Relationships (I) of International Classification of High-resolution Computed Tomography for Occupational and Environmental Respiratory Diseases with the ILO International Classification of Radiographs of Pneumoconioses for parenchymal abnormalities

Taro TAMURA[1]*, Narufumi SUGANUMA[2], Kurt G. HERING[3], Tapio VEHMAS[4], Harumi ITOH[5], Masanori AKIRA[6], Yoshihiro TAKASHIMA[7], Harukazu HIRANO[8] and Yukinori KUSAKA[1]

[1]Department of Environmental Health, University of Fukui School of Medicine, Japan
[2]Department of Environmental Medicine, Kochi University School of Medicine, Japan
[3]Department of Diagnostic Radiology, Radiology and Nuclear Medicine, Radiological Clinic, Miner's Hospital, Germany
[4]Department of Radiology, Finnish Institute of Occupational Health, Finland
[5]Department of Radiology, University of Fukui School of Medicine, Japan
[6]Department of Radiology, National Hospital Organization Kinki-Chuo Chest Medical Center, Japan
[7]Department of Surgery, Fukui Saiseikai Hospital, Japan
[8]Koyo Seikyo Hospital, Japan

Abstract: The International Classification of High-resolution Computed Tomography (HRCT) for Occupational and Environmental Respiratory Diseases (ICOERD) has been developed for the screening, diagnosis, and epidemiological reporting of respiratory diseases caused by occupational hazards. This study aimed to establish a correlation between readings of HRCT (according to the ICOERD) and those of chest radiography (CXR) pneumoconiotic parenchymal opacities (according to the International Labor Organization Classification/International Classification of Radiographs of Pneumoconioses [ILO/ICRP]). Forty-six patients with and 28 controls without mineral dust exposure underwent posterior-anterior CXR and HRCT. We recorded all subjects' exposure and smoking history. Experts independently read CXRs (using ILO/ICRP). Experts independently assessed HRCT using the ICOERD parenchymal abnormalities grades for well-defined rounded opacities (RO), linear and/or irregular opacities (IR), and emphysema (EM). The correlation between the ICOERD summed grades and ILO/ICRP profusions was evaluated using Spearman's rank-order correlation. Twenty-three patients had small opacities on CXR. HRCT showed that 21 patients had RO; 20 patients, IR opacities; and 23 patients, EM. The correlation between ILO/ICRP profusions and the ICOERD grades was 0.844 for rounded opacities (*p*<0.01). ICOERD readings from HRCT scans correlated well with previously validated ILO/ICRP criteria. The ICOERD adequately detects pneumoconiotic micronodules and can be used for the interpretation of pneumoconiosis.

Key words: Conventional radiography, Environmental lung disease, High-resolution computed tomography, ILO classification, Occupational lung disease, Pneumoconiosis, Silicosis

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*To whom correspondence should be addressed.
E-mail: tarou@u-fukui.ac.jp

Introduction

Pneumoconiosis is one of the oldest known occupational illness, and many attempts have been made over the years to prevent it in workers. Chest radiography (CXR) is used to evaluate the health hazards of dust exposure. The World Health Organization (WHO) and the International Labor Organization (ILO) use the ILO 2011-D International Classification of Radiographs of Pneumoconioses (ILO/ICRP) for secondary prevention of pneumoconiosis in the Global Program for Elimination of Silicosis (GPES). In fact, in many countries, the ILO/ICRP is used for screening and surveillance of pneumoconiosis[1, 2]. However, because of dimensional resolutions, CXR has limited ability to detect parenchymal changes in the lungs.

Computed tomography (CT), especially high-resolution CT (HRCT), plays a very important role in determining the diagnosis of respiratory diseases such as pneumoconiosis. An international expert meeting on the Helsinki Criteria recommended developing a standardized system for reporting the HRCT scans of asbestos-related disorders analogous to the ILO system[3, 4]. The experts developed the International Classification of HRCT for Occupational and Environmental Respiratory Diseases (ICOERD). The target of this classification was asbestos-related pulmonary diseases, silicosis, and tobacco exposure-related respiratory diseases such as emphysema[5].

