# Mixed-dust Pneumoconiosis in a Dental Technician: A Multidisciplinary Diagnosis

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**Case report**

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# Abstract

*Background*

Exposure to crystalline silica in dental laboratories can occur during procedures that generate suspended mineral dusts, e.g. dispersion of mixing powders, removal of castings from moulds grinding and polishing castings and porcelain, and use of silica sand for blasting.

*Case presentation*

We report a 55-year-old male dental technician who, after about 15 years of work, began to suffer from a dry cough and dyspnoea on exertion. The operations included in his job resulted in the generation of crystalline silica, aluminium, chromium, titanium dust. The worker did not regularly wear personal protective equipment and some of the above operations were not carried out in closed circuit systems.The Chest X-ray showed diffuse micronodulation in the lung interstitium in the upper-middle lobes bilaterally and a modest left basal pleural effusion, simple spirometry showed initial small airway obstruction, High Resolution Computerized Tomography of the chest showed bilateral micronodulation of a miliariform type, with greater profusion in the upper lobes, also present in the visceral pleura, bilaterally. Histological examination showed aggregates of pigment-laden macrophages forming perivascular macules or arranged in a radial pattern around a core of sclerohyalinosis. Scanning Electron Microscopy and Energy Dispersive Spectrometry revealed several mineral particles, whose composition is characterised by the presence of aggregates of crystalline silica and metals. The ambient concentrations of total dust and its respirable fraction were all lower than the relative TLV-TWA - ACGIH, but did not negligible.

*Conclusions*

The above findings and a multidisciplinary assessment led to the diagnosis of mixed dust pneumoconiosis s/q with 2/2 profusion of occupational origin. This diagnosis in a dental technician was supported by environmental exposure analysis for the first time in the literature.


# Background

Traditionally dentures are produced with a metallic infrastructure and a resin veneering layer with the "lost wax" technique. Chromium-cobalt-molybdenum alloy is used to make the metal structure. The refractory material used to create the metal skeleton mould is composed of quartz, one of the most frequent forms of crystalline silica found in nature (1). Chronic inhalation of mixed mineral dusts containing respirable particles of crystalline silica and metal, produced during manufacturing processes, can cause pneumoconiosis called mixed mineral dusts. In fact, the term Mixed Dusts Pneumoconiosis (MDP) has been used since the middle of the last century to describe certain forms of pneumoconiosis in foundry workers, who are simultaneously exposed to crystalline silica and other less or non-fibrous mineral dusts.

These present highly variable histological, functional and radiological pictures and are sometimes difficult to define nosologically (2–5).

Indeed, many cases of mixed-dust pneumoconiosis in dental technicians due to chronic inhalation of crystalline silica, silicon carbide, asbestos, cobalt, molybdenum beryllium and nickel dusts, have been described in the literature. (6–12). Particularly in the past, these workers could be exposed to the inhalation of mineral dusts, including crystalline silica ($SiO_2$), in poorly ventilated and unsuitable extraction systems. (13–15). A recent study conducted in Turkey on 893 dental technicians admitted to Ankara hospital in the period January 2007-May 2012 found 90 cases of pneumoconiosis with a prevalence of 10.1% (16). In the literature we did not find data on environmental concentrations of mineral dusts in dental laboratories.

# Case Presentation

We report the case of a 42-year-old Italian dental technician E.S., a former smoker for about 8 years who had smoked 20 cigarettes a day for about 13 years and who, after 15 years of work, had developed a dry and persistent cough and dyspnoea on exertion in the absence of other clinically evident cardio-respiratory pathologies.

The dental laboratory in which this technician had worked produced mobile skeletal dental prostheses. E.S. was engaged in the production of the metal skeleton which then, suitably coated with resin of a colour similar to that of the gums, serves as a support for the artificial teeth. The production process of the prostheses according to the "lost wax" technique is shown in Fig. 1. During the devesting phase (Fig. 1, point 7), the refractory material mould was removed and quartz-containing dust was formed. The operations were carried out in the absence of extraction systems and the worker reported that he did not regularly wear the personal protective equipment (PPE) provided by his employer. The sandblasting phase (Fig. 1, point 8), which involved the use of aluminium oxide sand, was carried out in a closed automatic sandblasting machine.

