Fire and ice: diagnosis of carbon monoxide poisoning in a remote environment

D M Crawford and N B Hampson

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Fire and ice: diagnosis of carbon monoxide poisoning in a remote environment

D M Crawford,[1] N B Hampson[2]

Following an explosion on board a British Navy submarine operating under the Polar ice cap, a 33-year-old sailor fought a fire without protective breathing apparatus. He was found confused, with soot about his nares. A suspected diagnosis of carbon monoxide (CO) poisoning was rapidly confirmed on site using a new non-invasive pulse CO-oximeter. Initial carboxyhaemoglobin (COHb) level was 28%. He was treated with high-flow oxygen and evacuated to a medical facility with hyperbaric oxygen treatment capability. Fifteen other crew members potentially exposed to smoke in the enclosed space were screened in less than 10 min and had normal COHb levels of 1–2%. This is the first case demonstrating the utility of pulse CO oximetry for diagnosing CO poisoning in remote environments. The information obtained allowed immediate delivery of appropriate on-site treatment and directed subsequent triage. The device was also shown to be effective for the rapid screening of numerous individuals. Not only does it have the potential to provide information that would otherwise be unobtainable in such a situation, but it could play an important role in mass casualty screening.

Carbon monoxide (CO) poisoning is common in the USA, accounting for an estimated 50 000 emergency department visits for diagnosed cases annually.[1] Because the signs and symptoms of CO poisoning are non-specific, it is likely that many more cases are unsuspected or attributed to other aetiologies and therefore go undiagnosed.

When CO poisoning is suspected clinically, measurement of blood carboxyhaemoglobin (COHb) is typically performed. A raised COHb level documents exposure to exogenous CO and supports the clinical diagnosis. COHb is typically measured in hospital laboratories by multi-wavelength CO oximetry. Not all hospitals have laboratory CO-oximeters,[2] increasing the difficulty of confirming the diagnosis. In such cases, blood samples have to be sent to a nearby outside laboratory for COHb measurement.

In some situations the environment may be so remote that even sending a blood sample is impractical. This report describes the use of a new non-invasive pulse CO-oximeter for measuring COHb and confirming the clinical diagnosis of CO poisoning in an extreme environment.

CASE REPORT

In March 2007 the University of Washington Applied Physics Laboratory Ice Station "APLIS", located atop an ice floe in the Beaufort Sea, received a distress call from a British Royal Navy submarine performing exercises under the Polar ice cap. During the course of manoeuvres the submarine had experienced an explosion which resulted in a fire in its forward compartment. The submarine's crew simultaneously fought the fire and navigated to an area of thin ice for surfacing. APLIS sent a snowmobile rescue caravan to assist in the care of three reported trauma victims.

Upon arrival at the submarine it was discovered that two of the three initial casualties had expired and the third individual, a 33-year-old sailor, was located in a makeshift medical treatment area. He had soot around his nares and was breathing from a portable 100% oxygen demand-valve "aviator" style full-face mask. Other crew members on board were breathing at the time from an emergency breathing system, using portable gas masks piped to a clean internal air source for use in the event of suspected contaminated atmosphere.

A portable non-invasive pulse CO-oximeter (Rad-57c; Masimo, Inc., Irvine, CA, USA) revealed that the injured sailor had a pulse CO oximetry COHb level (SpCO) of 28%, despite having breathed oxygen for the preceding 15 min. Functionality of the device was checked on several crew members who demonstrated SpCO levels of 1–2%. It was learnt that the sailor had fought the fire in the smoke-filled room, working without a gas mask for at least 4 min. When initially rescued he had been disorientated, but his mental status had improved when oxygen was administered.

While treatment options for his trauma and CO poisoning were being discussed, continuous monitoring with the Rad-57c demonstrated a decrease in SpCO consistent with COHb clearance in a patient breathing oxygen (fig 1). It was decided to evacuate the injured sailor to Anchorage where both trauma support and hyperbaric oxygen therapy were available.

DISCUSSION

In this case, CO poisoning was suspected clinically and confirmed immediately with a new handheld pulse CO-oximeter.[3] In addition to measuring conventional oximeter variables such as heart rate and SpO_2, this device is capable of measuring COHb with a precision of 2.19% in one laboratory study.[4]

It was recently reported that less than half of hospitals in one region of the country have laboratory CO oximetry capability.[2] Many deal with this by sending blood samples to other laboratories by courier. Because hospitals without CO-oximetry capability are more likely to be located in smaller rural towns,[2] it is possible that the distance and turnaround time for a result may be too great for this to be a reasonable option. In such a setting, the availability of pulse CO oximetry provides a reasonable alternative to blood sample shipment as it provides immediate results.

In a remote environment such as the one in this case, even sending a blood sample was clearly impractical for emergency management of the patient. With the knowledge that the patient had CO poisoning, high-flow oxygen therapy was administered followed by evacuation to a medical centre with hyperbaric oxygen treatment capability.