The ICOERD is used for many purposes, including the diagnosis, epidemiological reporting, and screening of respiratory diseases[6–9]. However, few studies have reported on the accuracy and reproducibility of the ICOERD. In terms of reproducibility, we reported that the selection of reference films was reliable, based on correspondence with the ICOERD developers[10], and that the reading results from multiple independent readings had a good correspondence when the readers used reference films[11].

The profusion scale (based on the ILO/ICRP) and the grade scale (based on the ICOERD) were intentionally and independently developed at different times. The developers did not consider the consistency or compatibility of these two different scales. However, following the establishment of the Helsinki Criteria[3], the ICOERD was developed for scaling pneumoconiotic fibrosis in the parenchyma as a scale analogous to ILO/ICRP. Therefore, it is meaningful to investigate evidence of profusion-grade relationships. To date, no comparisons of the ICOERD and pre-existing validated modalities have been performed. Accordingly, this study aimed to establish the extent of agreement between the degree of pneumoconiotic parenchymal small opacities on posterior-anterior CXR (according to the ILO/ICRP) and on HRCT images (according to the ICOERD).

High-resolution computed tomography has a higher sensitivity than CXR in the identification of pneumoconiosis. It is particularly useful for identifying early-stage pneumoconiosis. The usefulness of HRCT can be evaluated by studying the relationships between CXR and HRCT findings for patients with early-stage pneumoconiosis, who have profusions of 0/1, 1/0, and 1/1, according to ILO/ICRP. False positives and false negatives in HRCT of early-stage pneumoconiosis cases can be investigated as another aspect of its usefulness. To this end, we chose a study population which had as many early pneumoconiosis cases as normal controls.

Subjects and Methods

Subjects

The study subjects were 74 male patients. Forty-six patients with substantial occupational exposure to mineral dust were recruited from among outpatients seeing physicians for suspected pneumoconiosis in the Koyo Seikyo Hospital (Fukui, Japan) and 28 control participants, who had no occupational exposure to mineral dust, were recruited from clerical offices of a private occupational health provider. For all subjects, the experts recorded subjects' occupational exposure history and smoking history [including smoking status (e.g., current smoker, ex-smoker, non-smoker), the average number of cigarettes per day, and the number of years the subject had smoked]. The subjects comprised 46 patients with and 28 controls without mineral dust exposure (e.g., crystalline silica, asbestos, cement). With regard to the longest occupational dust exposure histories, there were 4 cases involved with transportation in tunnels, 20 cases involved with tunnel excavation, 21 mineworkers, and 1 case with cements. Other minor dust exposure histories involved working in the ceramics, stonemason, abrasive grinding, and brass industries. The median of total years of dust exposure history was 31 yr (5–52 yr). There were 39 current smokers, 32 ex-smokers, and 3 non-smokers. All subjects provided their written informed consent after the risks and benefits of CXR and HRCT had been explained to them. Each subject underwent CXR and HRCT on the same day. The current study protocol was approved by the ethics review board of the University of Fukui School of Medicine (Fukui, Japan).

Radiological examinations

All subjects were examined with digital radiography using the high-kilovoltage technique (120 KV, 200–250 mA, photo timer of 10–20 ms, grid ratio of 12:1) and a flat panel detector (FPD) (CXDI-11, Canon, Tokyo, Japan). For image processing of FPD digital radiographs, we used density, contrast, and enhancement parameters of 19, 12, and 1, respectively. These parameters differ from the FPD parameters recommended by the Ministry of Health, Welfare and Labour, Japan[12], which recommends density ranges from 17 to 20, contrast ranges from 14 to 17, and enhancement of 0 or 1. However, these image-processing parameters did not results in significantly different chest images from the images that were obtained by analog radiography and computed radiography[13]. The subjects also underwent HRCT scans. HRCT images of non-helical scanning were obtained using the Hi-speed Advantage RP CT scanner (GE, Fairfield, CT, USA), which uses a high frequency algorithm, at 120 kV, 180–200 mA, for 1 s, with 3-mm slice collimations, of DFOV 20.0 cm, and 15 mm intervals. Images were printed by using dry imagers. The names of the patients were masked, but their age and sex were not masked. We prepared two types of hard copy with settings of WW 1000/WL 600 and WW 2000/WL −400. The readers were able to use both images.

