

HISTORIC REVIEW

The arsenic eaters of Styria: a different picture of people who were chronically exposed to arsenic

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We have reviewed the case of residents of Styria, Austria, who are reported to have consumed large quantities of arsenic oxide (300–400 mg per dose) and remained in good health. Copyright © 2001 John Wiley & Sons, Ltd.

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INTRODUCTION

Arsenic is one of the few chemical elements that is almost universally recognized by the general public, who associate the word with poison, and, indeed, arsenic is much used as a metaphor for poison. For example, the elderly Brewster sisters mainly used strychnine and cyanide, not arsenic, to dispatch their gentlemen callers, but who has ever heard of a play called 'Strychnine and Old Lace'? In the movie version of Umberto Eco's book 'The Name of the Rose', further explanation of the poisoning of the monks was deemed to be unnecessary after the utterance 'arsenic', but the element is not even mentioned in the text of the book, and the symptoms of acute poisoning shown by the monks are not those associated with the ingestion of arsenic compounds.

There is no doubt that some arsenic compounds

are acutely toxic in rather small concentrations and that many unpleasant deaths can be attributed to the administration of arsenic trioxide, a white, odorless powder, of low aqueous solubility, that was once known as the 'inheritance powder'. However, modern forensic science can easily detect exposure to arsenic compounds, so poisoners have had to resort to more obscure chemistries for effective weapons.

On the other hand, arsenic compounds have a long history of use in medicine. Most commonly used were simple compounds such as the white oxide and the two sulfides, yellow orpiment, As₂S₃, and red realgar, As₄S₄, all of which have been used therapeutically for over 2000 years. The organic derivatives of arsenic, typified by Salvarsan ([(HO)C₆H₃(NH₂)As]₂·2 HCl·2 H₂O), which was used for the treatment of syphilis, were developed early in this century but have largely been superseded by more effective and less toxic drugs.

The use of orpiment and realgar for the treatment of abscesses and scrofula is described in Chinese medical books written about 200 BC. The oxide was used as an antimalarial in China as early as 1116 AD. Modern Chinese medicine includes about 50 drugs that contain arsenic, mainly as realgar, at a concentration of about 105 µg/g; the dose is up to 1 g of the drug. In the western world, Hippocrates and Pliny described the use of the sulfides in medicine. The oxide was not established as a poison until much later, around 1100 AD. Until very recently, arsenic compounds were used as medicine to treat a plethora of internal and external problems.

The best known use of arsenic in medicine was as Fowler's solution, a 1% solution of arsenic trioxide dissolved in potassium carbonate with a little tincture of lavender added 'merely for the sake of giving it a medicinal appearance';¹ others were

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Donavan's solution (AsI_3), and de Valagin's solution (AsCl_3). Fowler's solution entered the London Pharmacopoeia in 1809 and remained in the British Pharmacopoeia long after World War II. Fowler's treatment involved 24 doses at a rate of three per day; thus an adult received a total of 12 drops per dose for a total of 280 drops equivalent to about 1.75 grains (0.112 g) of arsenic trioxide. The maximum single dose recommended in the British Pharmacopoeia was 0.5 ml of the solution: 0.005 g of the oxide. The normal fatal human dose for ingested arsenic trioxide² is in the range 0.07–0.18 g, and acute symptoms may occur within minutes or hours after ingestion.

Arsenic was so widely prescribed in the 18th century to treat skin diseases, neuralgia, intermittent fever and malarious disorders, uterine affections, syphilis, lumbago, epilepsy, anemia, ulcerations etc. that it earned the name 'Therapeutic Mule'. However, there also were side effects, because, in a retrospective study of 262 patients treated with Fowler's solution, 21 cases of skin cancer were found and hyperkeratosis occurred in 106 of the group.^{3–4}

Recent claims have been made from China that the arsenic oxide and sulfides can be used to treat leukemia and other kinds of cancer.^{5–7} For example, intravenous administration of the oxide at 10 mg per day for 45 days, a total of 450 mg, was said to induce remission of acute promyelocytic leukemia. In the 2 February 1999 edition of the 'Apple Daily', a Hong Kong newspaper, it is said that patients experience apparently no side effects. This cure appears to be rediscovery of a 1931 'rediscovery'⁸ of the use of Fowler's Solution for treating myelocytic leukemia.⁹