For the above-mentioned respiratory symptoms, the laboratory occupational physician had requested a chest X-ray to be performed at the Unit of Occupational Medicine of the University Hospital Polyclinic of Bari (Italy). The radiogram was read out according to the National Institute for Occupational Safety and Health (NIOSH) guidelines (17). The presence of small rounded (q) and, above all, irregular (s) radiopacities, with 2/1 profusion, present above all in the mid-apical fields of the two lungs, of parenchymal fibrotic outcomes of the inferior-anterior segment of the right basal bronchus, with a partially calcified fibrotic stria at the base on the right and a "frontal" calcified diaphragmatic pleural plaque on the right was thus found (Figs. 2, a.). For further investigations the subject was admitted to the Unit of Thoracic Surgery of the University Hospital Polyclinic of Bari (Italy). Simple spirometry showed only initial obstruction of the small airways. The lung diffusion of CO was normal, with an increased lung CO diffusion (LCOD) to alveolar ventilation (AV) ratio of 24%. Chest High-Resolution Computed Tomography (HRCT), read out according to the International Classification of HRTC for Occupational and

Environmental Respiratory Diseases (18), confirmed the bilateral micronodulation of miliariform type, with greater profusion in the upper lobes, also present in the visceral pleura, bilaterally, and also showed a small parenchymal thickening at the base of the left lung and some lymph nodes increased in volume in the para-aortic, precarenal and subcarenal areas (Figs. 2, b.). Figure 2. *(a.) Chest X-ray showing radiopacity in the mid-apical fields and fibrotic findings (b.) Chest High Resolution Computerized Tomography (HRCT) showing bilateral miliary micronodulation.*

The surgeons performed an exploratory thoracotomy with pleural-parenchymal biopsy. Histological examination showed granulomatous lesions in a context of centro-lobular emphysema, particularly noticeable: gigantocellular cells, macula formed by perivascular interstitial aggregates of macrophages loaded with intracytoplasmic dust pigment material. In addition, were visible fibrotic mixed dust lesions characterised by interstitial aggregates of macrophages laden with intracytoplasmic dust pigment arranged in a radial manner with respect to a central core of scleroialinosis. (Figs. 3.).

Therefore, in order to better define the aetiological origin of the pneumoconiosis, with the informed consent of the worker, the occupational physicians requested the remaining biopsy specimen from the base of the left lung in order to carry out Scanning Electron Microscopy (SEM) (19).

The SEM revealed several mineral particles, whose composition (Figs. 4, a, b, c) was identified using an Energy Dispersive Spectrometer (EDS). The presence of multiple aggregates of silicates, crystalline silica, aluminium (Al), iron (Fe), chromium (Cr), cobalt (Co) and titanium (Ti) was detected (Fig. 4d).

We requested and obtained the Occupational Risk Assessment Document of the dental laboratory, which contained the safety data sheets of the substances used. These sheets documented the presence of quartz, cristobalite and magnesium oxide in the refractory material used in the investing phase (Fig. 1 point 4) and the presence of chromium, cobalt and molybdenum in the metal alloy used in the casting phase (Fig. 1 point 6). Moreover in the same document there were the results of the environmental analysis, carried out by means of constant flow sampling, four at a fixed location in the ceramics room, the plaster room, the sandblasting room and the finishing room, and two by means of personal samplers placed on the lapels of the lab coat of the plaster preparer and sandblaster. Each sample was taken for eight continuous hours. The amount of mineral dusts were determined by double weighing method using an electronic microbalance. (20).

The ambient concentrations of the inhalable fraction, ranging from 0.88 to 1.90 mg/m3, and its respirable fraction, ranging from 0.18 to 0.55 mg/m3, measured by fixed sampling at the various workstations, were all below the relevant Threshold Limit Values-Time Weighted Average (TLV-TWA) proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) (21) (Table 1).

The two concentrations of total dust, 1.41 and 1.55 mg/m3, and of its respirable fraction, 0.60 and 0.82 mg/m3, measured by individual sampling, were also all below the relevant TLV-TWAs (21) (Table 1).

