Miliaria rubra of the lower limbs in underground miners

A. M. Donoghue* and M. J. Sinclair†

*The Minerals Industry Safety and Health Centre, University of Queensland, Brisbane, Queensland 4072, Australia; and †Qantas Aviation Medicine Unit, Sydney, New South Wales 2020, Australia

This report documents a case series of miliaria rubra of the lower limbs in miners at a deep underground metalliferous mine in tropical arid Australia. During the summer months of February and March 1999, all cases of miliaria rubra of the lower limbs in underground miners seen at the mine's medical centre were clinically examined and administered a questionnaire. Twenty-five patients were seen, an incidence of 56.4 cases per million man-hours. Miliaria rubra was most often located between the ankle and knee (88% of cases). Twenty-four percent had concurrent folliculitis and 20% had concurrent tinea. Thirty-two percent had a personal history of asthma. Walking through ground-water and splashing of the legs was common. Three to 4 weeks of sedentary duties in air conditioning was generally required to achieve resolution of miliaria rubra.

The incidence of miliaria rubra of the lower limbs is 38% of the incidence of heat exhaustion at the same mine. The length of disablement is greater, however. Atopics may be at increased risk of miliaria rubra. Control measures are discussed.

Key words: Dermatology; heat; hypohidrosis; miliaria rubra; mining; skin; sweat.

INTRODUCTION

Miliaria rubra is a non-follicular, erythematous, papular eruption caused by extravasation of sweat into the skin, as a result of obstruction of the sweat ducts.1 It occurs after prolonged and profuse sweating, in those exercising in a hot environment.1–3 It causes severe pruritis and a burning sensation. The affected skin is anhidrotic because of the sweat duct obstruction. Miliaria rubra causes heat intolerance in those with as little as 17% of the body surface area affected.4,5 Heat intolerance persists for 21–28 days in those without further exposure to heat or heavy exercise.6 Hypohidrosis can be induced artificially by occlusion of the skin with impermeable plastic for 3 days, or by immersion in water for 3–24 h.2,5 The effect persists much longer after occlusion (2–3 weeks) than immersion (90 min).2 Miliaria rubra occurs after 3 days of occlusion, the severity being greatly increased by concurrent heat exposure.2,5 Artificially induced hypohidrosis is associated with an expansion of the microflora, principally cocci. Treatment of occluded skin with antibacterial substances prevents expansion of the microflora and hypohidrosis.2 Histological examination of miliaria rubra induced by occlusion reveals the formation of an amorphous plug of periodic acid–Schiff (PAS) positive material deep in the duct.4 This is followed by migration of inflammatory cells through the epidermis and into the duct to form a dense conglomerate.4 The impaction sloughs off after approximately 3 weeks due to epidermal renewal.2 Experiments placing various strains of staphylococci under occlusive dressings have demonstrated that only Staphylococcus epidermidis strains which produce PAS positive extracellular polysaccharide substance (EPS) induce miliaria rubra.6 These strains are a relatively common component of skin microflora, comprising about 35% of staphylococci strains isolated from the skin of healthy subjects.6 It seems, therefore, that although prolonged heat exposure is required for miliaria rubra to occur in non-experimental settings, a specific bacterial colonization of the skin may also be required for its development.

The literature on miliaria rubra in mining is slight. Twenty cases were reported in a British underground coal mine and more were suspected.3 Fifty consecutive cases were reported from the Chamber of Mines Hospital in South Africa in 1964.7 The incidence of miliaria rubra was said to be rising with the increase in deep-level mining, but no incidence data were provided. Brief reference to miliaria rubra in Australian miners was...
made in 1958 and 1964, but without description of the type of mining, or elucidation of the incidence.\textsuperscript{8,9}

While working at a deep underground metalliferous mine in tropical arid Australia, we noted that miliaria rubra in underground miners was relatively common, especially in summer and that it often affected the skin of the lower limbs, in particular, the dorsum of the foot, ankle and leg. We elected to standardize our assessment of these cases with a questionnaire that was administered during consultation. The objectives were to determine the incidence of miliaria rubra of the lower limbs, describe the location of the rash on the lower limbs and elsewhere, and to determine the frequency of suspected occupational risk factors and concurrent dermatoses. This paper presents the findings obtained during the summer months of February and March 1999.

