Int Arch Occup Environ Health (1997) 69 : 482–486

ORIGINAL ARTICLE

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Computer-assisted classification system for chest X-ray and computed tomography findings in occupational lung disease

Received: 23 September 1996 / Accepted: 11 November 1996

Abstract The ILO classification of pneumoconiotic changes in the lungs and pleura has become a standardized and widely accepted method of documentation in occupational medicine. Recently a classification system for computed tomography/high-resolution computed tomography (CT/HRCT) findings in the lung has been proposed as well. For both classification systems, computed-assisted programs have been developed that allow the storage and archiving of the results as well as further statistical processing. The programs are compatible with usual hardware configurations, have a comprehensible and transparent structure, and are easy to learn and adaptable to individual needs. The use of the computer-assisted classification systems is presented in the example of an insulator exposed to asbestos. The system of data documentation and processing has proved to be very practicable in the more than 2000 patients studied thus far.

Key words ILO classification · CT · HRCT · Pneumoconiosis · Asbestos · Occupation

Introduction

Computer-assisted diagnostics, documentation of findings, and data management are increasingly being used in medicine. The advantages of storing information directly on data carriers include, e.g., easier data management and evaluation and rapid transfer of data and findings between different institutions, especially with the spread of internal data networks in hospitals as well as via the Internet. In addition, standardized, computerized data storage is very helpful during scientific evaluation of study results.

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In occupational medicine a standardized and internationally accepted method of documentation has been carried out for many years for the evaluation of pneumoconiosis. The so-called ILO classification of pneumoconiotic changes in the lungs and pleura has become established for conventional X-ray photographs (Bohlig et al. 1972, 1981) and will continue to play an important role, particularly in the documentation of asbestos-related diseases, which, due to their long latency periods, will continue to increase over the next 20–30 years. In the United States, more than 14 million persons have previously been occupationally exposed to asbestos dust (Nicholson et al. 1982). In Germany, more than 335,000 workers are presently registered as having been occupationally exposed to asbestos and take part in regular surveillance programs every 3–5 years. In 1994 alone, more than 38,000 X-ray examinations of the thorax were carried out in this group of persons. X-ray findings in the lungs and pleura associated with pneumoconiosis are classified according to the ILO code by specially trained A- and B-readers using a special evaluation sheet. The findings are entered by hand on the sheet and must then be input into a computer for further processing or statistical evaluation. To our knowledge, a computerized version of this coding system that allows findings to be entered directly in the computer exists only for special tutorial programs and for Macintosh computers (Gurney 1993). Our aim was therefore to develop an easy-to-learn, computerized version of the ILO classification.

In recent years, computed tomography (CT), particularly high-resolution computed tomography (HRCT), has also gained importance in special areas of occupational-medical health care, above all in the assessment of pneumoconiotic diseases (Raithel et al. 1993, 1996). A simple, practicable, and, above all, standardized method of documentation was therefore also necessary for CT and HRCT. A standardized method of documentation based on the ILO classification for pneumoconiotic changes objectified using CT was developed and tested as part of the research project “Early Diagnosis of Asbestos-associated Diseases.” A detailed description of the classification system has

been published elsewhere (Kraus et al. 1995, 1996). The second step was, to develop a computer-assisted classification system to store and archive the results and to allow further statistical processing, as for the findings from chest X-ray examinations.

Methods

A system of CT documentation was established in interdisciplinary collaboration, which, like the ILO classification for conventional X-ray photographs, allows the localization and spread of parenchymal and pleural changes in the CT to be coded and 28 supplementary symbols to be used. In addition, diagnosis of special occupational-medical relevance can be noted and additional comments can be given in text form (Hering et al. 1994). A detailed description can be found in Kraus et al. (1996). This CT classification system, together with the ILO classification that was established many years ago, served as the basis for a computer-assisted system.