Trial reading

Three National Institute for Occupational Safety and Health (NIOSH) B readers[14] independently read the CXRs in accordance with the ILO/ICRP. The ILO/ICRP uses 12 categories to classify the profusion of small opacities in radiograph readings.

Three experts who had been engaged in the development of the ICOERD independently read the HRCT findings in accordance with the ICOERD. The ICOERD uses 4-point categories to quantify the grades of well-defined rounded opacities (RO), irregular and/or linear opacities (IR), emphysema (EM), ground glass opacities (GGO), and honeycombing (HC) parenchymal opacities (Items) in the upper, middle, and lower zones of each lungs. The summed grade is calculated for each of the Items of the parenchymal abnormalities (RO, IR, EM, GGO, and HC) by adding the scores of each of the 6 zones. For more details on calculating the summed grades, Appendix 1 shows the coding system of the ICOERD[5].

On CXR, small rounded opacities have 3 size classifications. For rounded opacities, the ranges are designated as "p" (diameters up to 1.5 mm), "q" (diameters exceeding 1.5 mm and up to 3 mm), and "r" (diameters exceeding

3 mm and up to 10 mm). For irregular opacities, the widths have 3 sizes classifications, designated as "s" (widths up to 1.5 mm), "t" (widths exceeding 1.5 mm and up to 3 mm), and "u" (widths exceeding 3 mm and up to 10 mm). RO on HRCT also have 3 size classifications, designated as "P" (diameters up to 1.5 mm), "Q" (diameters exceeding 1.5 mm and up to 3 mm), and "R" (diameters exceeding 3 mm and up to 10 mm). To classify the profusion on CXR, the CXR image is compared with ILO standard radiographs to find the standard image with a profusion that appears to be closest to the profusion of the subject films. To classify the HRCT grade, the image is compared with ICOERD reference films to find the reference image that appears to be closest to the grade of the subject films.

The criterion for determining pneumoconiosis is a profusion of 1/0 or more, irrespective of shape or size (i.e., p, q, r, and s, t, u), according to ILO/ICRP. The criterion for determining the existence of parenchymal findings of the Items is the sum of grades of 1 or more, according to the ICOERD (i.e. the existence of RO of any size).

The NIOSH states that multiple readings, coupled with use of an appropriate summary measure (e.g., the median reading) can help minimize the impact of any one reader on the final determination[15]. GH McMillan *et al.*[16] used the median reading for profusion according to the ILO Classification. Therefore, we too used the median reading. There have also been a problem with systematic reader differences in the ICOERD. We used the median reading for the ICOERD as well as for ILO/ICRP.

When more than one reader recorded primary small opacities as regular for any diameter (p, q, or r), the subject was determined as having rounded opacities. When more than one reader recorded primary small opacities as irregular for any width (s, t, or u), the subject was determined as having irregular opacities. Subjects with rounded opacities were subsequently used in the correlation analysis. We compared the summed grades of RO (on a 19-point scale) based on the ICOERD with the profusion score (on a 12-point scale) based on the ILO/ICRP. One subject had primary irregular opacities based on the ILO/ICRP. However, the subject did not have RO, based on the ICOERD. Therefore, we removed this subject from the correlation analysis of the summed grades and the profusions.

Statistical analysis

The relationship between a patient's history of dust exposure and pneumoconiosis (diagnosed according to the ILO/ICRP) was evaluated using the χ^2 test. The agreement

of the 4-point profusion scale for each case of pneumoconiosis (based on the ILO/ICRP) or the 4-point grade scale (based on the ICOERD) for each lung zone was evaluated using weighted kappa statistics pairs of the 3 readers. The mean kappa values were interpreted according to the following guideline, proposed by Altman[17]: <0.20, poor; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, good; and 0.81–1.00, very good. The correlation between the ICOERD summed grades on the 19-point scale and the ILO/ICRP profusions on the 12-point scale was determined using the non-parametric Spearman's rank-order correlation analysis. For all analyses, we used the software package R version 2.11.1 (R Foundation for Statistical Computing; http://www.r-project.org/foundation/). For the χ^2 test, t-test, and Spearman correlation analysis, values of $p<0.05$ were considered significant.