The effects of chronic ingestion of arsenic in drinking water are currently seen all over the world, e.g. in China, Taiwan, India, Bangladesh, Chile, and Argentina, to name but a few areas. It is estimated that in the Ganges delta region, about 100 million people are exposed to potentially lethal concentrations of arsenic in what has been described as 'the largest mass poisoning in history' and 'the biggest arsenic calamity in the world'.^{10,11}

In 1988, the US EPA used data on arsenic exposure, mainly from Taiwan, to conclude that arsenic is a Group A human carcinogen, by the oral route,¹² with skin cancer being the health effect end point. The same forum concluded that the current US Maximum Contaminant Level (MCL) of 50 $\mu\text{g/l}$, provisional since 1945, should be lowered considerably, perhaps to 2 $\mu\text{g/l}$, to achieve an 'accep-

table' risk. The suggested WHO-threshold is 10 $\mu\text{g/l}$. Since then, more evidence from Taiwan and other countries, such as Chile, indicates that arsenic exposure can also result in bladder and lung cancer. One recent study suggests that about 8% of the deaths of people over 30 years of age in Region II of northern Chile can be attributed to arsenic ingestion.¹³

These and other results were used in a recent re-evaluation of arsenic in drinking water by the US National Research Council. Again, the recommendation was that the US MCL for arsenic in drinking water of 50 $\mu\text{g/l}$ requires downward revision as promptly as possible.¹⁴ In June 2000 the USEPA suggested a new MCL of 5 $\mu\text{g/L}$ based on the findings that the MCL of 50 $\mu\text{g/L}$ is not protective of human health. The US National Resources Defence Council stated that even 5 $\mu\text{g/l}$ of arsenic is too high. Nearly 57 million Americans have a 1 in 10 000 cancer risk from consuming drinking water containing more than 1 $\mu\text{g/l}$ of arsenic.¹⁵ The final decision on the MCL is due in January 2001.

However, notwithstanding widely held fears concerning the toxicity of arsenic trioxide, it appears that as long ago as the 17th century, Styrian peasants developed the habit of eating arsenic trioxide in amounts that would normally be supposed to be life threatening.

ARSENIC EATERS IN STYRIA

Information about the existence of arsenic eaters in Styria, now a region of Austria near Graz, first came to public notice in the UK in the middle of the 19th century.¹⁶ An account of the practice of arsenic eating, *Arsenikophagie*, is available in the form of a Ph.D. thesis submitted by Karl Heinz Most to the Department of Pharmacy of the University of Graz, Austria, in 1939. This thesis was given to the authors by the late Professor K.J. Irgolic. The present authors have tried to contact Dr Most without success. According to Most, some inhabitants of the eastern and western regions of Styria adopted the practice of eating arsenic in the 12th century.¹⁸ These arsenic eaters usually consumed arsenic trioxide, commonly named white arsenic, in portions of 300–400 mg over periods of 30 years or more (Fig. 1), but some arsenic eaters preferred a yellow mixture known as 'artificial orpiment', containing up to 90% of arsenic trioxide, made by melting the oxide with sulfur.¹⁷ It was believed that the consumption of arsenic trioxide in amounts that should

He (Flecker) is 66 years old and has been married since 1837. His daughter is 20 years old. His father, who was also an arsenic eater, lived till he was 77. Flecker started to take arsenic when he was 30 years old. Mostly he takes orpiment and sometimes arsenious acid. Generally he eats arsenic once a week, or more when he feels sick or when he is working at his job as a traveling tailor and must go into houses where someone is ill. Dr. Knapp and Dr. Butcher observed how he ate 0.14g orpiment with bread. Later they analyzed his urine.