*Table 1: Concentration of inhalable fraction and respirable fraction, obtained by stationary and individual samplers, in the workplace*

| Sampling method | Sampling site | Inhalable fraction[a] ($mg/m^3$) | Respirable Fraction [b] ($mg/m^3$) |
|---|---|---|---|
| Stationary | Ceramic room | 0.88 | 0.51 |
| | Plaster room | 1.90 | 0.49 |
| | Sandblasting room | 1.76 | 0.55 |
| | Finishing room | 0.86 | 0.18 |
| Individual | Plaster preparation worker | 1.55 | 0.60 |
| | Sandblasting worker | 1.41 | 0.82 |
| TLV-TWA (Threshold Limit Value - Time Weighted Average) by the American Conference of Governmental Industrial Hygienists: | | | |
| [a] Inhalable fraction = 10 $mg/m^3$; | | | |
| [b] Respirable Fraction = 3 $mg/m^3$ | | | |

In view of all the clinical, radiological, histological, mineralogical and toxicological findings available, was established the diagnosis of MDP s/q with 2/2 profusion, predominantly affecting the parenchyma of the bilateral mid-apical lung fields, with a slight functional impairment (2).

## Discussion And Conclusions

Probably for the first time in the literature, it was possible to demonstrate that, in a dental laboratory and in the absence of appropriate extraction systems, dispersion of crystalline silica and metal dusts in the respirable fraction into the working environment can occur at low, but not negligible doses. These dusts corresponded to the raw materials and to the metals used in the production of skeletal dental prostheses. Their toxicological data sheets were included in the laboratory's occupational risk assessment document.

Mineralogical examination confirmed the presence in the lung biopsy fragment of mineral particles inhaled by the worker, who did not regularly use personal respiratory protective equipment.

Clinical data, functional respiratory examination and, above all, histological examination, and imaging, read out according to NIOSH guidelines, and the determination of non-negligible concentrations of respirable dust (although below TLV-TWA) made it possible to give further biological plausibility to the results of the toxicological investigations carried out on the environment and lung tissue.

The case described shows that good industrial hygiene and occupational medicine practices and collaboration between specialists from different medical and mineralogical disciplines provided the necessary documentation to establish the causal link between a dental technician's occupational exposure to respirable mineral dusts and the onset of an uncommon MDP.

For preventive purposes, however, it is necessary to remember that employers must always engage in primary and secondary prevention (22) to reduce workers' exposure to health risks and that workers must use PPE responsibly.

# Abbreviations

ACGIH: American Conference of Governmental Industrial Hygienists

AV: alveolar ventilation

EDS: Energy Dispersive Spectrometer

HRCT: High-Resolution Computed Tomography

MDP: Mixed Dusts Pneumoconiosis

LCOD: lung CO diffusion

NIOSH: National Institute for Occupational Safety and Health

PPE: personal protective equipment

SEM: Scanning Electron Microscopy

TLV-TWA: Threshold Limit Values-Time Weighted Average

# Declarations

**Financing** Not applicable, no funding was received to contribute to the preparation of this manuscript.

**Conflicts of interest/competing interests** The authors have no conflicts of interest to declare that are relevant to the content of this article.

**Ethical approval for case studies** Approval was obtained from the ethics committee of the University Hospital Policlinico di Bari. The procedures used in this study complied with the principles of the 1964 Declaration of Helsinki.

**Consent to publish** The participant consented to the submission of the case report to the journal.

**Author contributions** Conceptualisation: Luigi Di Lorenzo, Filippo Cassano, Giosi Longo, Rossella Attimonelli; Methodology: Luigi Di Lorenzo (Rx and HRTC standardised read out), Eugenio Maiorano (Histological analysis), Rocco Laviano (Mineralogical analysis), Filippo Cassano (Environmental analysis); Writing - preparation of original draft: Antonella Pipoli, Nicola Mariano Manghisi; Writing - revision and editing: Luigi Di Lorenzo, Antonella Pipoli.