Results

ILO/ICRP based reading results of the 3 readers

On the basis of the median profusion values of the ILO/ICRP, there were 23 subjects with small parenchymal opacities. Twenty-two subjects had rounded opacities (i.e., p, q, or r) as the primary opacity, and one subject had irregular opacities (Table 1). On the 4-point scale, 51 subjects had a profusion of 0; 17 subjects had a profusion of 1; 5 subjects had a profusion of 2; and 1 subject had a profusion of 3. Using the 4-point profusion scale, the mean of kappa value of pairs of readers was 0.772. The relationship between the history of mineral dust exposure and pneumoconiosis was significant at $p<0.01$ (based on the 2 × 2 contingency table) (Table 2).

ICOERD based reading results of the 3 readers

Based on the median values of the summed grades of each of the Items that were 1 or more, there were 21 subjects with RO, 20 subjects with IR, 23 subjects with EM, 1 subject with GGO, and 1 subject with HC. The mean weighted kappa values of pairs of readers were 0.538 for RO, 0.212 for IR, and 0.399 for EM (Table 3).

Cases excluded from the relationship analysis between ILO/ICRP and ICOERD in terms of parenchymal opacities

The relationships between the profusion and the summed grade of RO are shown in Table 4. There were 3 cases without RO based on the ICOERD but with small parenchymal opacities based on the ILO/ICRP. Specifically, one of the 3 cases had primary irregular opacities of 2/1 profusion on the ILO/ICRP and a summed grade of 6

Table 1. Primary shape on CXR based on ILO/ICRP (n = 74)

Primary shape	No. of patients
R	22
IR	1

R: small rounded opacities (e.g., p, q, r), IR: Small irregular opacities (e.g., s, t, u), CXR: Chest radiography, ILO/ICRP: International Labor Organization Classification/International Classification of Radiographs of Pneumoconioses

Table 2. Relationship between mineral dust exposure and pneumoconiosis based on ILO/ICRP (n = 74)

Dust exposure history	Pneumoconiosis		Total	p
	No	Yes		
Yes	24	22	46	
No	27	1	28	
Total	51	23	74	<0.01*

*χ^2 test of mineral dust exposure history and pneumoconiosis.

for IR on the ICOERD. Since this subject did not have any RO, IR predominated over RO. The subject's occupational history did not involve definite asbestos exposure, but this subject was involved in tunnel excavation for 34 yr with no or very little asbestos exposure. In this line of work, the subject only had a history of crystalline silica exposure. However, the subject had primary irregular opacities based on ILO/ICRP without any RO based on the ICOERD. Thus, we excluded this subject from the subsequent correlation analysis. We included the other 2 cases because they had the primary rounded opacities based on the ILO/ICRP without RO based on the ICOERD.

Correlation between the ILO/ICRP profusion of small rounded opacities and the ICOERD summed grades of RO

The correlation coefficient (Rho) of the median reading results between the profusion of the small rounded parenchymal opacities on the ILO/ICRP 12-point scale and the summed grades of RO on the ICOERD 19-point scale was 0.844 with $p<0.01$ (n=73) (Fig. 1).

Discussion

Since all the patients in the present study had had mineral dust exposure, nearly all the patients had small rounded opacities rather than small irregular opacities (Table 1). The occupational exposure history of crystalline silica generally presents as silicosis with small rounded parenchymal opacities on CXR. In many of the study

Table 3. Interpretation of the results of HRCT by ICOERD Items (n=74)

ICOERD	No. of patients indicated by the				Weighted kappa**
	3 Readers*	Reader 1	Reader 2	Reader 3	
	as having parenchymal abnormalities				
RO	21	14	22	23	0.538
IR	20	23	29	22	0.212
EM	23	15	21	37	0.399
GGO	1	6	8	2	
HC	1	0	3	3	

HRCT: High-Resolution Computed Tomography; ICOERD: International Classification of HRCT for Occupational and Environmental Respiratory Diseases; Items: RO, IR, EM, GGO, or HC. RO: well-defined rounded opacities; IR: irregular opacities; EM: emphysema; GGO: ground glass opacities; HC: honeycombing findings
*The criterion for determining the patients having parenchymal abnormalities was the median of summed grades being 1 or more among the 3 readers.
** Mean of weighted kappa for the grades of each zone of pair of readers.

