

CASE REPORT

Mercury toxicity due to the smelting of placer gold recovered by mercury amalgam

A. M. Donoghue

The Medical Centre, Mount Isa Mines Limited, Mount Isa Queensland, Australia

A 19-year-old man developed tremor in both hands and fatigue after starting work at a placer gold mine where he was exposed to mercury-gold amalgam. Examination revealed an intention tremor, dysdiadochokinesis and mild rigidity. The 24-h urinary mercury concentration reached a peak of 715 nmol/l (143 µg/l) shortly before the clinical examination, after which he was removed from working in the gold room [Mercury No. Adverse Effect Level: 250 nmol/l (50 µg/l)]. On review 7 weeks later his tremor had almost resolved and the dysdiadochokinesis and rigidity had gone. The 24-h urinary mercury concentration had fallen to 160 nmol/l (32 µg/l). The principal exposure to mercury was considered to be the smelting of retorted gold with previously unrecognized residual mercury in it. The peak air concentration of mercury vapour during gold smelting was 0.533 mg/m³ (Mercury Vapour ACGIH TLV: 0.05 mg/m³ TWA). Several engineering and procedural controls were instituted. This episode occurred at another mine site, unrelated to Mount Isa Mines Limited.

Key words: Amalgam; gold; mercury; mining; smelting.

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THE PROCESS

Gold deposits occur in quartz veins originally formed by hydrothermal fluid flows through faults, or fissures in the earth's crust. Gold that has been released from quartz veins by erosion and deposited in river bed gravels or beach sands is termed placer gold. The mining of placer gold is now commonly undertaken by hydraulic excavators which extract river bed gravel and deliver it to processing plants where the fine gold bearing material is separated by rotary screens and vibrating tables. This is then examined closely so that free gold particles can be collected (a process called 'tabling'), and the remaining gold bearing sands mixed with metallic mercury in barrels to extract the gold in the form of a mercury-gold amalgam. After washing in water to remove any remaining sand, the amalgam is placed in a sealed retort and heated until the mercury has been evaporated off, condensed and collected under water. The remaining gold along with free gold obtained at the 'tabling stage' is then placed in a crucible, smelted on a furnace and cast into ingots.

CASE HISTORY

A 19-year-old man developed tremor in both hands 2 months after starting work for a placer gold mine. He presented to me for clinical assessment 8 months later. His working week of 60 h consisted of 30 h operating the processing plant on the mine site and 30 h in the gold room. Of the 30 h in the gold room he spent approximately 2 h retorting mercury-gold amalgam, 2 h smelting gold and the remainder mixing amalgam, washing it and tabling gold. A full-face negative pressure respirator with mercury canister was used during mixing and retorting but not during the other activities. The gold room was the size of a two-car garage and for security reasons had no windows. It had only recently been constructed, retorting and smelting having previously been conducted in the open air. Ventilation consisted of a small exhaust fan in one corner of the room and air supply through an open door. Hygiene was poor, food was eaten in the gold room and there was no showering or changing before leaving work.

The tremor was most noticeable during handwriting, especially as he was about to make contact with the pen and paper. Once he applied some pressure to the pen, the tremor eased a little. He was quite sure that he had never had a tremor before. He had also developed mild persistent fatigue about 7 months after the onset of his tremor.

Correspondence (no reprint requests please) to: Dr A. M. Donoghue, Chief Occupational Physician, The Medical Centre, Mount Isa Mines Limited, Private Mail Bag, Mount Isa, Queensland 4825, Australia.

He denied irritability, memory impairment, mood disturbances, anxiety, insomnia, headache, visual abnormalities, speech abnormalities, paraesthesia, weakness, epistaxis, respiratory irritation, shortness of breath, gum tenderness, increased salivation and anorexia. His previous medical history, family history and social history were unremarkable and he was not taking any medication.

