Reliability of the Proposed International Classification of High-Resolution Computed Tomography for Occupational and Environmental Respiratory Diseases

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Abstract: Reliability of the Proposed International Classification of High-Resolution Computed Tomography for Occupational and Environmental Respiratory Diseases: Narufumi Suganuma, et al. Department of Environmental Medicine, Kochi Medical School—Purpose: We have developed a classification of high-resolution computed tomography (HRCT) images for screening, surveillance and epidemiological studies of respiratory diseases caused by occupational and environmental factors. The proposed classification consists of three parts: a guideline explaining the elements of the classification scheme, a reading sheet, and reference films to aid in assessing thin-section CT films. We assessed the reliability of the proposed classification system by blinded, independent trial reading. Materials and Methods: Seven independent radiologists and pulmonologists performed a trial reading to measure the reliability of the classification system using HRCT films from 27 pneumoconiosis patients and 7 normal controls. Results: The agreement was moderate to good for rounded opacities (weighted $\kappa=0.68$ and 0.64), irregular opacities (0.59, 0.48), honeycombing (0.65, 0.47), emphysema (0.76, 0.62) and large opacities (0.48, 0.52). Ground glass opacities (0.16, 0.20) showed poor to fair agreement. Intra-reader agreement of each of the seven readers was moderate to good (mean: weighted $\kappa=0.52$–0.80) for parenchymal findings, but the agreement was relatively low (mean weighted $\kappa=0.52$) for ground glass opacities. Conclusion: The proposed classification is able to describe early dust-related fibrotic changes and provide a semi-quantitative description of the HRCT features of major fibrotic changes in the parenchyma and pleura. Reliability, as measured by inter-reader agreement, was satisfactory.

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Key words: Classification, Computed tomography (CT), Lung diseases, Occupational and environmental diseases, Pleura diseases, Thin section
Radiological evaluation of dust-exposed individuals is important for epidemiological and clinical purposes. The chest radiograph has played an important role in this assessment for decades, and has become almost essential since the International Labour Office (ILO) revised the International Classification of Radiographs for Pneumoconioses in 19801, 2). However, the well-known limitations of the chest radiograph in the screening for pulmonary diseases caused by occupational and environmental dusts has created a demand for a new screening system using high-resolution (HR) or thin-section computed tomography (CT) for the detection of fibrotic changes3).

An ideal CT classification system for screening and surveillance would be reproducible, and would enable a systematic description of CT findings, which could serve as a tool for epidemiologic studies of dust-induced pleuropulmonary diseases. Since 1992, several classification or coding systems for evaluating pneumoconiosis in CT studies have been reported4-8). The relevance of such a classification system has been discussed in order to create an international standard describing pleuro-pulmonary diseases caused by asbestos3, 9). However, the inhalation of exogenous dust causing respiratory diseases is not limited to asbestos. Inhalation of silica, coal dusts, and other mineral dusts will surely lead to occupational and environmental respiratory diseases. We thus explored the possibility of harmonizing the previously reported classifications to develop an internationally agreed upon CT classification of occupational respiratory diseases.

We have developed a classification system for HRCT findings for screening respiratory diseases caused by occupational and environmental factors10). The majority of these diseases are pneumoconioses. This paper describes the features of the proposed classification system and its validation via a multiple reader trial. The classification reading sheet, samples of reference films, and guidelines for use are provided as appendices.

### Materials and Methods

#### Materials for the reliability assessment

Seven controls without discrete occupational dust exposure and 27 cases with occupational dust exposure or a diagnosis of occupational respiratory disease provided the image data used in this study. Of the 27 patients with occupational respiratory diseases, 21 were exposed to asbestos, 4 were silicotics, one was a welder, and one was an ex-coal-worker. An asbestos-weighted selection of the patients was made because the proposed classification system which includes rounded opacities, irregular opacities, ground glass opacities, honeycombing and pleural abnormalities, most of which are features of asbestosis. Individual clinical information was not available, as the purpose of the trial was to measure the agreement among multiple readers in describing thin-section CT signs according to the classification system being developed. When more than four readers agreed on the presence of the finding in both circulations of the trial reading, it was considered as positive for the applicable finding. The characteristics of thin-section CT images evaluated in the trial are summarized in Table 1.