Table 4. Reading results of CXR using the 4-point and 12-point scales for profusion based on ILO/ICRP, and of HRCT using the 19-point scale for grade based on ICOERD (n=74)

Profusion	No. of patients	Summed grades of RO									
		0	1	2	4	5	6	7	8	9	16
0	51										
0/0	45	44	0	0	1	0	0	0	0	0	0
0/1	6	6	0	0	0	0	0	0	0	0	0
1	17										
1/0	3	1	1	0	1	0	0	0	0	0	0
1/1	7	0	1	0	2	2	1	1	0	0	0
1/2	7	1	0	1	0	1	1	1	1	1	0
2	5										
2/1	3	1	0	0	0	0	1	0	1	0	0
2/2	2	0	0	0	0	0	0	1	1	0	0
2/3	0	0	0	0	0	0	0	0	0	0	0
3	1										
3/2	0	0	0	0	0	0	0	0	0	0	0
3/3	1	0	0	0	0	0	0	0	0	0	1

Standard radiographs were used to define the 4 categories. For classification of profusion on the 12-point scale of chest radiography (CXR), the image is compared with International Labor Organization (ILO) standard radiographs, to determine the profusion which is closest to that of the subject's film. For classification on the 19-point scale of the high-resolution computed tomography (HRCT), the image is compared with the International Classification of HRCT for Occupational and Environmental Diseases (ICOERD) reference films, to determine the grade which is closest to that of the subject film. RO: well-defined rounded opacities.

patients, the occupational history of dust exposure was associated with pneumoconiosis based on ILO/ICRP.

There was one subject with pneumoconiosis on CXR, but without an occupational history of dust exposure (Table 2). He had been enrolled as a control group subject. He was a clerical worker. The evidence of pneumoconiosis for him was the reading result of the CXR based on ILO/

ICRP for which the readers read the predominant shape of his small parenchymal opacities as "p". The median of profusion was 1/2 (1/0, 1/2, 2/1). No reader found RO or IR on HRCT. However, 2 of 3 readers found EM on HRCT. The median of the summed grade of EM was 4 (0, 4, 6). The patient had neither GGO nor HC, but he had smoked for 80 pack-years; therefore, he was appropriately
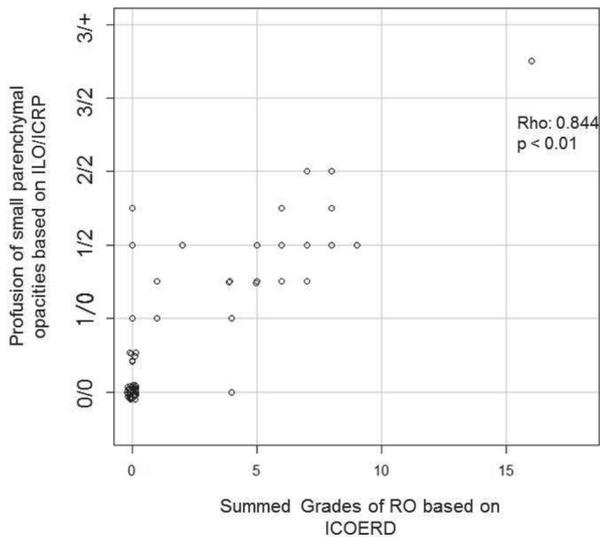
Fig. 1. Correlation between the median values of profusion of small rounded opacities, based on International Labor Organization 2011 International Classification of Radiographs of Pneumoconioses (ILO/ICRP), and the summed grades of well-defined rounded opacities (RO), based on International Classification of High-resolution Computed Tomography for Occupational and Environmental Diseases (ICOERD) (n=73).

judged as having emphysema caused by smoking.