Flecker is 1.65m tall. Chest measurement 0.94m... his weight is 72 kg. His bone structure is strong. His muscular system is well developed. He has little unnecessary fat. He looks very healthy and bright. His sense organs are normal... no glandular swelling. No goiter. His digestion works very well as well as lungs, heart and liver. Considering his age he hikes easily in the mountains. He probably has increased sexual potency. Sometimes he likes to drink alcohol. His fitness is quite good for his age. His intellectual and moral behaviour are normal. Flecker has never been ill, except once for two days. He believes that arsenic protects him against illness and motivates him to work or to begin new tasks. If he feels reluctant or lethargic he always takes some arsenic. A few hours later he will feel better. Before he starts on a long hike he takes arsenic. Other people are often astonished by him because he walks easily and can eat or drink whatever he wants. He has to eat something after each arsenic dose. Arsenic also helps him to digest heavy meals.

For 36 years this man has been eating enormous amounts of arsenic without any negative side-effects!

Figure 1 A typical description of a Styrian arsenic eater given in K.H. Most,¹⁷ translated by G. Przygoda.

be lethal required specific procedures to ensure that no harm would occur to the eater. This knowledge was passed from one generation to the next within families.¹⁷

Some of the reasons given by the arsenic eaters for their seemingly bizarre habit were:

- it enhances the beauty of women by improving their complexion (blooming checks);
- it increases the ability to breathe easily, even during strenuous hikes in the mountains (improves the wind);
- it acts as an aid to the digestion after heavy meals;
- it acts as a prophylactic against infectious diseases;
- it increases courage;
- it increases sexual potency.^{19,20}

The existence of a culture familiar with arsenic was first documented in court files of the mid-17th century, when nicknames like *Hittrichfeil* or *Hittrichhansl* appeared.¹⁷ *Hittrich* is the German expression for the white smoke, which consisted

mainly of arsenic trioxide, that emanated from the chimneys of the small huts that were used for smelting minerals. At the time, arsenic in the form of white arsenic was well known and feared in central Europe as a poison. During the epidemics of bubonic plague in the 17th and 18th centuries, arsenic compounds were used for rat poison and they became popular as a cheap and available drug that was taken internally, especially by poor peasants. The use of arsenic is not mentioned in a comprehensive book on the plague published in 1609,²¹ but it is included in another published in 1695.²² This use of arsenic was controversial, especially in the medical world of the time.²³

In the 17th century, the habit of feeding arsenic to horses was developed in the Styrian area. Stablemen, coachmen and others who worked with horses fed their horses arsenic in order to develop a healthy and active appearance in them and to increase their strength.²⁰ In addition, arsenic was traditionally used as magic poison and could be found in several magic cures.¹⁷

Because arsenic eating was related to magic,

practitioners were ostracized by the Church and the law. Arsenic purchases were illegal and plagues were considered to be of demonic origin, so cures were in the realm of the Church. Self-medication was regarded as a sin, so the arsenic eaters of this time kept their habit secret to avoid punishment. Later, the influence of the Church became less important, and following several plague epidemics and the Thirty Years War, farmers also started to eat arsenic around 1700 AD. At that time, the belief developed that in order for treatment of a horse with arsenic to be successful, the groom or farmer also had to eat the medicine. This belief was probably encouraged because arsenic eaters still needed an excuse for their habit. In those times, arsenic was mainly taken as a prophylactic against bubonic plague and other infections. With the disappearance of the plague in Europe, arsenic came to be consumed in the 19th century for its tonic properties.

Most countries in central Europe restricted access to arsenic, but it was still available, and many patients, mainly poor people, chose to use it for treatment because they could not afford a physician.

One of the problems with the use of arsenic as an internal drug was the difficulty in determining the correct dose for a patient. The liquid preparations of arsenic did not have known, reproducible concentrations, and treatment with these, often at the hands of doctors who found their patients in the market places, resulted in the occurrence of symptoms of poisoning or even the death of the patient.