#### Readers

The readers were five radiologists (HA, KH, TV, PG, MC) and two pulmonologists (ML, JP) who attended more than two of the four project meetings held to discuss the proposed classification system. The readers evaluated 34 randomly numbered HRCT cases twice, with an interval of at least four months. As the participants claimed that the reference film for ground glass opacities (GGO) did not have discernible radiological manifestations, a description of the findings was added as a supplement during the second round. The participants examined each film, compared it with the reference films, and described the findings on the reading sheet according to the guideline. The scores for each parenchymal

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**Table 1. Summary of the findings and the agreement on the readings used for the reliability assessment**

<table>
<thead>
<tr>
<th>Exposure</th>
<th>RO</th>
<th>IR</th>
<th>GG</th>
<th>HC</th>
<th>EM</th>
<th>LO</th>
<th>PL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No exposure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Asbestos</td>
<td>0</td>
<td>13</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Silica</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Welder</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>15</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>18</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: RO=rounded opacities; IR=irregular opacities; GG=ground glass opacities; HC=honeycombing; EM=emphysema; LO=large opacities; and PL=pleural abnormalities. * Positive findings: more than four readers agreed on the presence of the respective finding in both rounds of the trial readings.
abnormality within six lung zones, and the size and extent of the pleural abnormalities were subjected to statistical analysis for inter-reader and intra-reader agreement.

**Imaging techniques**

This was a retrospective study using images that met the parameters outlined in the consensus report on radiological screening for asbestos-related respiratory diseases. The collimation was 1 to 2 mm; a minimum of 6 slices were required for inclusion, with one slice at the carina, one slice above the carina, and 4 slices equally spaced below the carina. Alternatively, 1- to 2-mm slices were obtained from the apex to the base of the lungs at intervals of 1.0 to 2.0 cm. Exposure times were 1 sec or less, with 120 to 150 kV and 40 to 100 mAs according to the consensus report. However, the material included some images scanned with up to 300 mAs. Scans were done at full inspiration and reconstructed using a high-resolution algorithm. For visualization of pleuroparenchymal appearances, a window width (WW) of 2000 and a window level of –400 Hounsfield units (HU) was used for the study. The images had a matrix of 512 × 512 pixels or more, and not more than 12 images were on standard 35 cm × 43 cm film. In most cases, images obtained in a prone position were available. This considerable technical variation was due to the multicenter source of the material and the retrospective nature of our study.

**Development of the coding system**

Descriptions for HRCT findings were created based on discussions with experts. The terms used to guide the proposed classification system were consistent with previously published articles on occupational and environmental respiratory diseases. The selection of findings was finalized by a consensus of the project participants who referred to the ILO classification system and the previous CT classifications as described in our previous study.

**Development of the reading sheet**

The selection of findings was finalized by a consensus of the project participants who referred to the ILO classification system and the previous CT classifications as described in our previous study. The prototypes for the proposed international classification system were basically the German and Japanese classifications. Regarding the grading system of pleural abnormalities, the French summation method was incorporated into the present classification system.

**Selection of reference films**

Preliminary selection of the reference films was accomplished in a trial reading using the reading sheet. A multiple reader trial reading was performed to select candidate slices to illustrate profusion or extent of the abnormal findings. Altogether 19 thin-section CT films of subjects with substantial dust exposure were obtained from six institutes. The candidate films included grade 2 reference films selected by the 6 core researchers that described 1) small rounded opacities, 2) irregular opacities, and 3) pleural abnormalities. Slices for which...
A brief explanation of the classification system

The reading sheet starts with documentation of the patient’s name, ID, and imaging parameters, along with the quality of the CT films and the position of the patient. There is an assessment of the parenchymal lesions including rounded opacities, irregular opacities, inhomogeneous attenuation, honeycombing, emphysema, and large opacities. A graded score for each of these findings (4-point scale: 0, 1, 2, and 3) is determined for the three zones of each lung. The summed grade is calculated for each of the parenchymal lesion types by adding the scores for each of the six zones. Scoring for pleural abnormalities is not done for each zone, but the overall extent and the most abnormal width are reported on a 4-point scale for each hemithorax. Summation of the scoring for the extent of pleural abnormalities is made on the slice at the level of the carina (Fig. 1). The presence of rounded atelectasis (RA) or parenchymal bands (PB) is considered a sign of visceral pleura involvement, thereby allowing differentiation between a parietal-type pleural thickening and a visceral-type pleural thickening. Less frequent but informative findings are listed as symbols that are to be ticked when they are present. The proposed coding system, the reading sheet, and samples of the reference films are shown in Appendices 1, 2 and 3, respectively.