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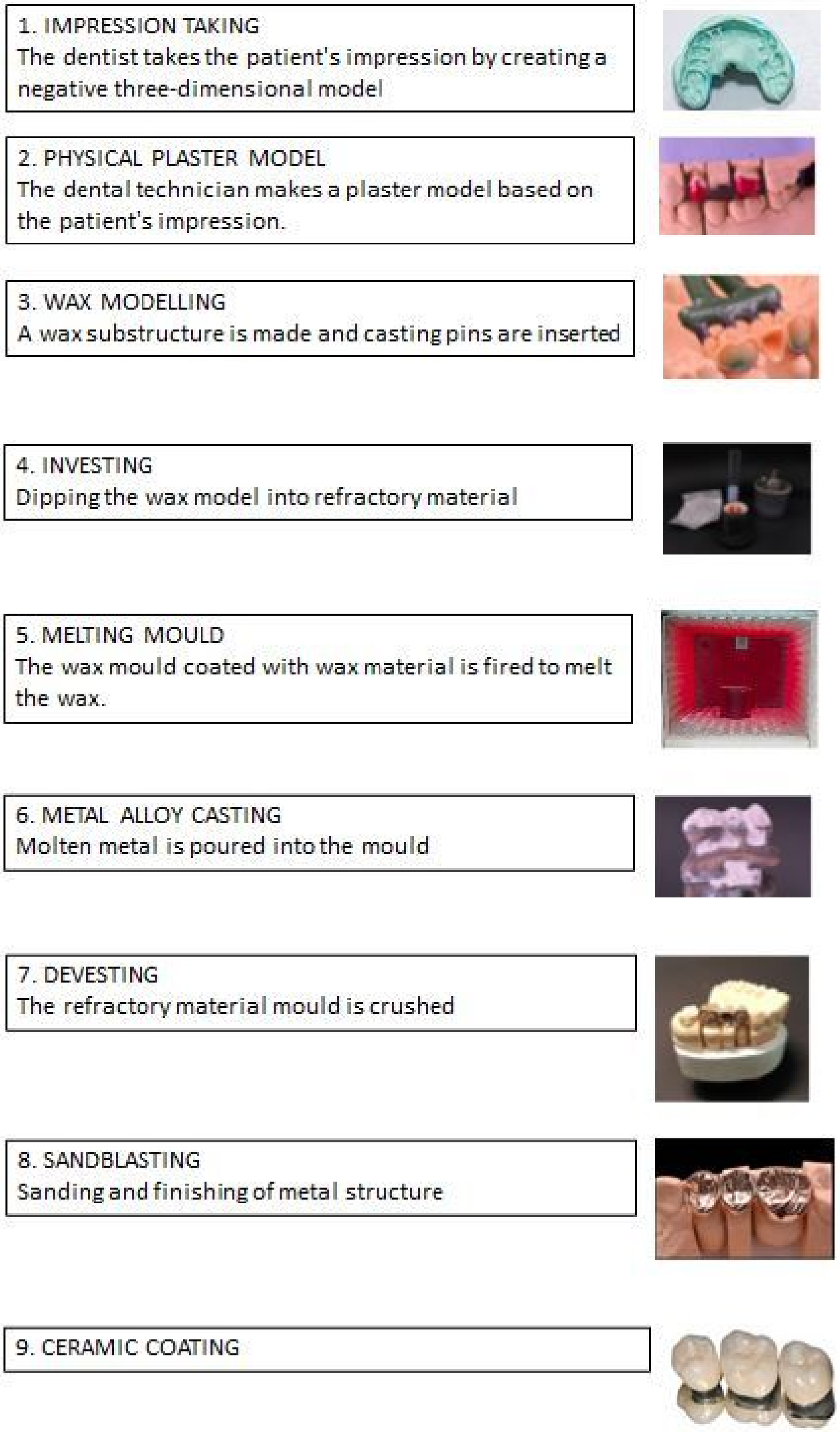
