 minutes; general radiologists, one hour 42 minutes; and residents, two hours 22 minutes, respectively.)

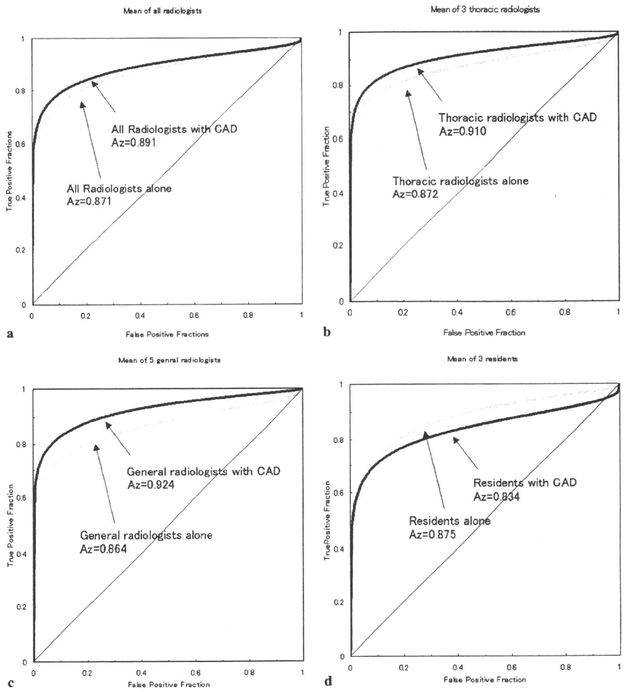

Fig. 3. Graphs of receiver operating characteristic (ROC) curves. **A** Graph shows ROC curves for all radiologists in the detection of lung nodules without (area under receiver operating characteristic curve) (A_z = 0.871) and with (A_z = 0.891) CAD output images, indicating a significant difference ($P < 0.05$). **B** ROC curves for three thoracic radiologists in the detection of lung nodules without (A_z = 0.872) and with (A_z = 0.910) CAD output images, indicating a significant difference ($P < 0.05$). **C** ROC curves for five general radiologists in the detection of lung nodules without (A_z = 0.864) and with (A_z = 0.924) CAD output images, indicating a significant difference ($P < 0.05$). **D** ROC curves for three residents in the detection of lung nodules without (A_z = 0.875) and with (A_z = 0.834) CAD output images. A statistically significant difference could not be seen

Discussion

The basic goals of CAD are to provide a computer output as a second opinion and to assist radiologists' image interpretation by improving the accuracy and consistency of radiological diagnosis and also by reducing the image reading time. A number of CAD systems that emphasize clinical applications have already been developed for chest radiograph and chest CT.[19–26] Lung screening with CT generates a large number of images, and as a result, the diagnostic accuracy of the radiologist may be adversely affected by the increased workload. We performed more than 30 000 CT lung cancer screenings during the past 5 years, and have found that the substantial increase in the number of images which needed to be processed on a daily basis to be problematic. It is feared that under such a workload readers might make misjudgments or even overlook some nodules.

The increased cost of interpretation when two readers are employed for a double reading has also motivated the development of the CAD method with the idea that CAD could be used to replace the second reader.

Armato et al. reported that a large fraction (84%, 32 of 38) of missed cancers in a database of low-dose CT scans were detected correctly with an automated lung nodule detection method.[27] Their method achieved 80% detection sensitivity with an average of 28.3 false-positive detections per scan. Although they had proven the great efficacy of CAD on LSCT, it had not yet been fully confirmed whether CAD could improve a reader's diagnostic accuracy or consistency. For establishing the practical value of CAD, it is indispensable to compare observers' performance in detecting nodules between with and without use of CAD. Also, there are a few CAD systems available for lung screening with LDCT.[19,24,26]

In this paper we propose a new CAD system that works well with "low dose" CT and responds to subsolid nodules like atypical adenomatous hyperplasia or well-differentiated adenocarcinoma. In the current study, when using CAD, the average A_z values for all observers increased. For the positive cases, the number of cases affected beneficially was significantly greater than those affected detrimentally, which demonstrates that CAD was effective in increasing detection accuracy of pulmonary nodules on LDCT. In CT screening for lung cancer, the detected nodule typically is either part-solid or non-solid. But such a nodule is more likely to be malignant than a solid one, even when nodule size is taken into account, as emphasized by Henschke et al.[27] Therefore, part-solid and non-solid nodules need to be studied in greater detail. In the current study not only solid nodules but also subsolid nodules (a total of 16 readings) were rescued from being overlooked by using the CAD system. Thus, we believe, such CAD is useful in preventing the oversight of both solid and subsolid pulmonary nodules on LDCT.