Statistical analysis

The grading scale (0 to 3 within each of 6 zones) and the sum grade of parenchymal findings (0–18) were assessed by weighted $\kappa$ statistics for inter-reader agreement among the 7 readers. Intra-reader agreement was also assessed with weighted $\kappa$ statistics. All the statistical analyses were performed using SPSS version 11.0 computer program (Illinois, Chicago). The weighted $\kappa$ statistics values were interpreted as proposed by Altman: values <0.20=poor; 0.21–0.40=fair; 0.41–0.60=moderate; 0.61–0.80=good; and 0.91–1.00=very good13).

Results

Summary results of the trial readings

Agreed reading results on the presence of pneumoconiotic findings are summarized in Table 1. Of the 21 asbestos-exposed workers, 13 had irregular opacities, 2 had GGO, 2 had honeycombing, and 18 had pleural abnormalities. Also one large opacity and 5 emphysema cases were found among them. Of the 4 silica-exposed workers, 3 had rounded opacities, 2 had irregular opacities, 2 had large opacities and 2 had emphysema. A coal worker and a welder had only emphysema. Seven controls without dust exposure displayed no pneumoconiotic findings, except for one individual with emphysema.

Intra-reader agreement

The results of the reliability assessment for the 4-point scale are summarized in Table 2, and for the 0–18-point scale in Table 3.
scale in Table 3. The score of the 4-point scale was obtained by taking the highest grade from the 6 zones. The mean value of the intra-reader agreement of the 4-point scale as assessed by seven readers was moderate to good (mean weighted $\kappa=0.52–0.80$) for parenchymal findings; relatively low agreement was observed for ground glass opacities (mean weighted $\kappa=0.52$), and for large opacities (mean weighted $\kappa=0.60$). Similarly, the mean value of the intra-reader agreement of the seven readers showed fair to good agreement (mean weighted $\kappa=0.58–0.81$) for the summed grade of each parenchymal finding. However, when stratified into radiologists and pulmonologists, the pulmonologists showed higher repeatability of grading small opacities than the radiologists, but lower repeatability for honeycombing, ground glass opacities, and large opacities.

All readers had good to very good agreement for both the extent (mean weighted $\kappa=0.78$) and width (mean weighted $\kappa=0.75$) of pleural thickening.

**Inter-reader agreement**

Inter-reader agreement for rounded opacities (weighted $\kappa=0.68$ and 0.64, respectively, for each of the two rounds of trial readings), irregular opacities (weighted $\kappa=0.59$, 0.48), honeycombing (weighted $\kappa=0.65$, 0.47), and emphysema (weighted $\kappa=0.76$, 0.62) showed moderate to good agreement. Poor to fair agreement was noted for ground glass opacities (weighted $\kappa=0.16$, 0.20). Inter-reader agreement for lesions and parenchymal scores showed consistency between the two reading trials. As for pleural thickening, the scores for extent and width were in good agreement in both trials.

Similarly, acceptable inter-reader agreement was observed for the summed value of the 6 lung zones, with the exception of ground glass opacities (weighted $\kappa=0.27$, 0.20), as shown in Table 3. The weighted $\kappa$ values for small parenchymal opacities, including rounded opacities (weighted $\kappa=0.76$, 0.64) and irregular opacities (weighted $\kappa=0.74$, 0.57), as well as emphysema (weighted $\kappa=0.78$, 0.59) showed good agreement among the readers. The summed value of honeycombing showed fair agreement (weighted $\kappa=0.31$, 0.44).