METHOD

During the summer months of February and March 1999, all cases of miliaria rubra of the lower limbs in underground miners seen by the authors at the mine’s medical centre were administered a questionnaire (the authors were the only medical officers at the medical centre during this period). February and March are the hottest months of the year and were chosen because of an expected peak in the incidence of miliaria rubra, based on clinical experience in previous years. The diagnosis was made clinically on finding a non-follicular, erythematous, papular eruption. The questionnaire elicited information on age, underground experience, boot type, frequency of walking through ground-water, frequency of water splashing on the legs, use of dry socks at meal breaks, use of barrier cream, frequency of showering, duration of the rash, and personal history of asthma, hayfever and eczema.

The incidence rate for the condition was calculated as cases per million man-hours, using the total number of underground miners (1252), and the average number of hours worked per miner during the study period (354). The location of miliaria rubra on the body and any concurrent dermatoses were noted.

Statistical analysis

Descriptive statistics were undertaken using Microsoft Excel.

RESULTS

Twenty-five cases of miliaria rubra of the lower limb in underground miners were observed during the two summer months of February and March 1999. This equated to an incidence rate of 56.4 cases per million man-hours. All cases were male. The mean age was 31.8 years (SD 8.4, median 30.0, range 18-50). By way of comparison, the study population was almost entirely male and the mean age was 35.7 years (SD 8.6).

The mean length of underground service was 7.5 years (SD 6.2, median 5.0, range 0.06-20). Only three miners had worked elsewhere.

Two types of boot were allowed underground. One was a rubber boot, which extended up the calf to just below the knee. The other was a leather boot, which extended to just above the ankle. Sixteen patients (64%) wore rubber boots exclusively, seven (28%) wore leather boots exclusively and two (8%) wore both types of boot.

Twenty-one patients (84%) walked through ground-water on more than 25% of work days. Seventeen patients (68%) had water splash over their legs on more than 25% of work days.

Only six patients (24%) changed into dry socks at ‘crib time’ (meal break). Three patients (12%) used a barrier cream (unspecified) routinely on the legs. Seven patients (28%) had one shower per day, 14 (56%) had two showers per day, and three (12%) had three showers per day (no data for one patient).

Eight patients (32%) had a personal history of asthma, six (24%) had a personal history of hayfever and two (8%) had a personal history of eczema.

Eighteen patients (72%) had no previous leg rash. The mean length of underground service in this group was 7.7 years (SD 7.0, median 6.0, range 0.06-20) and the mean duration of the rash on presentation to the medical centre was 4.0 weeks (SD 4.2, median 2.8, range 0.14-16).

The location of miliaria rubra on the body was as follows. On the foot or ankle in 12 patients (48%), from above the ankle to the level of the knee in 22 (88%), on the thigh in eight (32%), on the trunk in six cases (24%), and on the arms in 10 patients (40%). Miliaria rubra was present at or below the level of the knee in all patients.

Six patients (24%) had concurrent folliculitis within the area of skin affected by miliaria rubra. Five patients (20%) had concurrent clinical tinea within the area of skin affected by miliaria rubra. Skin scrapings were taken from these five men and fungal hyphae were seen in four of the samples on microscopy after potassium hydroxide staining.

Miners with miliaria rubra often told us that the pruritis and burning sensations were quite severe. Air conditioning relieved their symptoms, while a return underground resulted in a prompt exacerbation of symptoms, often shortly after getting out of the cage (approximately 1200 m depth). Outdoor recreation, which occasionally occurred despite advice to the contrary, produced similar exacerbation. Only after 3-4 weeks of sedentary duties in an air-conditioned environment on the surface did these heat-related exacerbations abate.

