

Ocular surface and respiratory tract damages from occupational, sub-chronic exposure to fluorspar: case report and other considerations

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Abstract

Objectives To report the ocular surface and respiratory tract damages due to a sub-chronic (3 months), occupational exposure to fluorspar dust in case of inconsistent use of personal protective equipment.

Methods A 50-year-old man was referred to our clinic with bilateral conjunctival injection, ocular foreign body sensation and symptoms of ocular discomfort. He reported having 3 days before an urgent hospital admission for dyspnoea with odynophagia, hyposmia, nausea, vomiting, headache and asthenia. Otorhinolaryngological examination revealed a severe hypertrophic rhinopharyngitis and a significant decrease in overall sensitivity to olfactory stimuli. General anamnesis was negative for previous diseases or medication use.

Results Ocular examination revealed a diffuse injection of the ocular surface with some areas of conjunctival and limbal ischaemia, a best-corrected visual

acuity of 20/25 in both eyes, an intraocular pressure of 23 and 21 mmHg, respectively, in the right and in the left eyes, and a normal *fundus oculi*. Assessment of the tear film and ocular surface showed the presence of dry eye disease. Based on medical history and clinical tests, initial diagnostic hypothesis was ocular surface burn due to chemical exposure, i.e. to fluorspar. Therefore, anterior segment fluorescein angiography was performed to confirm the extension of conjunctival and limbal ischaemia. Thus, ocular ischaemia was detected in approximately 10 clock hours of limbus and in 50% of conjunctiva.

Conclusions The present work remarks the importance of using protective equipment for preventing ocular and respiratory tract damages in workers occupationally exposed to the ‘acid-grade fluorite’.

Keywords Ocular surface ischaemia · Respiratory tract damage · Fluorspar · Occupational exposure

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Introduction

Pulmonary and dental effects due to chronic exposure to fluorides have been widely described and debated in the literature [1, 2]. Some fluorides, such as fluorspar, have a wide range of industrial applications and may be accidentally widespread in the environment. A serious contamination of air, soil and herds was detected in Sardinia in May 2017. This event is

believed to be related to professional exposure to fluorspar dust in the industrial area of Macchiareddu (Assemini).

In this work, we described for the first time the ocular surface and respiratory tract damages due to a sub-chronic (3 months), occupational exposure to dust of fluorspar in case of inconsistent use of personal protective equipment.

Case report

A 50-year-old man was referred to our clinic with bilateral conjunctival injection, ocular foreign body sensation and symptoms of ocular discomfort, including episodes of transient blurred vision in performing high concentration activities (as reading, writing and using computers).

Of note, he reported having 3 days before an urgent hospital admission for dyspnoea with odynophagia, hyposmia, nausea, vomiting, headache and asthenia. Specifically, symptoms of respiratory tract and ocular surface started since the second month of dust exposure and progressively worsened until the hospitalization. At that time, the patient was monitored for systemic effects, performing thoracic radiography, arterial blood gas and electrolytes analysis and cardiac monitoring (e.g. QT interval).

Otorhinolaryngological examination was also required immediately, thus revealing the presence of a severe hypertrophic rhinopharyngitis with reduced mucous secretion. A significant decrease in overall sensitivity to olfactory stimuli on olfactometric analysis was also detected.

General anamnesis was negative for previous diseases or medication use. The occupational anamnesis disclosed a daily fluorspar exposure of 8 h for 5 days a week for 3 months, in the absence of consistent/correct use of personal protective devices (masks and/or glasses). Particularly, in the context of his work as a crane operator for a mining factory, the patient performed only outside tasks close to collections of fluorspar dust, which were conserved outdoors, unprotected and therefore free to disperse in the surrounding environment.

Ocular examination revealed a diffuse injection of the ocular surface with some areas of conjunctival and limbal ischaemia, a best-corrected visual acuity (BCVA) of 20/25 in both eyes, an intraocular pressure

(IOP) of 23 and 21 mmHg, respectively, in the right and in the left eyes, and a normal *fundus oculi*. Assessment of the tear film and ocular surface showed a score of McMonnies and OSDI questionnaire of, respectively, 15 and 60, a fluorescein break-up time (FBUT) of 5 s, a fluorescein staining of the cornea and conjunctiva (graded according to the Oxford system) of three (\leq Panel D) and a normal Schirmer I test. The diagnostic procedures in this report were the same as those used in previously published studies [3, 4].