Computerized documentation of data must meet the following demands:

1. Compatibility with usual hardware configurations
2. A comprehensible and transparent structure to the program
3. A high degree of suggestivity of the operator interface with a short familiarization period
4. Rapid documentation of findings and advantages over manual documentation
5. A function for saving storage space and archiving without additional work
6. Rapid availability of the data
7. The possibility of selecting certain data according to freely selectable criteria for immediate evaluation

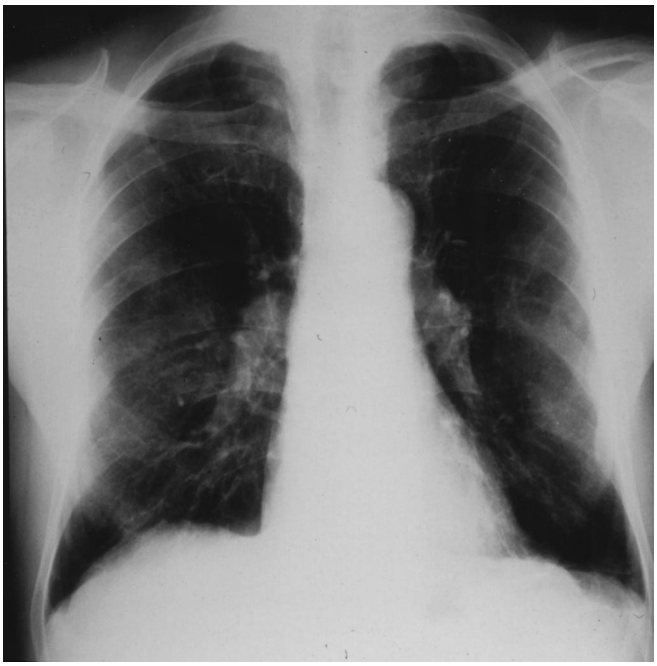


Fig. 1 Chest X-ray of an insulator exposed to asbestos for 39 years. ILO classification: small irregular opacities t 1/0, both middle and lower lobes, adherence of the left costophrenic angle, pleural plaques 3b, right and left chest wall and diaphragm, pleural calcification 2, left and right diaphragm; *Symbols* inactive tuberculosis