Our findings differ from previous reports, which have stated that CAD was effective for all readers independent of their radiology experience.[19,20,22,26] According to MacMahon et al., when CAD was used on chest radiographs detection accuracy was significantly higher for all reader categories including chest radiologists, general radiologists, radiological residents, and non-radiologists.[22] In our study, however, CAD was not effective for residents. Although nodules of up to 10 mm in maximum diameter would have been previously obscured by the heart or the diaphragm on a chest radiograph, all readers could now readily see them on LDCT. In cases of a ground-glass attenuation nodule and a small nodule adjacent to the pulmonary vessels, however, the reader still needed to master basic pulmonary anatomy prior to being able to recognize them on LDCT. Even though our CAD system readily detected well-differentiated adenocarcinomas and atypical adenomatous hyperplasias when they appeared as hazy opacities (ground-glass attenuation) on LDCT, inexperienced readers who were not aware that atypical adenomatous hyperplasias showed as a hazy opacity on LDCT misdiagnosed them as regions of no interest even after being identified correctly by CAD. Generally, residents tended to display poor judgment when evaluating unfamiliar opacities. As a result, we believe that our CAD system would be most effective when used by knowledgeable and experienced radiologists. Furthermore, a large number of false positives might have confounded some inexperienced radiologists who have had limited knowledge in pulmonary anatomy or who were not familiar with the CAD system. The study resultsseem to suggest that bringing the CAD system into a reading room cannot be a substitute for providing basic education and knowledge of pulmonary nodules and pulmonary anatomy. For two neoplasm cases, two observers (one resident and one general radiologist) detected the lesions correctly at the initial reading, but they changed their responses at the second session with the CAD, probably because they considered the lesions to be false positives of the CAD. This detrimental effect on neoplasm cases seemed to be affected by the number of false positives.

There were several limitations to our study. First, this study was performed using a single-detector row CT. The current trend is that multi-detector row CT (MDCT) may be more suitable for primary lung cancer screening. Thus we need to adopt our CAD system to work with MDCT.[28–30] However, single-detector row CTs are still in widespread use throughout the world. We are sure that CAD adjusted to LDCT is required to help with a broad range of LSCT measures. The second limitation was the slightly high ratio of false positives using our CAD system. As our CAD system achieved a detection sensitivity of 80% with an average of 15 false-positive detections per scan, we believe that our system's performance was not lower than others, although it is hard to directly compare nodule detection accuracy amongst different systems because of the differences in data sets and methods.[23] Since our current CAD system was not always effective when used by residents, we are now improving our system by decreasing the number of false positives. Third, the number of thoracic radiologists and residents in our observer performance study was relatively small. The fourth limitation was the high positivity rate of the data set. This may be the most important factor which could affect the overall results. Expecting a high positivity rate, observers could make extra effort to detect the true positives. However, if the positivity rate goes down as we experience in a mass screening setting, the CAD outputs might tire observers, especially residents. Additional prospective studies in a mass screening setting with a large number of observers may be necessary to confirm the usefulness of this CAD. Finally, it has yet to be determined whether it would be acceptable to substitute the second reader by CAD when performing a double reading in a clinical situation. Therefore, future research comparing the performances of a single reader assessment with CAD and a double reader assessment without CAD is necessary.

Conclusion

Our results suggest that the CAD system is beneficial in the detection of lung nodules on LDCT when used by experienced radiologists. It seems that this CAD system has potential to improve the accuracy of lung cancer detection on LSCT.