As was shown in this case, the pulse CO-oximeter can be used to assess multiple individuals in rapid fashion. One operator was capable of using the device to measure COHb levels in <45 s per person in a mass casualty triage scenario. The speed with which results may be

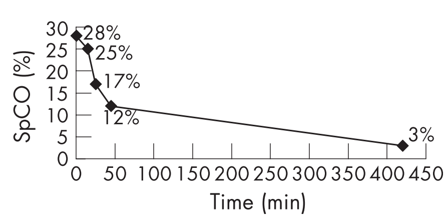

Figure 1 Carboxyhaemoglobin level measured by pulse carbon monoxide (CO) oximetry (SpCO) in a sailor with CO poisoning while breathing high-flow oxygen.

obtained using the Rad-57c may apply to other situations such as fires or contaminated atmospheres, use in small or remote emergency departments without access to rapid laboratory capability, or public health investigations of environmental CO contamination. This equipment has the potential to affect treatment decisions when medical supplies or personnel are limited.

If one is organising the medical supplies for a wilderness expedition and plans to take a pulse oximeter, substitution of a pulse CO-oximeter should be strongly considered. The added information obtained about COHb levels may be very useful in patient management, especially if oxygen will be available on-site or emergency evacuation is possible in the case of severe CO poisoning.

[1] Submarine Development Squadron Five, United States Navy; [2] Virginia Mason Medical Center, Seattle, Washington, USA

Correspondence to: Dr D M Crawford, Comsubdevron 5 Attn: Medical Dept, 7111 Sealion Road, Silverdale, WA 98315, USA; david.m.crawford@navy.mil

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REFERENCES

1. **Hampson NB,** Weaver LK. Carbon monoxide poisoning: a new incidence for an old disease. *Undersea Hyperb Med* 2007;**34**:163–8.
2. **Hampson NB,** Scott KL, Zmaeff JL. Carboxyhemoglobin measurement by hospitals: implications for the diagnosis of carbon monoxide poisoning. *J Emerg Med* 2006;**31**:13–6.
3. **Hampson NB,** Weaver LK. Noninvasive CO measurement by first responders: a suggested management algorithm. *J Emerg Med Serv* 2006;**24**(Suppl):10–12.
4. **Barker SJ,** Curry J, Morgan S. Measurement of COHb and MetHb by pulse oximetry: a human volunteer study. *Anesthesiology* 2006;**5**:892–7.

Images in emergency medicine

An unusual tracheobronchial foreign body

A 66-year-old man, who underwent total laryngectomy for a laryngeal tumour 5 years previously, was admitted because he had aspirated a large nail. He was admitted to the emergency department with mild respiratory distress and agitation. A chest *x* ray revealed a very large nail in the tracheobronchial tree (fig 1A). After applying topical anaesthesia, the nail was removed with McGill forceps. Remarkably, the nail was over 12 cm long (fig 1B). The patient tolerated the procedure well and was discharged the same day.

The presence of a permanent tracheal stoma in laryngectomised adults is a predisposing factor for foreign body aspiration.[1] At 12.5 cm, this is the longest nail recorded to have been aspirated into the tracheobronchial tree.

Patient education is the key to preventing the aspiration of foreign bodies in patients with tracheal stomas. They should be advised that objects near the stoma should be handled with great care.

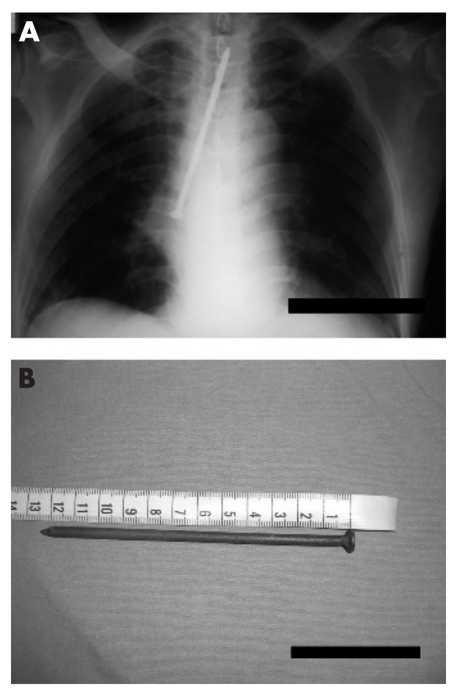

Figure 1 Chest *x* ray (A) revealing a long nail (B) in the tracheobronchial tree.

M M Erol,[1] C Tekinbas,[1] S Ozsu,[2] S Turedi,[3] A Gunduz[3]

[1] Department of Thoracic Surgery, Karadeniz Technical University, Faculty of Medicine, Trabzon, Turkey; [2] Department of Chest Disease, Vakfikebir Government Hospital, Trabzon, Turkey; [3] Department of Emergency Medicine, Karadeniz Technical University, Faculty of Medicine, Trabzon, Turkey

Correspondence to: Dr M M Erol, Department of Thoracic Surgery, Karadeniz Technical University, Faculty of Medicine, Karadeniz Teknik Üniversitesi, Tıp Fakültesi, Göğüs Cerrahisi AD 61080, Trabzon, Turkey; muharremerol@hotmail.com

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REFERENCE

1. **Nwiloh J,** Fortson J. Aspirated foreign body in a laryngectomized patient: case report and literature review. *Ear Nose Throat J* 2001;**80**:744–6.