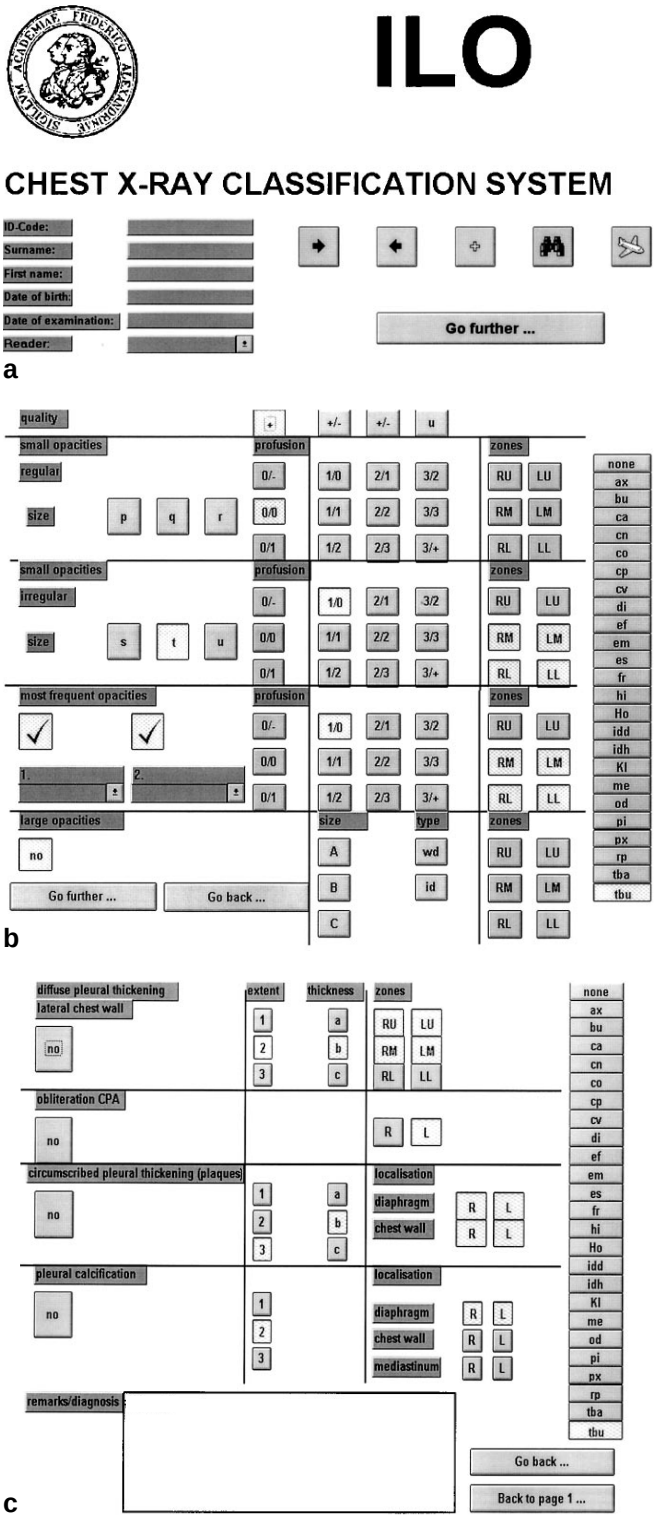


Fig. 2 a–c Three masks of the chest X-ray classification (according to the ILO system). **A** patient's data can be entered directly or loaded from other files. Clicked buttons are *colored* (*Symbols* → next patient, ← last patient, + add patient, *binoculars* search patient, *airplane* exit program)

8. The ability to print out the findings and the results of evaluation
9. Adaptability of the operator interface to suit individual needs

Results

A program was developed that was based on an IBM-compatible data-bank system running under Windows that allows effective documentation of both chest X-ray (International Labour Office 1980) and CT findings. The design of the operator interface of the programs was based on the ILO classification forms and CT/HRCT coding (Schickor et al. 1995; Kraus et al. 1996). The reader clicks the coding boxes using a mouse-driven cursor. Additional comments can be made in text form. The data are therefore available for immediate statistical evaluation and can be printed out or stored on data carriers with no problem. The error-provoking and time-consuming manual transfer of data or code numbers is no longer necessary. The storage space of the data banks is minimized by the selection of suitable field types and table structures.

The system, which consists of three (ILO program) or four (CT program) masks, is presented with examples in Figs. 1 and 2, respectively. Fields that are clicked are marked in colour, and errors can be corrected with no problem by reclicking of the same fields. Several roll-up menus give specific explanations and examples of special functions, e.g., help in searching for certain patients in the patient file. Data coding and the limited number of user licenses ensures data protection. Classification using these systems is demonstrated in the example of a worker with long-term exposure to asbestos. The patient is a 70-year-old man with 39 years of exposure to asbestos dust as an insulator.

The chest X-ray (Fig. 1) was coded according to the ILO classification as follows: no small regular opacity, small irregular opacities, size t, profusion 1/0, both middle and lower lobes, no large opacity, adherence of the left costophrenic angle, no diffuse pleural thickening, pleural plaque extension 3, thickness b, right and left chest wall and diaphragm, pleural calcification extension 2, left and right diaphragm (*symbols* inactive tuberculosis; Fig. 2).

A representative HRCT section of this patient is shown in Fig. 3. There are several pleural plaques on the left chest wall and a calcified plaque on the right diaphragm with parenchymal bands. The classification of all the slices is presented in Fig. 4.

Testing of the computerized coding system in practice was carried out as part of the documentation of conventional and CT X-ray photographs for the research project "Early diagnosis of asbestos-associated diseases." The system of data documentation proved to be very practicable in the more than 2,000 patients studied thus far (Kraus 1994; Kraus et al. 1996). It can therefore be recommended for widespread use by occupational-medical physicians and by radiologists. As the structure of the program allows adaptation to suit special needs with no problem, it can be recommended not only in scientific areas of use but also for use in daily routine.