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症例報告

胸部CT検診の逐年検診で発見された教訓的な肺がんの4症例

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はじめに

胸部CTを用いた肺がん検診では、胸部単純X線写真のそれと比較して肺がん発見率が高く、特に導入当初では胸部単純X線写真の数倍の率で発見される[1~3]。

一方で、経年的に胸部CT検診を継続してくると、発見率が低下するだけでなく、炎症や胸膜変化などとの鑑別に苦慮する症例を経験する。

今回は、自施設で行ってきた11年間の胸部CT検診で、最近発見された興味深い症例の供覧を行う。

対　象

1998年4月から2008年12月に胸部CT検診を実施した、実人数16,492人(男性：女性＝13,954：2,538)、検査件数63,469件(男性：女性＝53,552：9,917)、平均年齢は57歳である。

発見肺がんは、105病変(初回64病変、経年41病変)で、Ⅰ期は89病変(84.7%)、うちⅠA期83病変、ⅠB期6病変である。

今回提示の4症例は、いずれも初回受診時には肺がん疑いと判断していないが、経年変化を観察することで診断に至った症例である。

方　法

撮影条件は、導入当初はシングルスライスCTで行っていたが、2006年1月より日立メディコ社製ROBUST　マルチスライスCT　管電流16 mAs(可変)・管電圧120 kV・pitch5・3.75 mm×4列・CTDI 1.4 mGyである。

症例供覧

症例1；初回受診時との比較が診断に有用だった症例　Fig. 1 (a) ～ (c)

69歳、男性。過去喫煙者(40本×27年)。

2009年2月の検診では右S10に径11 mmのpart-solid noduleを認める。2008年2月との比較では、サイズに変化がはっきりせず非特異的な炎症の所見と鑑別が困難である。しかし、初回受診時の2001年では病変が存在せず、緩やかに増大する腫瘍性病変が疑われ、医療機関紹介となった。

病理；adenocarcinoma with mixed subtype, pT1N0M0

症例2；高危険群への積極的な受診勧奨により発見された症例　Fig. 2 (a), (b)

65歳、男性。現喫煙者(20本×45年)。

2001年の初回受診時に肺気腫を指摘され、禁煙指導を行った。退職を契機に当施設での職域型人間ドックから他施設での健康診断に変更されていた。2007年に肺気腫症例の経過観察を目的としたプログラム[3]への参加を案内し、6年ぶりのCT検診を実施した際に、右S3に充実成分が優位な径26 mmのpart-solid noduleを発見された。

病理；mixed papillary and acinar adenocarcinoma

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症例3；緩徐な増大のために炎症との鑑別が困難だった症例　Fig. 3 (a), (b)

69歳、男性。非喫煙者。

2003年の初回受診時に、左S6に径10 mmの淡い索状陰影を認めたが、炎症性変化と判断された。以降のCT検診でも経年変化が乏しかったが、2007年時では径20 mmであり緩やかな増大ありと判断され、医療機関紹介となった。医療機関で1年経過観察の後に肺がん疑いで内科から外科転科し手術となった。

