Health Hazards of Volcanic Eruptions

PETER J. BAXTER, MD, MRCP(UK), Senior Employment Medical Adviser, Health and Safety Executive, Employment Medical Advisory Service, Barking, Essex

Before the eruptions of Mount St Helens (USA) in 1980, little information was available in the medical literature on the health effects of volcanic eruptions. This article summarises the principal health lessons learnt from the new interest in volcanoes aroused by Mount St Helens; more detailed information can be found elsewhere[1-6].

Of the two main types of active volcanoes, the explosive (mainly ash-producing) like Mount St Helens are more common than the effusive (mainly lava-producing) ones found, for example, in Hawaii; volcanoes with features of both types also exist. Explosive volcanoes are the most dangerous, at least 10-15 explosive eruptions occurring in the world every year. The main hazards arise from the sudden release of hot volcanic material, heavy ashfalls and devastating mud flows. On the other hand, the lava flows of effusive volcanoes can cause immense destruction but, as the flow is usually no faster than walking pace, it can be readily avoided. Both types can produce large amounts of gases that may harm people living downwind and scientists studying the eruption.

Principal Hazards

Ejecta and Pyroclastic Flows

Rocks of varying sizes can be flung several kilometres without warning; apart from the risk of being hit by these missiles, their great heat can cause fires. More deadly are such phenomena as pyroclastic flows or hot avalanches, directed blasts, pyroclastic surges and ignimbrites; these consist of extremely hot (hundreds of degrees Centigrade) mixtures of gas, ash, pumice and dense rocks which are explosively released and can travel at high speeds for considerable distances. The force of such debris-laden blasts will flatten most natural objects in their paths, and the high temperatures can cause severe burns. At least 58 people died in the lateral blast of the Mount St Helens' eruption on 18th May 1980; in 18 of 23 cases that were autopsied, asphyxiation from the dense hot ash was the commonest cause of death[7]. The only effective protection is to stay outside areas at risk, often at several kilometres away from an active crater and on high ground.

Mud Flows

Melting snow and ice from the heat of an eruption, or a heavy rainfall, can cause large volumes of water to mix with erupted material and older rock debris to form mud flows (lahars). Mud flows move with the consistency of wet concrete and are among the most destructive of volcanic phenomena, capable of travelling fast under the force of gravity for many kilometres down slopes and valleys, causing lakes and rivers to flood. Apart from the obvious risk of people becoming engulfed or drowned, damage to water and sewage utilities may pose hazards from infectious diseases. Still water areas left afterwards can contain much putrefying matter and bacteria, and may provide ideal breeding grounds for mosquitoes, an unwelcome result in areas where mosquito-borne diseases such as malaria are prevalent.

Ashfalls

Heavy ashfalls can cause chaos and destruction up to hundreds of kilometres away from a volcano. In addition, respiratory problems may arise if a large proportion of the ash is of respirable size (<10 µm), causing airways irritation in asthmatics and exacerbating the condition of patients with chronic lung disease. In the 18th May 1980 eruption of Mount St Helens over 90 per cent of the ash particles were in the respirable range, and an ashfall of only 1 mm in depth was sufficient to cause an increased incidence of asthma and bronchitis in affected communities. In this instance no deaths were attributed to the acute effects of ash on the respiratory system. But deaths might occur after similar eruptions in developing countries where the population has inadequate shelter and a high susceptibility to fatal respiratory infections. In developed countries the community can use lightweight, high-efficiency, disposable industrial masks that are capable of filtering particles of sub-micrometre size, but heavy-duty respirators and protective goggles are advisable for occupational groups who have to work outdoors in fine ash. Rainfall is a key factor in reducing exposure after an eruption, as it removes the ash from the air and leaves a crust on the surface of the deposited ash, making re-suspension more difficult. However, strong winds and traffic can repeatedly stir up the ash until it eventually becomes incorporated into the soil, a process which may take many months.

As soon as possible after an eruption, bulk samples of ash should be collected for mineralogical analysis and measurement of particle size. The ash should be collected from an uncontaminated surface, such as a plastic sheet laid out during an ashfall, before it has been rained upon.
As the composition of ash can vary between eruptions of the same volcano, samples should be obtained whenever an appreciable ashfall occurs (even a 1 mm layer of ash in Iceland was enough to kill foraging animals by fluoride poisoning after the eruption of Hekla in 1970). Ash with a high total silica content (>55 per cent) can contain appreciable amounts of crystalline silica as quartz, crystobalite and tridimite, in some instances up to 15 per cent by weight. Certain outdoor workers (e.g. agricultural workers) may run the risk of silicosis if exposed to high levels of such respirable ash over many years, a possibility if a volcano erupts frequently. Analysis for crystalline silica will be difficult if the presence of plagioclase feldspar causes interference on X-ray diffraction and spurious results may be obtained if an appropriate ‘clean-up’ of the sample is not performed. Although crystalline silica is the main factor determining the fibrogenic potential of the ash, the physical and chemical characteristics of the silicates present may also be important; further in vitro and animal testing may be required[6]. Useful information on community and occupational exposure to respirable ash can be gained from personal and static monitoring devices. Ash samples obtained by personal samplers located close to the breathing area are most likely to be representative of the size and type of ash inhaled. Thus it was confirmed that in certain outdoor workers exposure to ash in the weeks following the May 18th eruption of Mount St Helens exceeded the occupational standard recommended by the US National Institute for Occupational Safety and Health for crystalline silica of 50 µg/m³, the ash containing 3.7 per cent of crystalline silica by weight. The ash should also be checked by scanning electron-microscopy to exclude the presence of large quantities of asbestiform fibres that might be carcinogenic.