**Discussion**

The ILO/ICRP-like scheme for classifying HRCT findings of occupational and environmental respiratory diseases, that we are proposing is a prerequisite for HRCT becoming a public health tool for surveillance and screening for the occupational and environmental respiratory diseases. The proposed internationally acceptable classification scheme will offer clinicians a standardized method for evaluating the HRCT images of occupational respiratory diseases. A standardized description tool of HRCT findings with the guide of reference films and list of findings on the reading sheet is desirable for physicians to describe lung and pleural diseases caused by occupational and environmental factors. With the help of the proposed classification system, international readers showed acceptable reliability in describing most of the parenchymal opacities and pleural abnormalities seen in occupational lung diseases. It is our hope that the proposed classification system may simplify the detection of early pulmonary manifestations in individuals with occupational or

### Table 3. Inter-reader and intra-reader agreement of the sum grade (0–18) of 6 zones of the lungs for each parenchymal finding by weighted $\kappa$

<table>
<thead>
<tr>
<th>Finding</th>
<th>RO</th>
<th>IR</th>
<th>GG</th>
<th>HC</th>
<th>EM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-reader agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All readers (n=7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>0.76</td>
<td>0.74</td>
<td>0.27</td>
<td>0.31</td>
<td>0.78</td>
</tr>
<tr>
<td>2nd</td>
<td>0.64</td>
<td>0.57</td>
<td>0.20</td>
<td>0.44</td>
<td>0.59</td>
</tr>
<tr>
<td>Intra-reader agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All readers (n=7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.81</td>
<td>0.77</td>
<td>0.58</td>
<td>0.67</td>
<td>0.79</td>
</tr>
<tr>
<td>(std)</td>
<td>(0.27)</td>
<td>(0.15)</td>
<td>(0.35)</td>
<td>(0.28)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>Radiologists (n=5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.75</td>
<td>0.75</td>
<td>0.61</td>
<td>0.83</td>
<td>0.88</td>
</tr>
<tr>
<td>(std)</td>
<td>(0.31)</td>
<td>(0.14)</td>
<td>(0.35)</td>
<td>(0.08)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Pulmonologists (n=2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.95</td>
<td>0.83</td>
<td>0.51</td>
<td>0.27</td>
<td>0.56</td>
</tr>
<tr>
<td>(std)</td>
<td>(0.06)</td>
<td>(0.21)</td>
<td>(0.47)</td>
<td>(0.07)</td>
<td>(0.40)</td>
</tr>
</tbody>
</table>

See Table 2 for abbreviations.
environmental dust exposure.

Whether we should introduce HRCT as a screening tool for non-malignant occupational and environmental respiratory diseases is a complicated issue, with concerns of radiation exposure, initial and running costs, and costs for following up patients. However, the present surveillance and screening performed with chest radiograph has been questioned, especially in developed countries where CT scans were available in hospitals. Compared to conventional CT, HRCT reveals fine structural changes in the secondary lobule, where most of the earliest manifestations of occupational and environmental respiratory diseases occur. The proposed new classification system provides a systematic, semi-quantitative and reproducible system for the description of the earliest manifestations of occupational lung diseases, which could be a starting point for debating the pros and cons of HRCT screening.

When CT screening for occupational lung diseases is an issue, it is often confused with thick-section CT screening for occupational lung cancer as opposed to the correct meaning of thin-section CT screening for non-malignant occupational respiratory diseases. In some parts of Europe it is customary to perform thin-section CT screenings on asbestos-exposed workers to detect parenchymal and pleural changes. Where there is public concern regarding the carcinogenicity of asbestos, the screening should be performed with thick-section CT; in addition to thin-section CT, to detect lung cancer among the workers exposed to carcinogenic dusts. If mass screening programmes are to succeed, lowering the radiation dose of thin-section CT plus thick-section CT, while still maintaining high image quality, will be important. The imaging parameters proposed in the consensus report meet this demand and have been successfully used for on-going screening programmes in Germany, France and Finland. Considerably low effective doses of 0.7–0.9 mSv are used at a clinic of one of the authors (KH) with the following parameters: 120 kV, 20 mAs with a scan length of 30–35 cm using a multi-detector CT. These values are remarkably low compared to the average effective dose emitted by a typical lung CT scan of about 10 mSv. As the size of intralobular or honeycomb cysts can range from tiny to the size of the secondary lobule, the cysts may be easily confused with paraseptal emphysema, especially when there are only a few cystic lesions. Honeycombing in this trial was subtle, as the patients were in the relatively early stages of the asbestosis, and it is sometimes difficult to differentiate lesions during the early stages of asbestosis when irregular opacities and tiny honeycomb lesions coexist.