病理；adenocaricinoma（詳細不明）

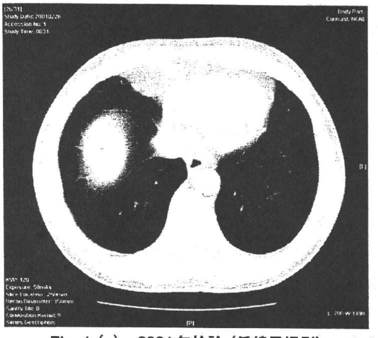

Fig. 1 (a)　2001年検診（低線量撮影）

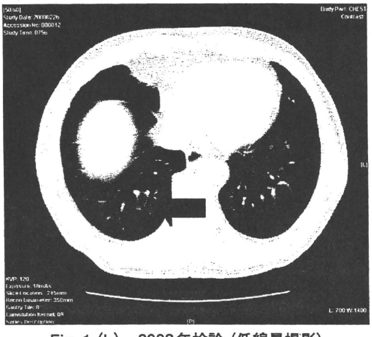

Fig. 1 (b)　2008年検診（低線量撮影）

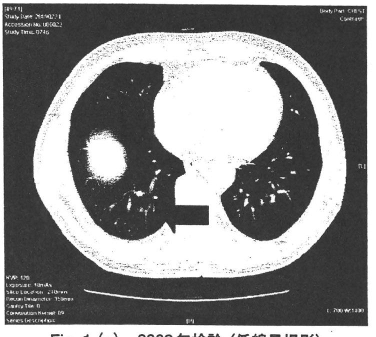

Fig. 1 (c)　2009年検診（低線量撮影）

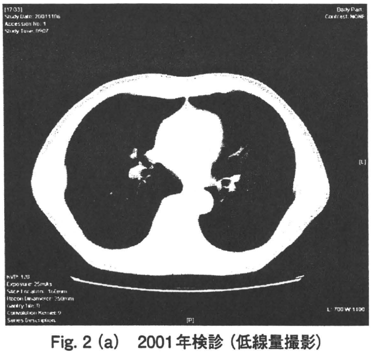

Fig. 2 (a)　2001年検診（低線量撮影）

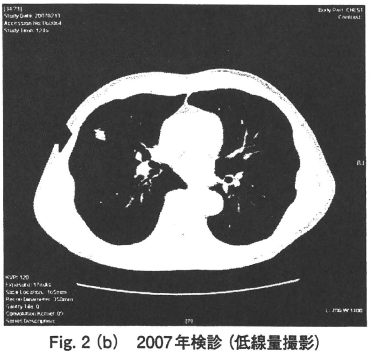

Fig. 2 (b)　2007年検診（低線量撮影）

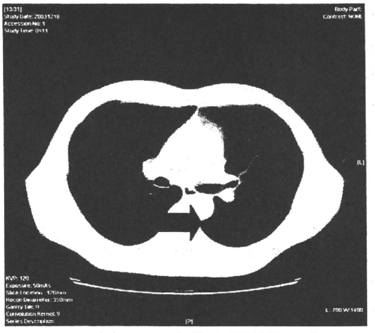

Fig. 3 (a)　2003年検診（低線量撮影）

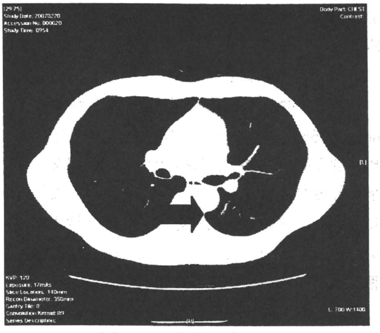

Fig. 3 (b)　2007年検診（低線量撮影）

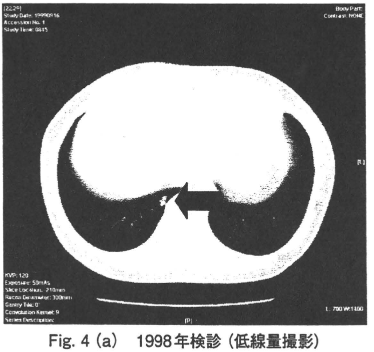

Fig. 4 (a)　1998年検診（低線量撮影）

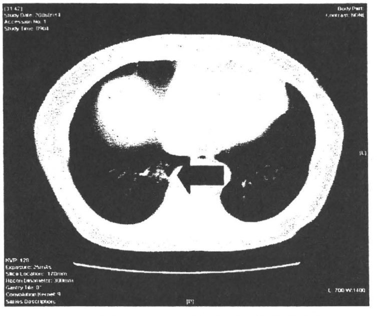

Fig. 4 (b)　2006年検診（低線量撮影）

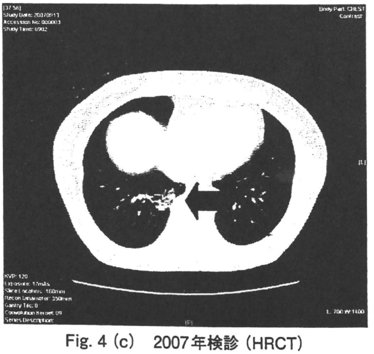

Fig. 4 (c)　2007年検診（HRCT）

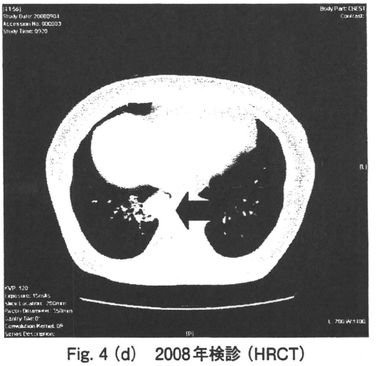

Fig. 4 (d)　2008年検診（HRCT）

症例4；骨棘に伴う変化と判断した症例

Fig. 4 (a) ~ (d)