No underground thermal measurements were made at the time of presentation of these patients. However, measurements taken the year before, during a study of heat exhaustion at the same mine, indicate how adverse the thermal conditions can become.\textsuperscript{10} Mean psychrometric wet bulb temperature was 29.0°C (SD 2.2, range 21.0-34.0). Mean dry bulb temperature was 37.4°C (SD 2.4, range 31.0-43.0). Mean air velocity was 0.54 m/s (SD 0.57, range 0.00-4.00).
DISCUSSION

The incidence of 56.4 cases per million man-hours represents the peak incidence during summer. Our experience over four consecutive summers was that the occurrence of miliaria rubra was markedly seasonal, with very few cases occurring during the winter months. The incidence of heat exhaustion at the same mine during February 1998 was 147 cases per million man-hours. Although the incidence of miliaria rubra of the lower limbs is only 38% of the incidence of heat exhaustion, the duration of temporary disablement is much greater. Most cases of miliaria rubra required 3–4 weeks of sedentary duties in an air-conditioned environment on the surface, whereas most patients with heat exhaustion returned to their normal duties on the following shift or required only 1 day of such duties. The occurrence of miliaria rubra and heat exhaustion indicates the need for improved ventilation and refrigeration. This is particularly so, given there is no effective treatment for miliaria rubra and heat exhaustion indicates the need for improved ventilation and refrigeration. This is particularly so, given there is no effective treatment for miliaria rubra, apart from avoiding exercise and hot conditions while awaiting epidermal renewal.1–3

Walking through ground-water and splashing of the legs was common amongst our patients. Miliaria rubra was most commonly found on the leg between the ankle and knee. Most cases wore long rubber boots, which would tend to trap saturated water vapour around the leg if splashes of ground-water entered the boots. It is possible that over-hydration of the skin may be a risk factor for miliaria rubra. The mechanisms may be expansion of the microflora or the hypohidrosis of immersion. It is also possible that dust, ground-water irritants and friction from the boots and trouser legs predispose towards miliaria rubra. Another possibility is that boots may be a microbial reservoir, which promote miliaria rubra if they harbour abundant EPS-producing Staphylococcus epidermidis strains.

There was wide variation in the length of underground service in our case series. A similar observation was made in a large cross-sectional study of British Army personnel in south-east Asia during the late 1940s.10 The prevalence of miliaria rubra, in relation to length of tropical service, was 4% in those with less than 1 month’s service, 54% in those with 4–5 months’ service and 20% in those with at least 24 months’ service. A similar distribution was observed in 1945 on Guam amongst US Navy personnel. In a series of 50 cases reported from the Chamber of Mines Hospital in South Africa, the length of underground service varied from 3 to 35 years and the average was 13.4 years. The mean length of underground service in the 18 cases of our series who had no previous history of leg rash was 7.7 years (SD = 7.0, range 0.06–20). Such wide variation suggests a cumulative assault on the skin’s defences, individual susceptibility or an irregular exposure to a risk factor. It is possible that profuse colonization of the skin, clothing or boots with EPS-producing Staphylococcus epidermidis strains may be just such an irregular risk factor.

The concurrent folliculitis and tinea probably reflects how conducive the hot, humid environment is for microbial growth. An association between folliculitis and miliaria has been observed elsewhere.12,13 Keeping the feet and legs dry would prevent damage to the barrier function of the skin and may also help prevent miliaria. Suggested methods include:

- pumping ground-water out of work areas where practicable (this also reduces the risk of heat exhaustion by decreasing humidity);
- education to avoid unnecessary walking through ground-water and splashing of the legs;
- changing into clean, dry socks at meal breaks;
- daily washing and drying of clothes;
- drying of the boots between shifts.

There may be a role for the preventative application of topical antibacterial solutions such as hexachlorophene to the legs, given that treatment of occluded skin prevents expansion of the microflora and hypohidrosis.2 A trial, however, would be required to establish any benefit and whether unintentional dermatitis resulted.

The routine cleaning of boots with disinfectants may also be a useful control, by preventing reservoirs of EPS-producing Staphylococcus epidermidis.

A personal history of asthma was more common in our patients than expected. We are not aware of any previous reports of this association. Perhaps atopics are at greater risk of miliaria rubra. The lack of a frequent history of eczema may be a ‘healthy worker’ effect, atopic dermatitis being commonly exacerbated by work in mines.14

The time between the onset of miliaria and presentation to the medical centre was relatively long. Several patients described repeated exacerbations on going underground, presenting to the medical centre only on reaching their limit of tolerance. Education concerning the importance of presenting early is clearly needed, in order to prevent secondary infection, chronic impairment of the skin’s barrier function and an increased risk of heat exhaustion.

Further research to determine the prevalence of EPS-producing Staphylococcus epidermidis strains on the skin, clothing and boots of miners with and without miliaria rubra is suggested.

REFERENCES