The toxicity of the ash should also be routinely investigated. When ash falls through the eruption plume, gases and elements present in the plume adhere to the surface of the ash; these soluble constituents are readily leached out by rain and surface waters. Iceland has suffered from ashfalls with a high fluoride content that have poisoned foraging livestock, although no cases of human intoxication from contaminated water or food have been reported. To test for toxicity, leachate studies of the ash for pH and toxic elements should be undertaken by mixing together known quantities of ash in distilled water, e.g. a 1:10 mixture, to resemble the effects of ash falling into streams. Contamination of vegetables and the biological availability of toxic elements may warrant further study, including the analysis of milk from cows in affected areas. Special ash collections are necessary for the study of radioactivity caused by radon gas released during eruptions, although ash from Mount St Helens was found to have the same level of radioactivity as ordinary soil.

Ash can cause accidents due to roofs collapsing under its weight and roads made slippery by rain-soaked ash. Moist ash can also interfere with outside electrical installations, causing power failures. A heavy ashfall in a large modern city could disrupt transport and communications for several days, seriously impeding the running of medical and other emergency services.

Gases

Probably the greatest episode of air pollution in historic times was the Laki (Iceland) eruption of 1783, when parts of North America and Europe were periodically bathed by gases and particles for several months. The severe winter that followed prompted Benjamin Franklin’s original suggestion that volcanoes might influence world climate. The main volcanic gases are water, carbon dioxide (CO₂), sulphur dioxide (SO₂), and hydrochloric acid, and the lesser ones are hydrogen fluoride, carbon monoxide and hydrogen sulphide (H₂S). Deaths from H₂S, SO₂ and CO₂ have been recorded among people trapped near erupting volcanoes. Various elements in particle and vapour form also enrich gas plumes and some, e.g. mercury, may be in sufficient concentration at ground level to be hazardous if inhaled for prolonged periods. The respiratory effects of short- and long-term exposures to volcanic gases and their aerosols warrant further investigation, as does the potential for local pollution of drinking water and vegetation by fluoride and heavy metals. An interesting example is the Masaya volcano in Nicaragua, which, every 25 years, undergoes intense degassing lasting about five years (Fig. 1). As this volcano is lower than the countryside immediately downwind, a large populated area is regularly bathed in gas during this period. The main problem is the ambient air concentration of SO₂ which regularly exceeds WHO air

Fig. 1. The crater of the Masaya Volcano, Nicaragua (550 metres above sea level). During degassing, prevailing winds blow the plume of water vapour and gases on to inhabited areas downwind; over 1,000 metric tons of SO₂ are released daily.
pollution standards, damages vegetation and corrodes machinery. People complain of skin and eye irritation from rain made acid by the plume. The rain water is collected in large outdoor cisterns and stored as a source of drinking water. Emergency monitoring of gases to determine their type and concentrations should be part of the disaster plans in any inhabited volcanic area; even tall volcanoes that would normally release their gases at high altitudes away from populations may erupt unexpectedly from low vents in their flanks.

Conclusion

Volcanic eruptions are infrequent and usually occur in remote parts, but as Mount St Helens has shown, the USA and some other developed countries are prone to volcanic activity as surely as they are to earthquakes. It is evident that many of the investigations discussed above will be beyond the resources of poorer countries, especially when emergency provision of food and shelter for large numbers of evacuees may well be the overwhelming priority after massive eruptions. However, the remote-ness of volcanoes has been rapidly reduced by the expansion of world populations and the ease of international travel; thus doctors may increasingly find themselves having to provide advice to people visiting or living in volcanic areas. In addition, geologists and atmospheric scientists can now rapidly co-ordinate scientific studies of eruptions in quite remote parts of the world, and international disaster agencies could follow this example by attaching to their relief teams experts with appropriate technological support to investigate and advise on volcanic health hazards in the field. There is yet much to be learnt about the impact of volcanoes on health.

References

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Moving in State

Just how should the College move? This is clearly laid down in a Victorian one-page manuscript. Headed ‘Procession of the Royal College of Physicians’, it starts off with a blob to mark the Porter with staff. Behind him is a bigger blob for the Bedell with mace. Then come two blobs, side by side, for the Registrar carrying the College seal on a cushion and the Treasurer bearing the book of statutes. Behind them is a great big blob for the President (Sir William Jenner) carrying the Caduceus, with a dot behind him for his train-bearer. The procession is completed, two by two, by the pair of Vice-Presidents and the four Censors. At the bottom of the sketch is written ‘Including four Censors—10 persons’. Work that one out. Which two of the procession were non-persons?

A little research shows that this procession moved to greet Queen Victoria when she came to the Thames Embankment to lay the foundation stone of the Examination Hall on 24th March 1886. Her procession, including members of her family, arrived in six carriages. They were greeted by a distinguished gathering of well over a thousand people, sung to by the children of the Chapel Royal and blessed by the Archbishop of Canterbury. The cost of these celebrations came to £982. 17s. 2d., shared, like the cost of the building, between the Royal Colleges of Physicians and Surgeons.

The building of the Examination Hall by the two Colleges was the logical step following the creation of the Conjoint Examining Board. The Embankment site was chosen because of ‘its open situation, its extreme quiet, the respectability of the neighbourhood and the ready access to it from all parts’. A remarkable feature of the building was that its cost was £5,000 less than the original estimate of £30,000 accepted four years before the building was completed. Its subsequent history was financially disastrous. Despite letting rooms to bodies like the Metropolitan Asylums Board, the Surveyors’ Institute and the Church of England Society for Waifs and Strays, the income fell and the building was sold in 1908 to the Institute of Electrical Engineers. The sale price of £50,000 enabled a new smaller hall to be built.