Though many elaborate studies have been performed, most investigations of early cases of occupational lung diseases have been performed in the hospital where CT scans were available. Implementing HRCT classification to screening and surveillance of occupational and respiratory diseases will bring further understanding of the early changes of these diseases in the secondary lobule. The earliest manifestations start with subpleural dot-like lesions in the centrilobular area, then several dot-like lesions merge to become irregular opacities, such as interlobular lines or subpleural curvilinear lines, as the disease progresses. Also radiographic p-type pneumoconiosis usually does not have pathological silicotic nodules, and the pathologic basis for p-type opacities is peribronchiolar fibrosis, a mild chronic inflammation around the terminal bronchioles, which has a HRCT manifestation similar to centrilobular dot-like lesions in asbestosis.

The proposed classification provides a simple method for differentiating two types of pleural abnormalities based on the presence of rounded atelectasis (RA) and/or parenchymal bands (PB) as indicators of involvement of the visceral pleura (See Appendix 3). According to the definition by Lynch, pleural plaques are caused by thickening of the parietal pleura, while diffuse pleural thickening involves the visceral pleura. This differentiation will be useful for predicting the severity of respiratory dysfunction and for understanding the differences between plaques and diffuse pleural thickening, as defined by the ILO system.

Further revision of the proposed HRCT classification may include combined interlobular and intralobular lines, categorizing them by interstitial lines as done by Gamsu et al., or even summarizing rounded and irregular intralobular opacities as centrilobular opacities with well- and ill-defined variations. These will be considered through practical usage testing and through epidemiologic investigations among dust-exposed workers. A computer-assisted system may shorten the time needed to complete the reading sheet, accumulate the data, prepare the data for analysis, and disseminate the results. We are developing a system similar to the one developed for the German CT classification. A computer display system
that can display the reference film alongside the case CT slice may be valuable.

Although the limitation of this study is that we could not fully test the reliability of the proposed classification for all type of occupational and environmental respiratory diseases, we have at least evaluated the reliability of classifying asbestos-related parenchymal and pleural diseases, and emphysema that is usually caused by smoking. The lack of a direct comparison of the proposed HRCT classification with other diagnostic techniques is partially mitigated by the validation of the prototype of this classification with Technegas ventilation SPECT regarding nodules, emphysema, and septal lines. Inter-reader agreement concerning rounded opacities using the prototype of this classification was shown to be good in a previous study.

We have developed a new international classification system for thin-section CT images of occupational respiratory diseases with acceptable intra- and inter-reader agreement. The proposed classification system consists of a reading sheet for evaluating parenchymal lesions and pleural changes in conjunction with a set of reference images. The classification scoring will provide a semi-quantitative measure of thin-section CT findings in dust-exposed individuals to enable more sensitive medical screening and surveillance than is possible with plain chest radiographs. Implementation of CT screening among dust-exposed workers, however, is not justifiable before social consensus concerning radiation exposure of healthy workers and ex-workers, allocation of the running cost, and access to the CT scanners, is reached. This proposed classification would be a necessary but not a sufficient condition to start CT screening for occupational and environmental respiratory diseases.

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References

4) Hering KG. Evaluation and classification of CT findings in work-related lung and pleural changes in accordance with the ILO pneumoconiosis classification. Rontgenpraxis 1992; 45: 304–8 (in German).
Appendix 1. Coding system of the International Classification of HRCT for occupational and environmental respiratory diseases (reproduced from the Reference 10 with permission).

**Foreword**

The coding system has to be strictly descriptive and not diagnostic. It has to cover all aspects of occupational and environmental disorders dealing with parenchymal and pleural consequences. Although some of the descriptive terms are associated with pneumoconioses, e.g. rounded opacities with silicosis or interlobular septal and intralobular non-septal lines and honeycombing with asbestosis, there are overlapping patterns which have to be considered and a differential diagnosis reached.

Neither reference films nor text have precedence over each other. To classify an HRCT-study you have to take both into account.