The CT findings of respiratory bronchiolitis are usually a faint centrilobular GGO and it is unlikely that such shadows could be confused with small rounded opacities on CXR or well-defined RO on HRCT. When there are centrilobular GGOs, readers may record the opacities as "p" shadows, according to the ILO/ICRP, which should rather be described as the ICOERD "IR". However, there were no "IR" shadows reported in this case. On considering the history and findings, we may assume that the readers had recorded mild emphysema on HRCT as small parenchymal rounded opacities "p" on CXR due to the so-called summation effect.

According to ILO/ICRP, the cut-off points for the absence and presence of pneumoconiosis are 0/1 and 1/0, respectively, for profusions on the 12-point scale. However, the ICOERD does not have a so-called "boundary grade" cut-off points for the absence pneumoconiosis. In the present study, we used cut-off points of 0 and 1 for the summed grades of RO and IR on the 19-point scale of the ICOERD. One study in the literature used an HRCT category of 0/1 between 0 and 1, which is different from the ICOERD criteria[7]. Mineral dust exposure causes interstitial fibrosis in both lungs, and this disease is sometimes irreversible, progressive, and lethal. Based on this pathology, we may

have to consider the cut-off summed grades of RO or IR as 2 or more for patients in whom both lungs have grades of 1 or more at least in one zone for each lung.

We did not use the mathematical or arithmetic means of indices for micronodules on CXR and CT because the profusion and grade assessments use ordinal scales. Using the mode or median of the indices is the usual way to perform relevant research in the field of pneumoconiosis. Since there were only 3 readers for each system who calculated indices in the current study, we adopted the median values for both indices. With regard to the agreement among the 3 readers, the kappa results were moderate for profusions (based on the ILO/ICRP) and fair for the grades of RO (based on the ICOERD). This finding suggests that the reading results of the 3 readers were overall reliable for both classifications.

In the present study, despite the low subject number, the summed grades of RO had a significantly good correlation with the profusions of small rounded opacities. This may have show the accuracy of the ICOERD based on the ILO/ICRP. In this context, the reading results of the ICOERD can be compared with the knowledge accumulated by the ILO/ICRP studies. There is a long history of silicosis studies using ILO/ICRP, and much knowledge has been accumulated. Hnizdo et al.[18] reported a correlation between CXR and silicosis pathology. Vallyathan et al.[19] reported a relationship between CXR severity on the 4-point scale and pneumoconiotic pathological changes (e.g., macules, micronodules and macronodules), and progressive massive fibrosis among coal miners. These may now be utilized in studies and research using the ICOERD.

Findings on CXR usually represent superimposed parenchymal opacities. On the other hand, HRCT findings can distinguish different kinds of parenchymal opacities. As a result, disagreements can occur between CXR and HRCT. In many cases, HRCT and ICOERD methodology may be a better and more sensitive method of diagnosing pneumoconiosis than CXR and ILO/ICRP[20].

Many studies have suggested that CT has an advantage over CXR in terms of resolution[6, 21–23]. When using CT for screening and surveillance, many issues should be considered (e.g. radiation exposure, initial and running costs, and the costs of treating patients diagnosed by CT). CT screening has nevertheless been shown to reduce lung cancer mortality in high-risk smoking age groups[24]. Computed tomography screening and surveillance of asbestos-exposed workers at high risk has similarly been used in Germany to reduce lung cancer mortality[25]. CT is becoming more important in screening and surveillance as

well as in clinical diagnosis.

The ICOERD has harmonized and standardized the interpretation of HRCT results for occupational and environmental respiratory diseases. Therefore, the ICOERD is a good tool for clinical and possibly epidemiological fields of research purpose.

There were several limitations to the present study. We focused on patients with early-stage pneumoconiosis, and we selected these patients from a local hospital. The selection of the subjects enabled us to study to some extent the relationship between profusion 1 on the ILO/ICRP and the summed grade of 1 or a little more on the ICOERD. The readers using the ICOERD had all participated in its development and may thus be considered experts in the field. However, the subjects of the present study were not population-based.