67歳、女性。非喫煙者。

1998年の検診で、肺底部の椎体右側にpart-solid noduleを認めたが、椎体の骨棘に伴う肺野変化と判断された。2007年検診と初回を比較すると増大は明らかであったが、最近1、2年では著変なく遷延化した炎症と考え経過観察していた。2008年で充実部分が38 mmと急速増大し、医療機関紹介となった。

病理；mucinous-BAC , pT4N0M0

考 察

渡邊らは、初回CTにて瘢痕様の所見を呈していた肺がんは、既存肺に陳旧性炎症性変化や肺気腫、肺線維症などの変化を伴うことが多いが、腫瘍倍加時間が短い浸潤がんも多く予後不良な症例が見られると報告している[4]。症例2では背景肺野に肺気腫を生じており、腫瘍倍加時間の短い浸潤がんを早期発見するには短い間隔での定期的な検診受診を勧奨することが必要であると考える。また、症例4は既存肺に有意な変化が乏しい非喫煙者の女性であったが、micinous-BACのように急激にサイズが変化するがんの存在に留意する必要がある。

経年受診者では、直近の1、2年との比較読影だけでは、症例1や3のように緩徐な増大を判断することが難しいと考えられる。このような症例では、初回受診時を含め過去における全ての画像との比較を行うことで、正確な診断に近づくことが出来る。それをサポートするために、容易に過去画像やレポートの参照ができるシステム作りが望まれる。

がん検診は、それを受診する集団における死亡率減少効果を示すことで、それが有効であることが証明される。この精度を高めるには、受診者を定期的に経過観察したり転帰を確実に把握したりすることも重要である。症例2では、その重要性を再認識したが、さらにはCT検診受診者全体への禁煙支援を行い、検診での肺がん早期発見にとどまらずリスクの低減を目指した包括的な肺がん対策をすることも考えさせられた。

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A cautionary lesson from lung cancer screening study using low dose CT in eleven years. Four cases of lung cancer.

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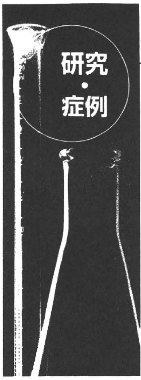

喫煙習慣の変化と身体組成，体力の変化との関連

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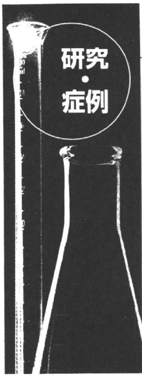

喫煙習慣の変化と身体組成，体力の変化との関連

宮武伸行* 西井研治** 後藤礼子*
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Summary 運動，食事，休養に関するアドバイスを行った者を対象に，禁煙が身体組成，体力に及ぼす影響を検討した。対象は男性 907 名（41.7±13.6 歳）であった。1 年間で喫煙者は有意に減少し，喫煙継続者（249 名）と禁煙達成者（39 名）では，年齢補正を行うと 2 群間で身体組成の変化の有意な差は認めなかったが，禁煙後の体重，body mass index（BMI），体脂肪率の増加と全身持久力の低下は有意に関連していた。以上より禁煙には，運動，食事，休養も含めた生活習慣改善のアドバイスが必要と思われた。

Key words 喫煙習慣，生活習慣，身体組成，全身持久力／cigarette smoking, life style, body composition, aerobic exercise level

はじめに

喫煙が，癌，心臓病，脳血管障害をはじめとしたさまざまな生活習慣病の危険因子であることは明らかであり[1)]，地域，職場で禁煙が勧められている。以前われわれは，喫煙習慣が，メタボリックシンドロームの重要な修飾因子であることも明らかにした[2)]。また，喫煙者では，運動，食事の生活習慣の乱れも認められたこと[3)]，ストレス解消法を持つ者の割合が有意に少ないこと[4)]，さらに，健康度測定実施時に禁煙も含めた運動，食事，休養に関する生活習慣改善のアドバイスによって喫煙者が有意に減少したことを，1 年間隔での健康度測定による調査[5)]，郵送法による調査[6)]で明らかにした。

一方，一般臨床の場では，禁煙達成者から，「禁煙によってかえって体重，体脂肪率が増加した」，「太って体力が落ちた」という声も多く聞く。肥満，内臓脂肪の蓄積はさまざまな生活習慣病の重要な原因のひとつであり，禁煙後の体重管理は重要な問題と思われる。