CLINICAL EXAMINATION AND BIOLOGICAL MONITORING

Examination revealed a fine tremor of the fingers which was worse on intention, dysdiadochokinesis and mild rigidity. Power, sensation, the reflexes and the cranial nerve examination were normal. His personality, mood and intellect seemed normal. There was no mercurial line or gingivitis. He did not have any dental fillings.

Twenty-four-hour urine collection for mercury had reached a peak of 715 nmol/l (143 ug/l) shortly before the clinical examination, after which he was removed from working in the gold room [Mercury No Adverse Effect Level: 250 nmol/l (50 ug/l)].¹ On review 7 weeks later his tremor had almost resolved and the dysdiadochokinesis and rigidity had gone. The 24-h urinary mercury concentration had fallen to 160 nmol/l (32 ug/l).

There was one other worker in the gold room who undertook similar duties. His urinary mercury concentration peaked at 500 nmol/l (random specimen) when he also was temporarily removed. He denied any symptoms of mercury toxicity however. All of the urinary mercury concentrations were uncorrected for specific gravity or creatinine.

WORKPLACE INVESTIGATIONS

Mercury vapour measurements were made by a mines inspector in the gold room using a direct reading instrument. During smelting the peak concentration was 0.533 mg/m³ and the room temperature was 20°C (Mercury Vapour ACGIH TLV: 0.05 mg/m³ TWA. OSHA PEL: 0.05 mg/m³ TWA).² The following day the room was heated to 27°C, no gold was smelted and the peak concentration was 'significantly lower' (data not available). On another day before any smelting was undertaken the peak concentration was 0.021 mg/m³ and the temperature was 'estimated to be' 15°C.

DISCUSSION

It seems likely that the greatest exposure to mercury vapour in this case occurred during the smelting process. The high air concentrations measured during smelting were not recorded when the gold room was subsequently heated to a higher temperature in the absence of smelting activity. This indicated the presence of residual mercury in the retorted gold. The mine operator had not realized this, and had not required the use of respiratory protec-

tion during smelting. Because appropriate respiratory protection was worn for retorting and mixing, the only other significant exposures could have been due to washing, or to background levels caused by contamination of the gold room. Washing may have contributed to the exposure, however most of the time the amalgam is under water during this process thereby minimizing evaporation. Unfortunately mercury vapour measurements were not taken during washing. The background air concentration of mercury vapour was below the TLV when the furnace was not operating. It is possible however that during furnace operation (4 h per week), higher temperatures may have led to evaporation of mercury contaminants within the room. A close inspection of the surfaces of the gold room was undertaken and small droplets of mercury were found, combined with sulphur and removed. Poor hygiene may also have contributed to the exposure, especially the wearing of work clothes home and the infrequent washing of work clothes.

Several engineering and procedural controls were instituted in the gold room following this episode. The general ventilation was improved and local exhaust ventilation was used where smelting was undertaken. Air conditioning was installed to reduce evaporation of mercury contaminants during the hot summer months. Appropriate respiratory protection was used during smelting, as well as during mixing and retorting. Regular environmental monitoring was instituted and biological monitoring was continued. Work clothes remained on site and were regularly laundered. The workers were required to shower before leaving work. Food was not permitted in the gold room. Following the introduction of these changes biological monitoring returned urinary mercury concentrations of approximately 50 nmol/l.

The hazard of mercury-gold amalgam is ancient. Ramazzini described the plight of gilders in the early 18th century: 'We all know what terrible maladies are contracted from mercury by goldsmiths, especially by those employed in gilding silver and copper objects. This work cannot be done without the use of amalgam, and when they later drive off the mercury by fire they cannot avoid receiving the poisonous fumes into their mouths, even though they turn away their faces.'³

Mercury toxicity has been previously reported in those using mercury to extract gold. However investigation of the workplace was not undertaken in these cases and air concentrations of mercury vapour were not given.^{4,5}

An industrial hygiene survey of an amalgamation plant at a gold mine found similar air concentrations to those obtained in this report, although no comment was made as to whether any of the workers had developed mercury toxicity.⁶

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