For screening purposes 6 to 8 slices are taken, distributed over all zones, preferably in the prone position. The reading sheet has correspondence for each zone. If more than one slice per zone is taken, all findings per zone have to be summarized and classified for each zone.

The “Comments/Summary”-Section (8.1) leaves the opportunity for free text.

**Basic data**

Name/No.:

Data for Registration

CT-Information:

Date and Number

CT-Modality

Sequential

Spiral Single-Slice

Spiral Multi-Slice

No. of slices for evaluation– at least 6 reference slices

Slice thickness–1–2 mm

Window settings–preferably 2 window settings

Quality:

1=good; 2=acceptable, with no technical defect likely to impair classification; 3=acceptable, with some technical defect but still adequate for classification purposes; 4=unreadable

Position–preferably prone position at least for the 6 reference slices

**Basic question**

“Is the film completely negative?”

If “Yes”, just fill date and signature at the bottom of the sheet; if “No”, the classification has to be done step by step for each item.

1. **Well defined rounded opacities**

   Absence (No) or Presence (Yes) has to be reported.

   Includes all measurable, well defined rounded opacities from <1.5 mm in diameter (=P), between 1.5 and 3 mm (=Q) 3 up to 10 mm (=R). (Dot-like acinar/centrilobular lesions with smooth margins, e.g. typical signs of an
allergic disease have to be reported as intralobular opacities)

NOTE: Remember 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 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 and above, middle (M) – arch of the aorta down to the inferior pulmonary vein, lower (L) – inferior pulmonary vein and below including the 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

1.1. It is possible to check more than one opacity, e.g. P and Q or another combination, but the predominant size P, Q or R has to be recorded.

1.2. Sum of grading, regardless of size, side and zone.
Possible ranging from 0 to 18.

\[
\begin{align*}
\text{e.g.} & & \text{R–U–3} & & \text{L–U–2} \\
& & \text{M–2} & & \text{M–1} \\
& & \text{L–0} & & \text{L–0}
\end{align*}
\]

\[
\text{Sum}=8
\]

2. Irregular and/or linear opacities

2.1. Absence (No) or Presence (Yes) has to be reported

2.2. Morphologic abnormalities of parenchymal disease

2.2.1. Interlobular opacities

2.2.2. Intralobular opacities

2.3. Intralobular opacities include dot-like lesions. Subpleural curvilinear opacities are a specific distribution of fibrotic intralobular core structures, parallel to the pleura, a few millimetres or less in thickness and usually 1 cm from the pleural surface and are reported as a symbol (“SC”). Parenchymal bands are peripheral linear opacities, arising from the surface of a thickened pleura. They have to be reported with pleural abnormalities separately as a symbol. If there is no visible contact to the pleural surface (perhaps due to limited number of slices) they should be mentioned as translobular bands and additional explanatory notes should be made without using a symbol.

2.4. Mark the absence (X) or presence (X) for each item and predominant type

2.5. The overall distribution is recorded in a grading system, regardless of type, for each side, right (R) or left (L), and each zone, upper (U), middle (M) and lower (L) (see 3.3):

0 = no definitive abnormalities
1 = mild, abnormalities definitely present but few in number
2 = moderate, numerous abnormalities
3 = severe, abnormalities very numerous, normal anatomical lung structures poorly visible

2.6. Sum of grading, regardless of type, side and zone.
Possible ranging from 0 to 18.

\[
\begin{align*}
\text{e.g.} & & \text{R–U–0} & & \text{L–U–0} \\
& & \text{M–2} & & \text{M–1} \\
& & \text{L–2} & & \text{L–2}
\end{align*}
\]

\[
\text{Sum}=7
\]

3. Additional parenchymal abnormalities

3.1. Inhomogeneous attenuation (IA):
Absence (No) or Presence (Yes) has to be reported.

Inhomogeneity is possibly due to mosaic perfusion (MP) or ground glass opacity (GGO). In cases where GGO is present grading has to be done for each side and each zone by judging the extent of the finding:

1 = focal
2 = patchy
3 = diffuse

In a case of mosaic perfusion related to air trapping or vessel obstruction use only the symbol “MP”.