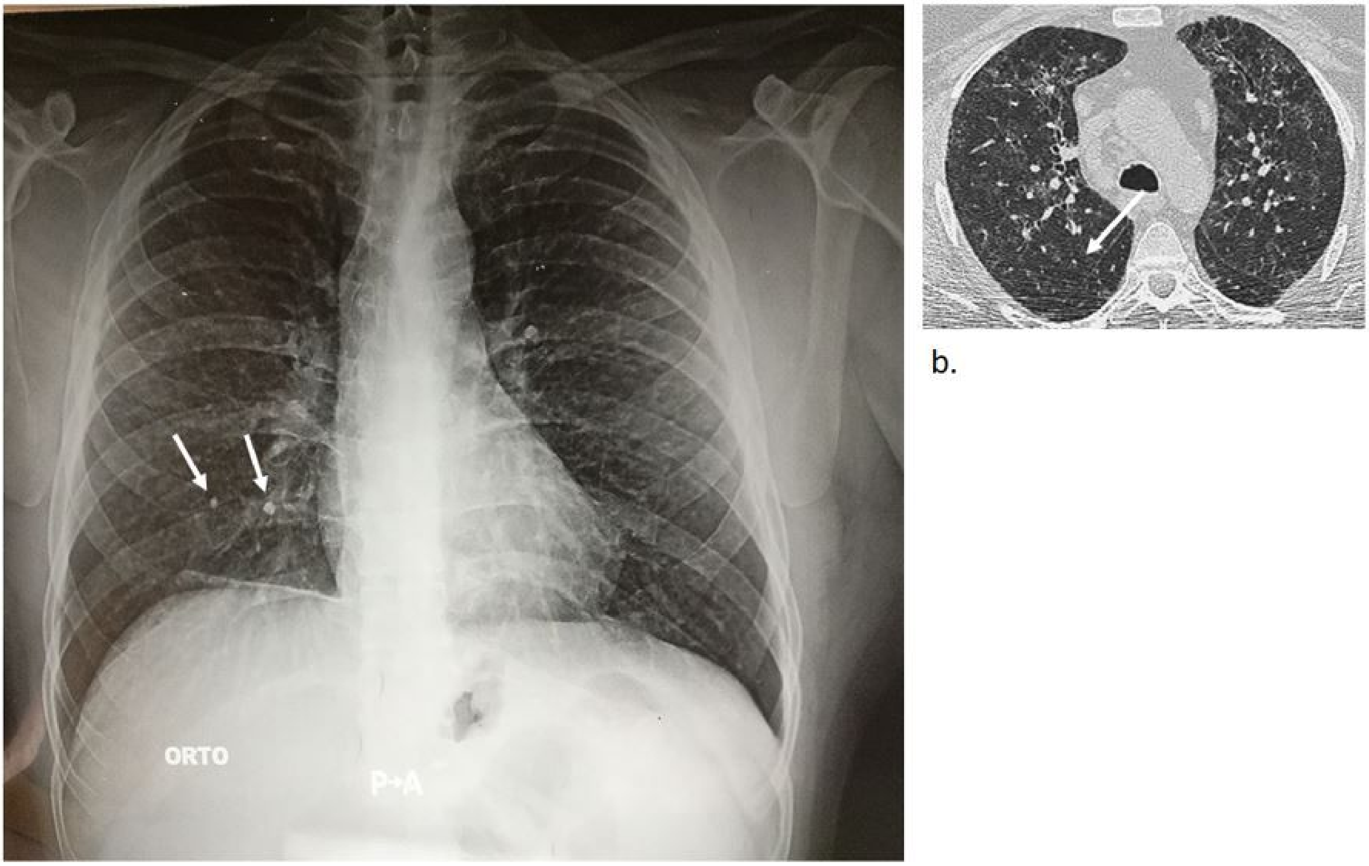
# Figures