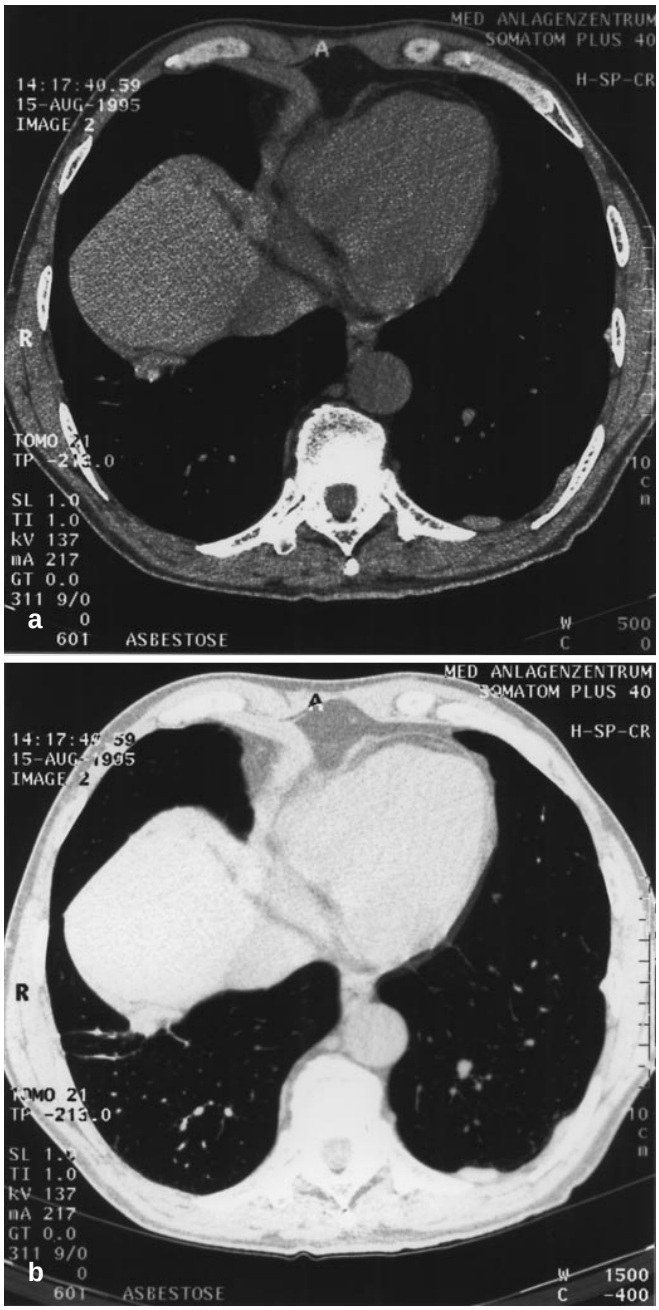


Fig. 3 a, b Representative HRCT scans of the insulator: several pleural plaques, left chest wall, and calcified plaque, right diaphragm, with parenchymal bands