The second limitation of this study was that the subject number was rather low. The selection criteria that we used and the small sample size may have biased the results.

The third limitation was that the mean kappa values for pair of readers' results for IR and EM were poor. The readers were experts who had also developed the ICOERD. However, in the current study, the readers did not have any meeting for agreement before the readings. They also read the films independently. This may explain the poor weighted kappa.

The fourth limitation was that we focused on patients with only small rounded opacities. We confirmed, by investigating an occupational history, that only one patient had asbestos exposure. However, even in this patient, small rounded opacities predominated. We could not study relationships between irregular small parenchymal opacities based on ILO/ICRP and IR based on the ICOERD.

In the present study, with the exception of pneumoconiotic micronodules, we could not fully study the correlations between the summed grades of IR, EM, HC, or GGO on the ICOERD and the ILO/ICRP variant findings. It may be possible to determine correlations between these factors by recruiting new patients with IR, EM, HC, and GGO in the ICOERD criteria.

In conclusion, the findings of the present study indicate there is an adequate association between the ICOERD and the ILO/ICRP reading results for determining pneumoconiotic micronodules in the lungs. Interpretations based on both systems were mostly in agreement, suggesting that the ICOERD may be useful for both clinical and epidemiological studies of pneumoconiosis in terms of micronodules.

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Appendix 1.
The procedure to calculate the summed grade of well-defined rounded opacities.

1. Coding system of International Classification of HRCT for Occupational and Environmental Respiratory Diseases (ICOERD).

Well-defined rounded opacities
Absence (No) or Presence (Yes) has to be reported.
It includes all measurable, well-defined rounded opacities{xe "rounded opacities"} from <1.5 mm in diameter (= P{xe "P"}), between 1.5 and 3 mm (= Q{xe "Q"}), to 3 up to 10 mm (= R{xe "R"}).
NOTE: It has to be remembered that hardcopy CT images are diminished and the dimensions of opacities recorded should be true or life size measurements.
The overall distribution is recorded in a grading{xe "grading"} system, regardless of form and size, for each side right (R) or left (L) and each zone of the thorax: upper (U) − arch of the aorta{xe "arch of the aorta"} and above, middle (M) − arch of the aorta down to the inferior pulmonary vein{xe "inferior pulmonary vein"}, lower (L) − inferior pulmonary vein and below including diaphragm{xe "diaphragm"}. The precise definition of the borderline of the zone is not crucial for the application of the system.
0 = no definitive opacities
1 = mild, small opacities definitely present but few in number
2 = moderate, numerous small opacities
3 = severe, small opacities very numerous, normal anatomical lung structures poorly visible
It is possible to check more than one opacity (e.g., P and Q or another combination) and then the predominant size P, Q, or R has to be recorded.
Sum of grading, regardless of size, side and zone.
Possible ranging from 0 to 18.

2. The reading sheet of the ICOERD.

CT-Classification

Name/No.	CT-No. / Date				Quality	Position
	No. slices		Sequential	kV	1	Prone
	Slice thickness		Single slice spir.	mA	2	Supine
	Window settings		Multi slice spiral	sec	3	
					4	

CT-FINDING 2001

Is the film completely negative? [No] [Yes]

Symbols: Ø, AX, BE, BR, BU, CA, CG, CV, DI, DO, EF, ES, FP, FR, HI, ME, MP, OD, PB, RA, SC, TB, TD

Lung

Well defined rounded opacities — No / Yes

	No	Yes	Predominant Size
P = < 1.5 mm			
Q = 1.5 - 3 mm			
R = > 3 - 10 mm			

Zones/Profusion

	R				L			
U	0	1	2	3	0	1	2	3
M	0	1	2	3	0	1	2	3
L	0	1	2	3	0	1	2	3

Sum Grade [ ]

Irregular and/or linear opacities — No / Yes

	No	Yes	Predominant Type
Intralobular			
Interlobular			

Grade

	R				L			
U	0	1	2	3	0	1	2	3
M	0	1	2	3	0	1	2	3
L	0	1	2	3	0	1	2	3

Sum Grade [ ]