3.2. Honeycombing (HC):

Honeycombing can occur with and without GGO. Absence (No) or Presence (Yes) has to be reported. Irregular
opacities within the HC-area are not classified separately.
Grading has to be done for each side and each zone:
1=mild, up to 10 mm in the subpleural area
2=moderate, >10 up to 30 mm in the subpleural area
3=severe, >30 mm up to the whole area

3.3. Emphysema:
Presence (Yes) or absence (No) has to be reported.
Emphysema is graded for R and L and for all zones.
1=mild, up to 15 % of the area of one zone
2=moderate, between 15 and 30%
3=severe, > 30%
Differentiation - e.g. acinar, panlobular, subpleural or cicatricial - must be given as a comment. If bullae are present, the symbol “BU” has to be noted.

3.4. NOTE: An overall sum of grading for both sides and all zones is required for GGO, Emphysema or Honeycombing, see 3.5 and 4.6.

4. Large opacities
4.1. Absence (No) or Presence (Yes) has to be reported.
4.2. Pneumoconiotic as well as non-pneumoconiotic opacities larger than 1 cm in diameter have to be reported. Rounded atelectasis (“RA”) is not reported as a large opacity. Usually in case of “RA” there is a definite connection to pleural thickening and this has to be recorded as “Visceral Type” with the symbol “RA”.

4.3. Opacities are measured in 2 perpendicular diameters, as soon as the mean diameter is >1 cm. All large opacities of both sides are combined. Additional symbols can be used, e.g. suspicious for carcinoma=symbol “CA”; for pneumonia=symbol “OD” with additional text.
4.3.1. A= One or more opacities, extent >1 cm up to 1/4 of the area (quadrant) of the right side of the CT-slice at the carina (see drawing)
4.3.2. B= Area of one or sum of more opacities larger than “A”, less than 1/2 of the area (2 quadrants) of the right side of the CT-slice at the carina
4.3.3. C= Area of one or sum of more opacities larger than half of the area of the right side of the CT-slice at the carina

5. Predominance
5.1. Reach a conclusion regarding the predominant finding from the recorded signs:
RO (Rounded opacities) IR (Irregular/linear opacities)
GGO (Ground glass opacities) HC (Honeycombing)
EM (Emphysema) LO (Large opacities)
5.2. If there are two or more findings of equal predominance, check each of them and give a comment.

6. Pleural abnormalities
6.1. Pleural abnormalities are differentiated according to the CT appearance into Parietal and Visceral types. Absence (No) or Presence (Yes) has to be reported.
6.1.1. The term “Parietal Type” includes the typical tableland-shape as well as the flat (less elevated) thickening of the pleura without subpleural fibrosis. For classification there should be no lower limit. If detectable and measurable it should be reported.
6.1.2. “Visceral type” is often described as “Diffuse Pleural Thickening” and is always associated with the presence of subpleural fibrosis or parenchymal bands and rounded atelectasis. Additional information is obligatory when a visceral type is reported as a pleural abnormality, either irregular and linear opacities or symbols like “PB” or “RA”.
First, report the presence (X) or absence (X) of each item, location (see 8.3) and predominant type, secondly document the distribution of both types combined for right and left and for each zone.
6.2. Extent and Width are reported independently for each side, but again for both types combined.
6.2.1.Extent:All abnormalities of the wall and mediastinum except the findings at the diaphragm are measured. Choose the slice with the most extensive pleural thickening for each zone and transfer and add it (virtually) to the slice, positioned at the carina (see drawing). Extent is measured in terms of degrees of the circumference of 360° for each side:
6.2.2. Width: The thickest part of the parietal or the visceral type of the 3 chosen slices measuring:

1. up to 90° (< 1/4)
2. ≥90° up to 180° (1/4–1/2)
3. ≥180° (>1/2)

6.3. Pleural abnormalities of the Mediastinum (“M”) and the diaphragm (“D”) should be documented as absent (X) or present (X). Findings at the diaphragm are not measured for extent and width.

6.4. Pleural calcifications:
Absence (No) or Presence (Yes) has to be reported.
If present, localisation has to be reported for the wall (W), mediastinum (M) and diaphragm (D). Per definition the paravertebral space belongs to the wall.