今回，岡山県南部健康づくりセンターでの健康度測定受診者において，運動，食事，休養に関するアドバイスを行った者を対象に，禁煙が身体組成，体力に及ぼす影響を検討した。

対象と方法

対象は，岡山県南部健康づくりセンターで，

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表 1　対象

	平均値±標準偏差
症例数	907
年齢	41.7±13.6
身長（cm）	169.1± 6.1
体重（kg）	68.0± 9.0
Body mass index（kg/m^2）	23.8± 2.8
腹囲（cm）	81.8± 8.3
ヒップ囲（cm）	93.2± 5.1
体脂肪率（%）	23.3± 6.3
推定 50%最大酸素摂取量（ml/kg/分）	19.0± 3.5
50%時仕事量（watt）	80.0±17.5
右握力（kg）	44.1± 7.9
左握力（kg）	42.3± 7.7
脚伸展力（kg）	65.1±16.0
脚伸展力（kg）/体重（kg）	0.96±0.22

メディカルチェック（尿，血液検査），ヘルスチェック（生活習慣状況調査，体力テストなど）を1年間隔で2度受診し，喫煙の有無に関する調査，全身持久力測定を受けた男性907名（41.7±13.6歳）であった（**表1**）。

メディカルチェック，ヘルスチェックは当センター会員になるために必須となっており，尿，血液検査，生活習慣状況調査，体力テストの結果などをもとに，医師，運動指導員，管理栄養士，保健師から禁煙も含めた生活習慣改善のアドバイスを行っている。さらに1年後にも受診してもらうことによって生活習慣改善の実践度を評価し，さらなる生活習慣改善継続に役立ててもらっている。

喫煙の有無は，自記式問診表により「吸う」，「吸わない」の2件法で評価した。体力は，身長，体重，腹囲，ヒップ囲，体脂肪率，全身持久力，筋力を計測，測定した。腹囲は立位，呼気時に臍部で計測し，体脂肪率は空気置換法（BOD POD body composition system）[7)8)]を用いて評価した。また，体重（kg）/身長^2（m）により body mass index（BMI）を算出

表 2　喫煙習慣の変化

前	後 喫煙者	後 非喫煙者	p	p（年齢補正後）
喫煙者	249	39	<0.0001	<0.0001
非喫煙者	17	602		

した。全身持久力は自転車エルゴメーターを用いて多段階漸増負荷法により評価した[9)]。筋力は，左右の握力，脚伸展力を測定した。握力は THP-10（SAKAI, Tokyo），脚伸展力は COMBIT CB-1（MINATO, Osaka）をそれぞれ用いて測定し，さらに体重の影響を考慮し，体重あたりの脚伸展力（脚伸展力：kg/体重：kg）も算出した[10)]。

結果は，平均値±標準偏差で表し，有意差検定はχ^2検定，ロジスティック回帰分析，対応のないt検定，共分散分析法を，相関関係はピアソンの相関係数を用いて行い，有意水準5%未満を有意とした。

なお，本調査研究内容については，岡山県健康づくり財団倫理委員会の承認を得た。

結　果

禁煙を含む運動，食事，休養の生活習慣改善のアドバイスを行った1年後の喫煙習慣の変化を**表2**に示す。喫煙者はもともと288名（31.8%）であったが，1年後には266名（29.3%）となり，有意な減少が認められた。

喫煙継続者249名と禁煙達成者39名で，初回健康度測定時における年齢，身体計測，身体組成，全身持久力，筋力を比較した結果を**表3**に示す。禁煙達成者は喫煙継続者に比較して年齢が有意に高く，BMI，右握力が有意に低かった。年齢に有意差を認めたため，