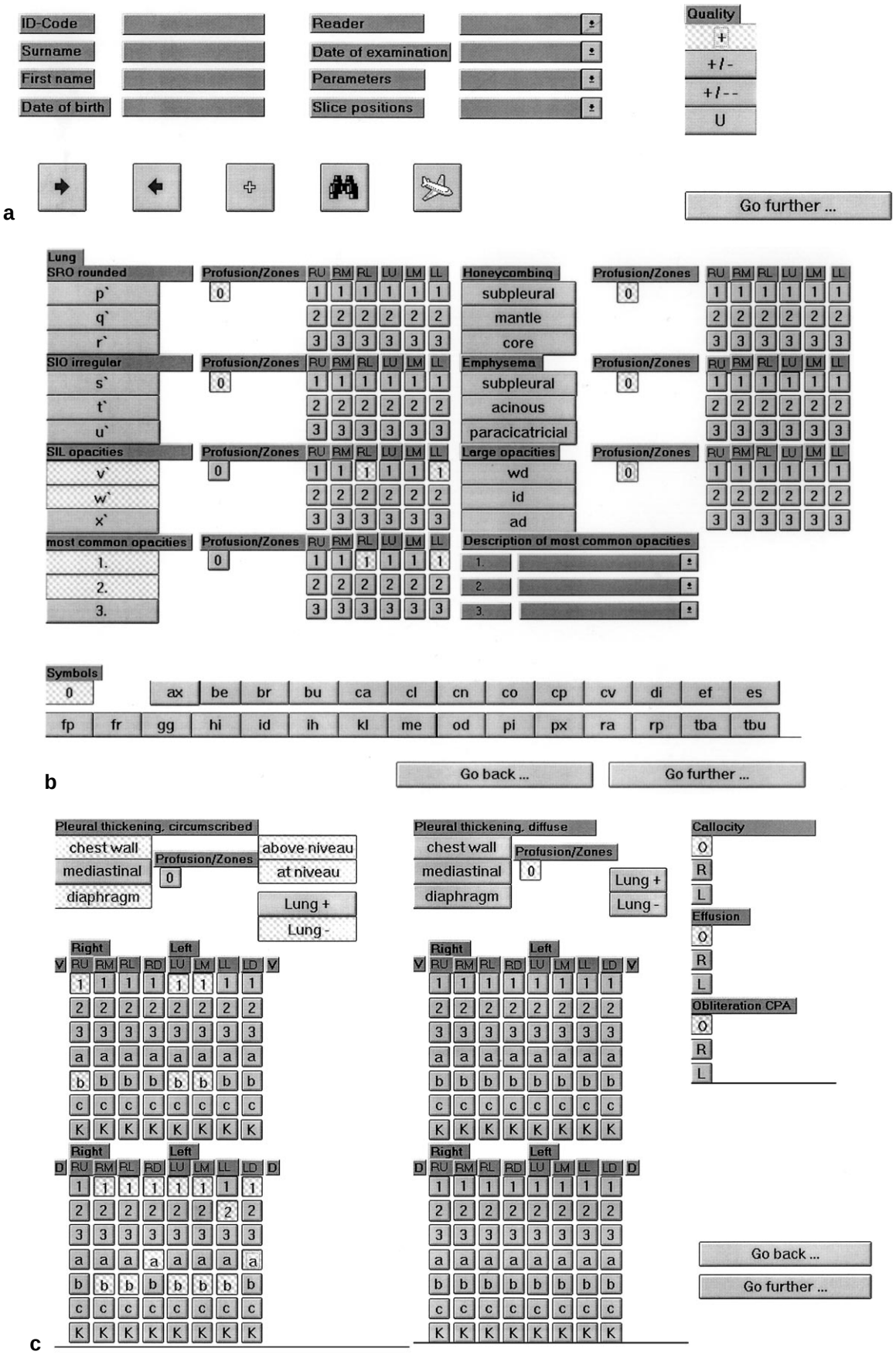
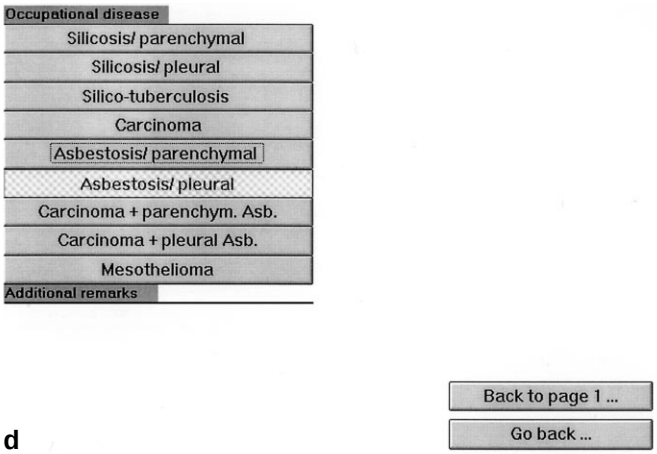


Fig. 4 a–c: Legend see next page



d

Fig. 4 a–d Four masks of the CT/HRCT classification system. A patient's data can be entered directly or loaded from other files. Clicked buttons are *colored* (*Symbols* → next patient, ← last patient, + add patient, *binoculars* search patient, *airplane* exit program)

Acknowledgements We would like to thank Mr. Frank Schickor for programming the system.