7. Symbols:
7.1. Symbols describe additional features related to dust exposure and other etiologies. The definitions of symbols assume a qualifying phrase such as “changes indicative of” or “compatible with” (Please refer to the box at the end of this annex 2).
7.2. Use capital letters to differentiate between ILO-symbols (used for the classification) and CT-symbols.

8. Comments/Summary:
8.1. Comments
Additional information for each section can be documented. If there are findings which are not covered by the evaluation sheet, e.g. descriptive terms for particular patterns of intralobular opacities, they can be recorded in this section of the Coding Sheet.
8.2. Summary
A conclusive summary is necessary, e.g. findings are compatible with occupational or non-occupational disease; differential diagnostic considerations should be mentioned.

Explanation of symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>AX</td>
<td>Coalescence of small pneumoconiotic opacities</td>
</tr>
<tr>
<td>BE</td>
<td>Bronchiectasis: all types, including traction bronchiectasis</td>
</tr>
<tr>
<td>BR</td>
<td>Bronchial wall thickening</td>
</tr>
<tr>
<td>BU</td>
<td>Bullae: additional information on emphysema</td>
</tr>
<tr>
<td>CA</td>
<td>Lung Cancer</td>
</tr>
<tr>
<td>CG</td>
<td>Calcified Granuloma</td>
</tr>
<tr>
<td>CV</td>
<td>Cavity: central necrosis, liquid and/or air containing</td>
</tr>
<tr>
<td>DI</td>
<td>Distortion of intrathoracic structures and organs</td>
</tr>
<tr>
<td>DO</td>
<td>Dependent Opacity</td>
</tr>
<tr>
<td>EF</td>
<td>Effusion: free or loculated pleural fluid</td>
</tr>
<tr>
<td>ES</td>
<td>Eggshell calcification of hilar and/or mediastinal lymph nodes</td>
</tr>
<tr>
<td>FP</td>
<td>Fat Pad: extrapleural/subcostal fat</td>
</tr>
<tr>
<td>FR</td>
<td>Fractured Rib(s)</td>
</tr>
<tr>
<td>HI</td>
<td>Enlargement of Hilar and/or mediastinal lymph nodes, &gt;1.5–2 cm</td>
</tr>
<tr>
<td>ME</td>
<td>Malignant Mesothelioma of the pleura, the pericardium or the peritoneum</td>
</tr>
<tr>
<td>MP</td>
<td>Mosaic Perfusion</td>
</tr>
<tr>
<td>OD</td>
<td>Other Disease: comments under “Additional Findings”</td>
</tr>
<tr>
<td>PB</td>
<td>Parenchymal Band, due to pleuroparenchymal scars</td>
</tr>
<tr>
<td>RA</td>
<td>Rounded Atelectasis</td>
</tr>
<tr>
<td>SC</td>
<td>Subpleural curvilinear lines</td>
</tr>
<tr>
<td>TB</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>TD</td>
<td>Tree in Bud</td>
</tr>
</tbody>
</table>
Appendix 2. The reading sheet of proposed classification of thin-section CT for pneumoconioses (reproduced from reference 10 with permission).
Appendix 3. The reference films of the proposed International Classification of HRCT for Occupational and Environmental Respiratory Diseases

Top Row: From right: The reference films for rounded opacities (RO-1Q, RO-2Q and RO-2P) and irregular opacities (IR-1, IR-2a, IR-2b). Note the size of small rounded opacities is bigger in RO-2Q than in RO-2P. IR-2b shows intralobular opacities (grade 2), which are different from the IR-1 and IR2a that show interlobular opacities. Second row: The reference films for grade 1 to 3 ground glass (GG-1, 2, and 3) and mosaic perfusion (MP). The former have diffuse distribution of increased attenuation in the full inspiration scan and the latter have decreased attenuation in full expiration scan that suggest air-trapping. Third row: The reference films of grade 1 to 3 honeycombing (HC-1, 2, and 3), coalescence (AX) and large opacity B (LO-B). Bottom row: The reference films for grade 1 to 3 emphysema (EM-1, 2, and 3) and pleural abnormalities. PL-p shows a parietal type of pleural thickening which is usually called pleural plaque whereas PB shows a visceral type of pleural thickening with parenchymal bands (arrow); RA also shows a visceral type of pleural thickening with rounded atelectasis (arrowhead) (Reproduced from Reference 10 with permission).