The Styrian arsenic eaters preferred to use the solid arsenic compound, arsenic trioxide, white arsenic, instead of arsenic solutions, because the solid has the advantage that the concentration of arsenic is known, and is stable and reliable. The solid has a porcelain appearance, giving the Styrian peasant an indication of the purity of the compound. The yellow 'artificial orpiment' was used in the same way.¹⁹ The solid arsenic compounds were preferred to solutions because absorption of the solid arsenic trioxide, especially by a consumption of pieces, is much slower and not complete.²⁴

Usually, arsenic eaters began to eat arsenic in small amounts of about 10 mg, which they increased every 2 or 3 days up to amounts of 300–400 mg. Maclagan reported²⁵ that a Styrian poacher even took large quantities of 14 grains (950 mg) in his presence. This regime helped the arsenic eater to control the dose according to the response. They cut their arsenic dose with their

knife from a bigger piece and, like a cook who measures herbs by eye, they learned to guess exactly the correct amount for themselves.¹⁹ Most arsenic eaters ate arsenic together with bread and bacon. The combination of fat and arsenic was claimed to reduce the absorption and heartburn. Among these arsenic eaters, accidental poisonings were rare because the detailed knowledge and expertise developed was passed on secretly from generation to generation. They were able to evolve a regime that allowed them to consume arsenic in considerable doses over long periods (30–40 years) without any harm.^{26,27}

ARSENIC EATERS—FACT OR MYTH?

Many scientists have expressed skepticism about the existence of arsenic eaters, and this was especially true at the time of von Tschudi's publication in 1851. The most popular counter argument was that eating arsenic trioxide conflicted with both toxicological knowledge and common sense.^{27–29} The fact that uneducated peasants had been able to develop such detailed procedures for safe arsenic consumption, whereas physicians from a higher social class were unable to prescribe safe arsenic cures for their patients, seemed difficult to believe. The supposed connection of arsenic eaters with magical practice gave rational scientists another excuse for disbelief in their existence. Because the number of arsenic eaters was relatively small, and because they were very secretive about their habit, it was difficult to provide unequivocal proof of their existence. However, some scientific opposition did accept that Styrian peasants ate a white powder as some kind of secret tonic, but maintained that it could not be arsenic trioxide because of its toxicity.^{18,30} Taylor suggested that the compound might be the harmless zinc oxide.³¹ These negative views were summed up in modern times by Lenihan, who likens reports of arsenic eating to sightings of flying saucers and Loch Ness monsters.³⁰ Nevertheless, there is a considerable body of scientific evidence that the Styrian peasants did indeed deliberately ingest the poisonous arsenic trioxide.

Thus, in 1860 an analysis by Professor Roscoe showed that the substance allegedly consumed by the peasants was arsenic trioxide.¹⁸ At a conference in Graz, the 48th Meeting of the Association Deutscher Naturforscher und Ärzte, Dr Knapp

presented two arsenic eaters, one of whom consumed 400 mg of arsenic trioxide and the other 300 mg of 'yellow orpiment' in front of the audience.³² Samples of their urine were analyzed by using Marsh's test, and the results, which clearly showed the presence of arsenic in the urine of both volunteers, were presented to the conference audience.^{18,32} Several other reports on *Arsenikophagie* were made by medical practitioners from the Styrian area.^{18,32} For example, Dr Knapp reported on the absence of diseases caused by chronic exposure to arsenic and denied effects such as impotency or symptoms of paralysis. Because of the possibility that arsenic eaters really existed, judges and lawyers involved in trials that centered around accusations of arsenic poisoning were obliged to consider if the victim might have been an arsenic eater and have consequently self-administered the fatal dose. Such arguments, which became known as the Styrian defense, were used in a number of well-known criminal cases, including a poisoning trial in 1822 in Styria,¹⁷ the Madeleine Smith trial, in Edinburgh, in 1857,³³ the Maierhofer arsenic poisoning trial, in Graz in 1937,¹⁷ and in the trial of Mrs Maybrick in Liverpool, in 1889.³⁴ This trial of Mrs Maybrick for the murder of her husband offers considerable insight into the use and availability of arsenic in the Victorian era in England.

Mrs Maybrick was accused of poisoning her husband with arsenic obtained by soaking fly-papers in water (each fly-paper contained approximately 2 grains (two times 0.064 g) of arsenic (as arsenate)—about a lethal dose). She claimed that she was using the solution for cosmetic purposes—one side of the Styrian Defense. She was convicted and sentenced to death, but the sentence was soon commuted to penal servitude for life as a result of public protest. She was released in 1904. The other side of the Styrian Defense was based on the fact that Mr Maybrick was in the habit of using arsenic, which he obtained from a local druggist, as was confirmed by Mr Edwin Heaton when he was examined for the defense by Sir Charles Russell.