References

Bohlig H, Hain E, Woitowitz HJ (1972) Die ILO U/C 1971 Staubklassification und ihre Bedeutung für die Vorsorgeuntersuchung staubgefährdeter Arbeitnehmer. Prax Pneumol 26 : 688–700

Bohlig H, Hain E, Valentin H, Woitowitz HJ (1981) Die Weiterentwicklung der Internationalen Staublungenklassifikation und ihre Konsequenzen für die arbeitsmedizinischen Vorsorgeuntersuchungen staubgefährdeter Arbeitnehmer (ILO 1980/Bundesrepublik). Prax Pneumol 35 : 1075–1154

Gurney JW (1993) Pneumoconiosis Assistant: a hypermedia-based classification of the Pneumoconioses. J Thorac Imaging 8 : 143–151

Hering KG, Tuengerthal S, Kraus T, Wiebe V, Wegener HO, Raab W, Bohlig H (1994) CT-Untersuchung und standardisierte Befundung bei berufsbedingten Lungen- und Pleuraveränderungen in Anlehnung an die ILO-Staublungen-Klassifikation von 1980. Röntgenpraxis 47 : 262–269

International Labour Office/UC (1980) International classification of radiographs of pneumoconiosis. (Occupational safety and health series, vol 22, rev 80) International Labour Office, Geneva

Kraus T (1994) Erste Erfahrungen mit standardisierter HRCT-Befundung bei einer Kohorte asbestexponierter Personen. Proceedings, 7. Fortbildungsveranstaltung der Arbeitsgemeinschaft Diagnostische Radiologie bei berufs- und umweltbedingten Lungenerkrankungen der Deutschen Röntgengesellschaft, Oktober 7–8, Heidelberg

Kraus T, Raithel HJ, Hering KG, Michalik S, Mohrmann W, Raab W, Tuengerthal S, Wegener OH, Wiebe V, Lehnert G (1995) Frühdiagnostik asbestverursachter Erkrankungen – erste Ergebnisse eines interdisziplinären Forschungsvorhabens. In: Schiele R, Beyer B, Petrovitch A (eds) Verhandlungen der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin, 35. Jahrestagung. Rindt-Druck, Fulda, pp 233–239

Kraus T, Raithel HJ, Hering KG, Lehnert G (1996) Evaluation and classification of high-resolution computed tomographic findings in patients with pneumoconiosis. Int Arch Occup Environ Health 68 : 249–254

Nicholson WJ, Perkel G, Selikoff IJ (1982) Occupational exposure to asbestos: population at risk and projected mortality 1980–2030. Am J Ind Med 3 : 259–311

Raithel HJ, Kraus T, Hering KG, Mohrmann W, Wiebe V, Lehnert G (1993) Die Computertomographie als entscheidungsrelevantes diagnostisches Verfahren bei der Begutachtung fraglich berufsbedingter asbeststaubinduzierter Erkrankungen. Arbeitsmed Sozialmed Umweltmed 28 : 279–287

Raithel HJ, Kraus T, Hering KG, Lehnert G (1996) Asbestbedingte Berufskrankheiten – aktuelle arbeitsmedizinische und klinisch-diagnostische Aspekte. Dtsch Ärztebl 93 : 685–693

Schickor F, Kraus T, Hering KG, Tuengerthal S, Raithel HJ, Wiebe V, Mohrmann W, Raab W, Wegener OH, Michalik S, Lehnert G (1995) Entwicklung eines EDV-gestützten Kodierungssystems für konventionelle und computertomographische Röntgenaufnahmen in Anlehnung an die ILO-Klassifikation. In: Schiele R, Beyer B, Petrovitch A (eds) Verhandlungen der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin, 35. Jahrestagung. Rindt-Druck, Fulda, pp 313–314