

The Death of Napoleon, Cancer or Arsenic?

J. Thomas Hindmarsh¹ and John Savory^{2*}

Napoleon Bonaparte died on May 5, 1821, at the age of 51 on the island of Saint Helena, his prison for 5 years. Four autopsy reports, including 2 from the French contingent, revealed the cause of death to be an extensive carcinoma of the stomach complicated by terminal bleeding, the same disease that took his father and several close relatives, including a purported illegitimate son (1). Napoleon was reasonably well until the autumn of 1820, when he developed recurrent abdominal pain, weakness, and stubborn constipation, and toward the end intractable vomiting, hiccupping, and possibly thrombophlebitis-migrans.

In the 1960s, when neutron and other activation techniques became available to measure trace elements in individual hairs, a series of articles appeared reporting that increased arsenic concentrations had been found in Napoleon's hair, leading to claims that he had been deliberately poisoned while on Saint Helena (2, 3). However, the increased concentrations were measured in hair samples dating back to 1805, including samples taken while he was on Elba in 1814. Indeed, an Italian group has recently reported concentrations of 8 ppm ($\mu\text{g/g}$) and 6 ppm (modern normal concentration <1 ppm) from 1770 when Napoleon was a baby on Corsica (4). Also, samples of equal provenance have shown both normal and increased arsenic concentrations from hair samples culled on the same day as samples with increased concentrations (5, 6). This confusing situation exemplifies the unreliability of trace-element values measured in individual hair samples; concentrations vary enormously from hair to hair on the same head. Thus, to improve reliability it is necessary to analyze a minimum of 1 g of hair taken from several sites on the head. Even with the use of this amount of specimen, hair arsenic values are only approximately related to degree of toxicity. In 2 persons living in the same house and equally poisoned (confirmed by electromyography) by ingesting arsenic con-

tained in well water, we confirmed differing hair concentrations of 47 ppm and 4.2 ppm (7). To ascribe poisoning on the basis of arsenic measured in hair samples, external contamination must be ruled out, a process that often is not possible.



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An elegant report, by Professor Ivan Ricordel, director of forensic laboratories of the Paris police, and his colleagues, published in the November 2002 edition of *Science et Vie*, labeled the poisoning claim *ferfelu* (harebrained) (8). Their investigation showed the following:

- The investigators' own hair, soaked in arsenic for periods of 1 month to 1 year, concentrated the arsenic, and although much could be removed by washing, large amounts remained. Thus, washing the hair sample is not useful for differentiating arsenic in hair derived from ingestion from that derived from external contamination.
- When inorganic arsenic is injected into patients with leukemia, it is deposited on outer body surfaces, similar to its location in external arsenic contamination, because arsenic is secreted in sweat and sebaceous secretions. We and others have shown that arsenic from ingestion and arsenic from external contamination can be found both in the core and on the outer surface of hair (9); thus the location cannot be used to differentiate the source as ingestion or contamination.
- Large variations in arsenic concentrations exist between hairs on the same head and on the same hair.
- Napoleon's sister Pauline Borghese³ had hair arsenic concentrations of 15 ppm in 1825.
- Napoleon had a lethal hair arsenic concentration of 296 ppm early in 1815, several months before he died. Although he was seriously ill, he was not moribund at that time.

¹ University of Ottawa, Ontario, Canada; ² University of Virginia, Charlottesville, VA.

* Address correspondence to this author at: UVA Health Sciences Center, Box 800214, Charlottesville, VA 22908; e-mail js2r@virginia.edu.

³ No visitor to Rome should miss the opportunity to see the nearly nude statue of Pauline Borghese by Canova in the Borghese Gallery. The sculpture was so lifelike that after it was completed her husband would not let anyone view it, not even its sculptor.

⁴ Artwork by Nader Rifai.

Kintz (10) has speciated the arsenic from Napoleon's hair and found it to be mostly pentoxide with some trioxide and claims that this finding supports a diagnosis of chronic arsenic intoxication. However, Yamauchi (11) has shown that contamination produces a similar pattern. Some have claimed that arsenic contamination would be evenly distributed along the length of the hair, but this distribution pattern does not occur. Therefore, we know of no way to determine from hair analysis whether arsenic got there from ingestion or external contamination.

No convincing clinical evidence indicates that Napoleon died from arsenic poisoning. He did not have the skin changes characteristic of chronic arsenic poisoning, rain-drop pigmentation, arsenic corns, or hyperkeratoses of his feet and hands. Neither did he demonstrate the typical progressive weight loss of arsenic poisoning. Sketches show that he gained much weight from 1815 to 1820. There are no formal records of his weight while on the island, but recently it has been confirmed that he gained weight from 1815 to 1820, then lost 11 kg in his last year as his cancer took hold. This information was obtained by a technique ingenious in its simplicity, the measurement of the waistbands of his trousers (12).

Given the conclusion that Napoleon did not suffer arsenic poisoning, what was the source of his hair arsenic? Arsenic was ubiquitous in the 19th century, being used extensively as a rodenticide, insecticide, and preservative and in face and hair powders (Napoleon used hair powder), clothing dyes, and even candy wrappers, as well as being extensively prescribed as a tonic (Fowler's Solution). Arsenic was also used as a green pigment (Scheele's and Paris Green) in wallpaper. The wallpaper in Napoleon's residence on Saint Helena contained some arsenic but probably not enough to increase his hair concentration.

There is no evidence from Napoleon's extensive medical records that the Emperor took arsenic as a medicine; indeed he was highly skeptical of doctors and their remedies, having stated "you medical people will have more lives to answer for in the other world than even we generals (13)." He could have ingested arsenic from his water supply. However, we have analyzed a water sample kindly supplied by the French Consul on Saint Helena, M. Michel Martineau, and found it to have a normal arsenic concentration.

External contamination with arsenic would explain the widely varying hair concentrations, including normal ones, seen throughout Napoleon's life. Only one study has investigated a reference interval for hair arsenic in the 19th century. Hamilton Smith and his colleagues, who analyzed many early hair samples from Napoleon, also analyzed 12 hair samples from separate funerary wreaths and locketts dating 1790–1849 and collected from around the city of Glasgow, Scotland.

Even when the results from grossly contaminated specimens were discounted, the arsenic concentrations ranged up to 59 ppm, with concentration in most samples 10 ppm or less (12). Thus, a "normal" range for the Napoleonic era cannot be accurately defined.

We suspect that the source of the arsenic in Napoleon's hair was from the common practice of adding a pinch of arsenic trioxide as a preservative to hair samples cut as mementoes and/or the use of arsenic-containing hair powder. The Emperor said, "History is but a fable oft repeated." We hope that modern scientific techniques have provided us with some improvement on this statement.

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