Based on medical history and clinical tests, initial diagnostic hypothesis was ocular surface burn due to chemical exposure, i.e. to fluorspar. Therefore, anterior segment fluorescein angiography was performed to confirm the extension of conjunctival and limbal ischaemia (Fig. 1). Thus, ocular ischaemia was detected in approximately 10 clock hours of limbus and in 50% of conjunctiva. Conversely, quantitative analysis of corneal epithelial thickness mapping using optical coherence tomography (OCT) was unremarkable.

Written informed consent to publish this case report and the accompanying images was obtained from the patient.

Discussion

Fluorspar (also called fluorite) is the mineral form of calcium fluoride (CaF_2). There are three main types of industrial applications for natural fluorite, commonly referred to as ‘fluorspar’ in these industries, based on different grades of purity: *metallurgical-grade* fluorite (60–85% CaF_2), *ceramic-grade* fluorite (85–95% CaF_2) and ‘acid-grade fluorite’ (97% or more CaF_2 , the highest grade). The latter represents approximately 95% of fluorite consumption in the USA, where it is used to obtain hydrofluoric acid and hydrogen fluoride by reacting the fluorite with sulphuric acid.

In the present work, the sub-chronic exposure to dust of ‘acid-grade fluorite’ led to eye abnormalities, including the ocular surface ischaemia and dry eye syndrome, as well as alterations of respiratory tract, in a previously healthy individual.

At present, the exact mechanism of toxic effects of CaF_2 on such tissues is unknown. Although fluorspar is thought to be stable (due to the stability of calcium-fluoride bond), its increased *concentration* and *residence time* on the mucosal epithelia (maybe helped by

Fig. 1 At presentation, slit-lamp biomicroscopy and fluorescein angiography of the anterior segment revealed diffuse and severe ischaemia of the ocular surface, involving approximately 10 clock hours of limbus and 50% of conjunctiva, in both eyes



an insufficient personal protection of eyes and respiratory tract, i.e. masks and glasses) could have promoted the onset of ischaemia and irritation because of in situ dissolution of F^- ions (i.e. fluoride or fluorine anion) [5]. In fact, CaF_2 has been known to be slightly *soluble in water* and not only in hot, acid solution.

As previously reported, free fluoride ions can be harmful to biological tissues and form complexes with magnesium, thereby depleting body storages of this mineral. For example, in case of skin exposure involving approximately 8% of body surface area, F^- ions can induce severe and refractory ventricular fibrillation [6].

In addition, ocular exposure may be responsible for corneal and conjunctival epithelium damages and cause conjunctival ischaemia and stromal corneal oedema. Deeper penetration of the fluoride ions may also cause delayed opacification of the cornea and necrosis of the ocular tissues [7].

Moreover, as reported by Ridley et al. [8], acute inflammatory response to fluoride ions may play a role in the subsequent development of fluoride-induced diseases.

In our case, the ocular ischaemia involved both the limbus (10 clock hours) and the bulbar/forniceal conjunctiva (50%). Such extent, according to the Dua's classification, is indicative of guarded to poor prognosis, regardless of initial corneal condition, thus suggesting a close monitoring of eye conditions over time [9].

Several authors described different cases in which a sub-acute exposure (2 months) to high dose of fluoride caused marginal damage to the lungs [10, 11]. Mullenix and colleagues also reported that in the USA there may be a large underestimation of the number of cases of fluoride poisoning due to the manipulation and omission of important data [11].

As regards the nasal mucosa, dusts and a broad range of manufacturing processes have been known to

induce hyposmia, by reducing the sensitivity of the trigeminal nerve [12].

For all these reasons, we strongly believe that the environmental concentrations of CaF_2 could be a concern for ophthalmologists, particularly in case of concomitant dry eye (where there is a reduction in dilution and washing of external debris from the eye globe, including CaF_2 dust), and for pulmonologists and otolaryngologists.

Conclusions

Considering the potential toxicity from sub-chronic exposure to dust of fluor spar, the present work remarks the importance of using protective equipment for preventing ocular and respiratory tract damages in workers occupationally exposed to the ‘acid-grade fluorite’.

Further studies are needed to better understand the exact pathogenetic mechanism that determines ocular injuries after acute or sub-chronic exposure to CaF_2 .

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Data availability The authors confirm that all data underlying the findings are fully available without restriction. Authors confirm that all data underlying the findings in the present study are freely available in the manuscript. No additional data available.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent The patient involved in this case report gave written informed consent to publish the present paper.

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