The court files from this and the other trials leave the impression that a number of individuals in Victorian society used arsenic for much the same purposes as the Styrians: as a tonic, as an aphrodisiac, and as an aid to digestion; they also indicate that some individuals increased their consumption of arsenic over time.³³ So perhaps the Styrians were not so strange in their behavior after all.

In modern times, the general population ingests

inorganic arsenic in food and drink, and the USEPA³⁵ has published a lowest-observed adverse-effect level (LOAEL) dose of human chronic oral exposure to inorganic as $0.014 \text{ mg kg}^{-1} \text{ day}^{-1}$, which for the idealized 70 kg person would be 1 mg of arsenic per day, just 1% of the arsenic eaters' intake. However, some segments of society are still being non-occupationally exposed to arsenic because of the essentially unregulated consumption of ethnic and homeopathic medicines. We have mentioned the continuing use of arsenic in Chinese medicine, but the practice exists in other cultures. For example, Kew *et al.*³⁶ describe the unfortunate consequences of consuming a remedy for eczema that was compounded by an Indian 'medical practitioner', a Hakim. The dose consisted of arsenic trioxide 105 mg, mercuric sulfide 654 mg and strychnine 0.7 mg. Arsenicum album as defined by the *Dictionary of Alternative Medicine*³⁷ is a remedy prepared from arsenopyrite (*sic*) and is claimed to be used for treating fear and anxiety linked to insecurity and over-sensitivity; it is also used for food poisoning, anxiety, angina, flu, skin problems, insomnia, etc. Homeopathic medicine containing arsenicum album is available over the counter or by mail order, e.g. Alpha Homeopathic remedy 38 and Hyland's Homeopathic Arsenicum Album, and at the higher dose regime the patient might as well be drinking Fowler's Solution.³⁸ Usually, both the supplier and the consumer are unaware of potential problems.

Arsenic eating in Styria was connected to a belief in magic, a fear of the supernatural, and distrust of conventional medicine.¹⁷ Practitioners did so in private because of a fear of reprisal and because the sale of arsenic was illegal in Styria. Has the situation changed over the centuries? Certainly, drugs available in one country are not necessarily available, or are even illegal, in another; marijuana, ethyl alcohol, and opium come mind. The results of a recent survey³⁹ reveal that most Americans are using alternative therapies along with standard medicine, but they are not telling their conventional health care-givers that they are using these other modalities. To quote from an article in *Chemistry and Engineering News*:⁴⁰

By taking these alternative paths, Americans are wrestling decision-making control from traditionally paternalistic physicians. And when they turn to nontraditional therapists, Americans usually find a willing listener and the spiritualism they seem to be seeking as the millennium approaches.

CONCLUSION

From the 17th century, a small number of the inhabitants of Styria were 'arsenic eaters' who had developed a procedure for the consumption of arsenic trioxide in fairly high amounts. Arsenic eaters usually consumed around 300–400 mg of solid arsenic trioxide per dose on a regular basis (every 2–3 days) over a lifetime. The amounts taken were often more than double that of the normal single fatal dose (70–180 mg arsenic trioxide). This was made possible by the intake of the solid form, which is absorbed in reduced amounts by humans. However, the consumed amounts are at least two orders of magnitude higher than the amounts ingested by individuals who would now be defined as being chronically exposed (1 mg of inorganic arsenic per day).

Consideration of the recent discussions on chronic arsenic poisoning and of the related reduction of threshold levels for arsenic in drinking water make the fact of arsenic eaters amazing and difficult to accept. It is clear that a whole range of possible effects (antagonistic as well as synergistic) and explanations should be considered. Merely to deny the phenomenon of the Styrian arsenic eaters on the grounds of 'common sense' is not scientifically tenable. However, the authors do not intend in this paper to question the danger of arsenic exposure.

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