## Figure 1

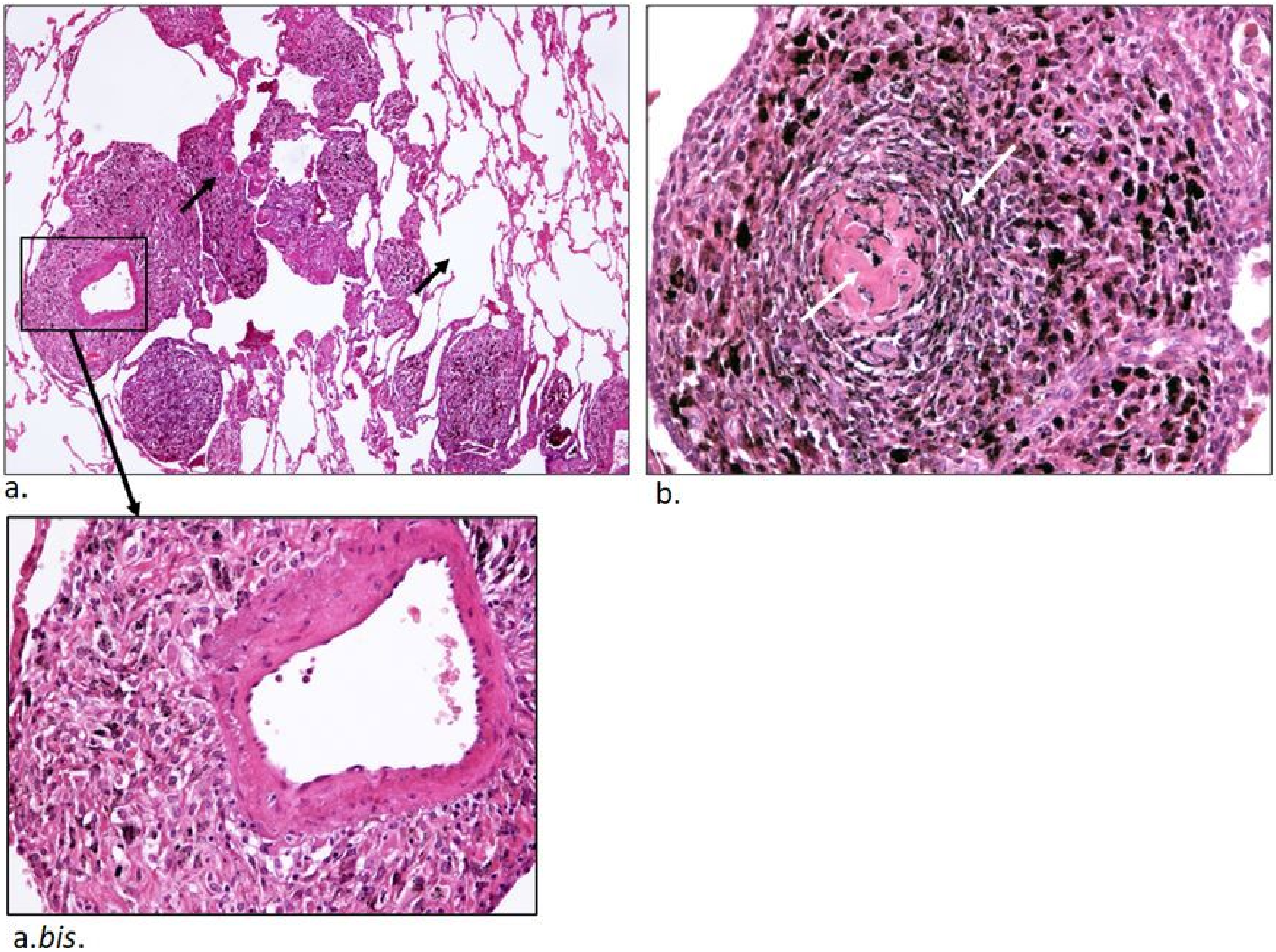
Production of dental prostheses using the “lost wax” technique




a.
b.