表 3 喫煙継続者と禁煙達成者の身体組成，体力の比較（前）

	喫煙継続者	禁煙達成者	p	p（年齢補正後）
症例数	249	39		
年齢	38.5±11.6	45.3±14.3	0.0011	
体重（kg）	69.1± 9.0	66.1± 8.6	0.0515	0.9751
Body mass index（kg/m²）	24.0± 2.8	23.0± 2.4	0.0348	0.9107
腹囲（cm）	82.4± 8.6	80.5± 8.5	0.2076	0.8443
ヒップ囲（cm）	93.8± 4.8	92.6± 4.9	0.1517	0.9886
体脂肪率（%）	23.0± 6.3	21.6± 6.2	0.1919	0.1187
推定 50%最大酸素摂取量（ml/kg/分）	18.9± 3.3	19.3± 3.9	0.4496	0.1467
50%時仕事量（watt）	80.6±15.8	79.3±17.8	0.6353	0.2729
右握力（kg）	45.4± 7.6	42.0± 7.6	0.0094	0.8524
左握力（kg）	43.3± 6.6	41.4± 7.0	0.0903	0.2059
脚伸展力（kg）	66.2±14.6	65.4±18.3	0.7740	0.0302
脚伸展力（kg）/体重（kg）	0.96±0.21	0.99±0.26	0.4423	0.0193

（平均値±標準偏差）

表 4 喫煙継続者と禁煙達成者における身体組成，体力の変化量の比較

	喫煙継続者	禁煙達成者	p	p（年齢補正後）
症例数	249	39		
体重（kg）	−0.2± 3.4	1.3± 3.7	0.0133	0.6362
Body mass index（kg/m²）	−0.1± 1.2	0.5± 1.2	0.0057	0.9661
腹囲（cm）	−0.5± 4.7	1.4± 4.9	0.0231	0.9703
ヒップ囲（cm）	−0.1± 2.5	0.6± 3.0	0.1247	0.2607
体脂肪率（%）	−0.8± 4.0	1.2± 4.1	0.0045	0.9284
推定 50%最大酸素摂取量（ml/kg/分）	0.2± 3.0	0.0± 2.4	0.6243	0.2555
50%時仕事量（watt）	2.0±13.4	2.6±11.2	0.8115	0.0288
右握力（kg）	−0.6± 4.6	0.9± 5.0	0.0512	0.0100
左握力（kg）	−0.8± 4.3	0.0± 4.9	0.2696	0.0151
脚伸展力（kg）	4.3±12.9	2.0±12.9	0.3011	0.1569
脚伸展力（kg）/体重（kg）	0.07±0.19	0.01±0.19	0.1020	0.1308

（平均値±標準偏差）

共分散分析法を用いて年齢を補正すると，禁煙達成者は喫煙継続者に比較すると脚伸展力は有意に低値を，脚伸展力/体重の値が有意に高値を示した。

喫煙継続者と禁煙達成者における身体組成，体力の変化量の比較を年齢を補正して行ったところ（**表 4**），禁煙達成者では，喫煙継続者に比較して 50%時仕事量，左右の握力が有意に上昇していたが，その他の体力および身体組成の項目での有意な差は認められなかった。つまり，喫煙継続者に比較して禁煙したことによる身体組成の有意な変化は認められず，一部の体力指標の向上が認められた。

禁煙達成者 39 名で，推定 50%最大酸素摂取量の変化量と身体組成の変化量との関連を検討したところ（**表 5**），推定 50%最大酸素摂取量の変化量と体重，BMI，体脂肪率の変化量との間に有意な負の相関を認めた（**表 5, 図**）。

表 5　禁煙達成者における推定 50%最大酸素摂取量変化量と身体組成変化量との関連

	r	p
体重（kg）	−0.339	0.0350
Body mass index（kg/m²）	−0.360	0.0244
腹囲（cm）	−0.236	0.1484
ヒップ囲（cm）	−0.118	0.4737
体脂肪率（%）	−0.368	0.0213

考　察

禁煙後の体重，身体組成の変化に関する検討に関してはいくつか報告がなされている。富永らは，働く世代の男性で，禁煙前後の体重変化と生活習慣の変化を検討している[11]。20〜39 歳の若年男性では，禁煙達成者は喫煙継続者に比較すると 2 年間で体重が有意に増加（3.7 kg）し，毎日間食する者が有意に多くなったと報告し，禁煙後の体重増加の原因として間食摂取の増加による摂取エネルギーの増加を示唆している。Kadowaki らは，禁煙後 6 年間の体重，BMI の変化を追跡し，禁煙後，18 カ月で，BMI が 1.10 kg/m^2，30 カ月で 1.55 kg/m^2増加し，その後，66 カ月まで次第に減少（1.00 kg/m^2）していたことを報告している[12]。今回われわれの検討でも，喫煙継続群に比較すると有意ではないものの，禁煙達成者では 1 年間で体重が 1.3 kg，BMI が 0.5 kg/m^2，腹囲が 1.4 cm 増加したが，生活習慣全般の改善のアドバイスを組み合わせたため，既報と比較して，比較的身体組成の変化は少なかったと思われた。