Inhomogeneous attenuation — No / Yes

Ground glass opacity grade — No / Yes

	R				L			
U	0	1	2	3	0	1	2	3
M	0	1	2	3	0	1	2	3
L	0	1	2	3	0	1	2	3

Sum Grade [ ]

Honeycombing grade — No / Yes

	R				L			
U	0	1	2	3	0	1	2	3
M	0	1	2	3	0	1	2	3
L	0	1	2	3	0	1	2	3

Sum Grade [ ]

Emphysema grade — No / Yes

	R				L			
U	0	1	2	3	0	1	2	3
M	0	1	2	3	0	1	2	3
L	0	1	2	3	0	1	2	3

Sum Grade [ ]

Large opacities — No / Yes

		R	L
A	U		
B	M		
C	L		

Predominant Parenchymal: RO | IR | GGO | HC | EM | LO

Pleura

Pleural abnormalities — No / Yes

		No	Yes	Predominant
W	parietal type			
	visceral type			
M				
D				

	R	L
U		
M		
L		

Extent / Width

R				L			
0	1	2	3	0	1	2	3
0	a	b	c	0	a	b	c

Pleural calcifications — No / Yes

Localisation: W | M | D

Comments / Summary

Date / Signature

Date	Signature

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3. Reference films to be compared with an image of the sample case.

A part of the reading sheet filled with RO grades in the sample case
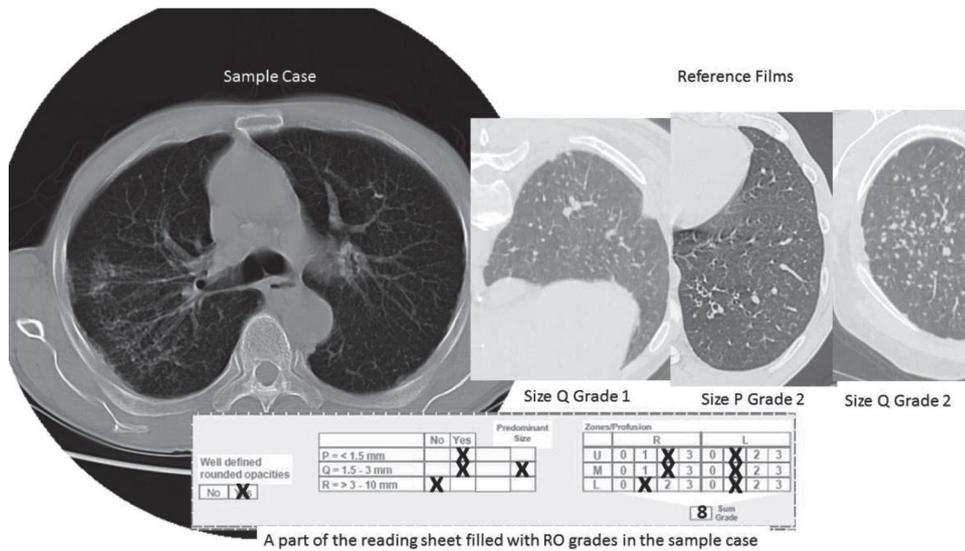
4. A representative example of calculation of the summed grades of well-defined rounded opacities (RO) in a patient.

The coding and calculating system for RO grades according to ICOERD are explained above. The sample case is shown in the left figure. Readers record the grades of RO in the 6 zones (upper, middle, and lower zones of each lung). In the right figure, there are 3 reference images of RO. The subject's image is compared with the references using software: ICOERD-Viewer Version 1.0, 2007, FUJITSU LIMITED (http://airp.umin.jp/ICOERDviewer.html). This sample case had grade 2 of "Q" shadow in the right middle zone, and grade 1 of "Q" shadow in the left middle zone. The reading sheet in the bottom figure shows grade 2 in the right upper zone, grade 1 in the left upper zone, grade 1 in the right lower zone, and grade 1 in the left lower zone. The grades of the 6 zones are summed to give a grade of 8.