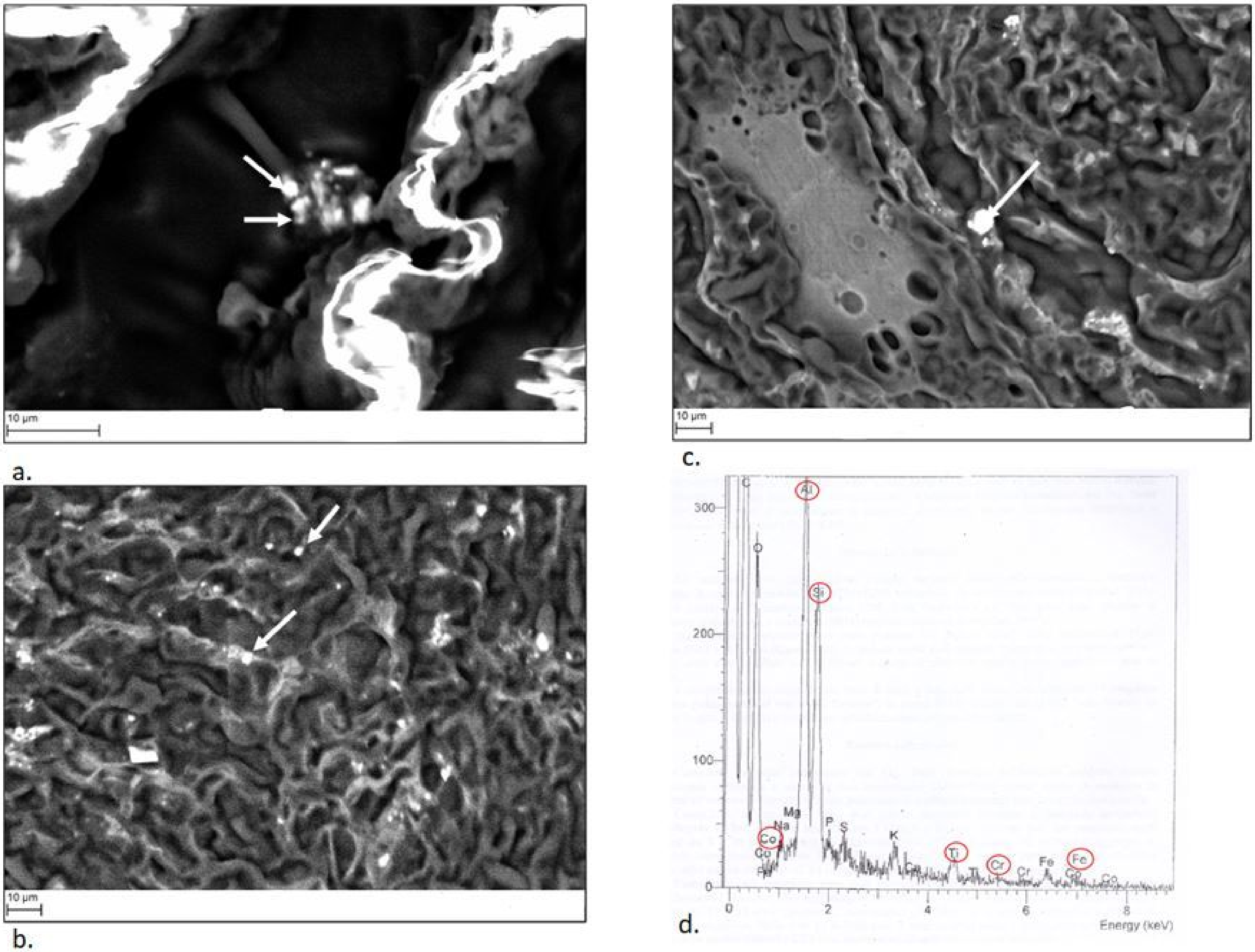
**Figure 2**

(a.) Chest X-ray showing radiopacity in the mid-apical fields and fibrotic findings (b.) Chest High Resolution Computerized Tomography (HRCT) showing bilateral miliary micronodulation.



## Figure 3

Photomicrographs of histological image, Haematoxylin Eosin staining: a. 40x magnification shows granulomatous lesions in a context of centrolobular emphysema, particularly noticeable: gigantocellular cells, macula formed by perivascular interstitial aggregates of macrophages loaded with intracytoplasmic dust pigment material; a.bis. 200x magnification of perivascular macula; b. Magnification 200x, showing fibrotic mixed dust lesions characterised by interstitial aggregates of macrophages laden with intracytoplasmic dust pigment arranged in a radial manner with respect to a central core of scleroialinosis.




### Figure 4

Photos of tissue sections examined (a, b, c) and Energy Dispersive Spectrometer (EDS) plotting of element peaks (d) produced by Scanning Electron Microscope (SEM), model EVO50XVP by LEO, equipped with Energy Dispersive Spectrometer (EDS), with Oxford Silicon drift X-max detector (80 mm2) equipped with Super ATW © (Super Atmosphere Thin Window).