Mitsumune らは，禁煙後 6〜18 カ月の男性 240 名を対象に，禁煙後には体重，最高血圧，総コレステロール，LDL コレステロール，HDL コレステロール，尿酸，AST が上昇したと報告している。さらに禁煙後の体重変化で 4 分割し，体重変化が最も少ない群では，HDL コレステロールのみが上昇し，その他の値は低下する一方，体重が 1.8 kg 以上増加した群ではすべての値が喫煙継続者に比較して上昇したことを報告している[13]。禁煙が生活習慣病予防，改善に有効である一方，肥満，内臓脂肪蓄積が生活習慣病の重要な危険因子であることが明らかである。また，今回われわれは禁煙と全身持久力，筋力との関連にも

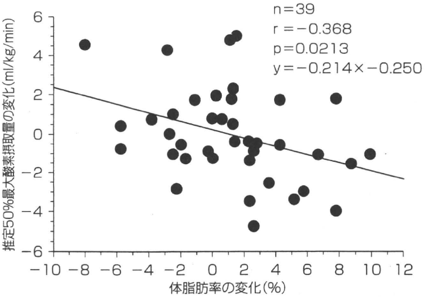

図　禁煙達成者における体脂肪率の変化と推定 50%最大酸素摂取量との関連

注目したが，禁煙達成者では，喫煙継続者と比較して禁煙後の有意な全身持久力，筋力の変化を一部認め，禁煙後の体重，BMI，体脂肪率の変化と全身持久力の変化との間に有意な負の関連を認めた。禁煙後の身体組成の悪化が全身持久力の低下の原因のひとつになっていることが示唆された。Mitsumuneらの報告のように禁煙後の体重増加は，血圧，血液検査値の悪化につながっていること，全身持久力自体が，健康寿命に関連していることが明らかとなっていることを考慮すると[14)]，禁煙後の体重増加をはじめとした体重，身体組成悪化予防のために有酸素運動を含めた適切な運動のアドバイスを行うことが必要と思われた。

今回の検討にはいくつかの問題点も残る。今回のアドバイスは禁煙だけに焦点をあてたものではなく，生活習慣全般にわたるアドバイスで，薬物療法の併用を行わなかったため禁煙達成者が39名と少数であった。また，1年間の追跡であり，さらなる継続調査が必要である。さらに全身持久力の評価は通常最大酸素摂取量やピーク時酸素摂取量を用いて評価することが多いが，心疾患などの潜在的な有病者がいる場合の危険性を考慮し，自転車エルゴメーターによる多段階漸増負荷法を用いて評価した。

以上，禁煙も含めた運動，食事，休養に関する生活習慣のアドバイスを行った者を対象に，1年後の喫煙習慣の変化および身体組成，体力に及ぼす影響を検討した。1年間で喫煙者は有意に減少し，生活習慣改善のアドバイスを組み合わせて行った場合，喫煙継続者と禁煙達成者では身体組成の変化の有意な差は認めなかった。しかしながら，禁煙後の体脂肪率等の増加と全身持久力の低下は有意に関連していたことからも，禁煙後の身体組成の変化に対する配慮が大切で，禁煙には，運動，食事，休養も含めた生活習慣改善のアドバイスが必要と思われた。

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ABSTRACT

Relationship between Changes in Smoking Cigarettes and Changes in Body Composition and Physical Fitness

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The link between changes in smoking cigarettes and changes in body composition and physical fitness was evaluated. We used data of 907 men with 1-year follow up. Subjects that smoked cigarettes were significantly reduced after 1-year. Significant differences were not noted in changes in body composition between subjects that smoked and those that did not after adjusting for age. However, changes in body weight, body mass index and body fat percentage were significantly correlated with changes in aerobic fitness level in subjects that did not smoke cigarettes. The present study indicated that lifestyle modification *i. e.* exercise, diet and mechanisms for coping with stress may be important in subjects that smoke cigarettes.

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原　著

院内感染事例での潜在性結核感染治療（予防内服）前のCTスクリーニングの有用性

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