ClassicsToday.com wishes to thank Dr. Josef Eisinger and the *The Beethoven Journal* for their kind permission to republish this article.

This article appeared in **The Beethoven Journal, Volume 23, Number 1 (Summer 2008) pp 15-17**

Was Beethoven Lead-Poisoned?

by

Josef Eisinger©
Professor emeritus, Department of Structural and Chemical Biology
Mount Sinai School of Medicine, New York, NY

Introduction

During the past several years numerous reports have appeared in the popular media claiming that Beethoven suffered from lead disease. That claim was based on the analysis of hairs from Beethoven's head, hairs that several of his admirers had collected as mementos of the great man shortly after his death. In several instances the provenance of such hairs is well established and documented.[1] The initial report stated that Beethoven's hair contained 'high levels of lead', but no quantitative information was provided at that time or subsequently, nor have the results of these hair analyses appeared in the professional literature to date.[2] The colossal publicity that Beethoven's purported lead-poisoning received in the press and other media seems out of proportion to the scant evidence on which these reports were based, evidence which, until recently, has received little scrutiny.[3]

Last year Dr. Christian Reiter reported the results of a different type of analysis of Beethoven's hair and his study has renewed speculation, not only regarding Beethoven's lead disease, but also regarding the cause of his death.[4] Dr. Reiter did not determine the lead content of Beethoven's hair, as had been attempted earlier, but measured the *distribution* of lead (Pb) along an individual hair. He interpreted this longitudinal Pb concentration profile as a temporal record of lead exposure during the last three months of Beethoven's life and by relating the dates of five peaks of the Pb profile to five hypothetical events, Dr. Reiter concluded that Beethoven's physician, Dr. Andreas Wawruch, had inadvertently lead-poisoned his patient and was responsible for his death.

Before reviewing Dr. Reiter's experiment and analysis, some general comments regarding the use of hair as an indicator of lead exposure are in order. Ever since the dangers of

ingesting lead became widely recognized, physicians and public health authorities have searched for reliable diagnostic indicators (biomarkers) of the severity of a person's lead exposure. Today, the most widely used indicator is the level of lead in blood (blood-Pb), although others are also used, including the levels of metabolites induced by lead exposure, and the level of lead stored in bone (bone-Pb), which can be measured non-invasively.[5, 6]

At first sight, the lead content of hair (hair-Pb) might represent a more convenient, less intrusive, and cheaper alternative to these methods, and consequently many investigators have studied and tested the effectiveness of hair-Pb as a biomarker.[7] Most recently, a panel of experts, convened by the U.S. Center for Disease Control examined the reliability of this approach, and concluded that hair-Pb is an ineffective biomarker.[8] Among the reasons given were the great variability among hair specimens from the same head, the inconsistency of assays performed by different laboratories, and the impossibility of distinguishing between endogenous and externally adherent lead.[9, 10] Hair-Pb was consequently not recommended as an indicator and there exist no established protocols linking hair-Pb levels to blood-Pb levels or to other indicators, or indeed, to the symptoms of lead disease.

Dr. Reiter's Experiment and Data Analysis

In this section I will briefly describe the novel experimental method used by Dr. Reiter to obtain the Pb profile of an individual hair, before examining critically the assumptions underlying his data analysis and conclusions.

Dr. Reiter obtained several hairs from Dr. Alfredo Guevara, Nogales, Arizona, who is the owner of a well-authenticated lock of Beethoven's hair. A narrow laser beam at right angles to a 4 cm-long hair was used to vaporize the hair along its length and the lead concentration in the resultant vapor was determined by means of a mass spectrometer. The data allowed Dr. Reiter to obtain the Pb concentration profile of the hair along its length. Now, human head hair grows at a variable rate, ranging from 0.2 to 1.12 mm/day, and on the average, about 1 cm per month.[11] Assuming that the hair had grown at a constant rate of 0.36 mm per day and had been cut off close to Beethoven's scalp, and making the tacit assumption that lead introduced into Beethoven's body appeared in his hair a few days later, and disappeared just as quickly, Dr. Reiter interpreted the hair's Pb

profile as a temporal record of Beethoven's lead exposure during the last 111 days of his life.

Using this time calibration, Dr. Reiter assigned dates to five narrow peaks in the Pb profile, with widths ranging from 2 to 5 days, and associated each peak with a medical intervention that took place shortly before the dates assigned to the peaks. The first of these interventions was an 'infection-fighting medication' that Dr. Wawruch prescribed on 5 December 1826 after diagnosing Beethoven's pneumonia;[12] the four others corresponded to the four paracentesis operations that Beethoven underwent on 20 December 1826, 8 January, 2 and 27 February 1827.[13] In these procedures Beethoven's abdomen was punctured and large amounts of fluid were drained in order to give him relief from his massive edema.

It is Dr. Reiter's hypothesis that (1) the 'infection-dissolving medication' contained lead, (2) that following each tapping, Dr. Wawruch dressed the puncture wounds with a lead-containing salve or putty, and (3) that lead internalized by Beethoven on these five occasions accounted for the five peaks in the hair's Pb profile. This hypothesis led Dr. Reiter to conclude that Dr. Wawruch had inadvertently lead-poisoned Beethoven so severely as to cause his death.[4]

Critique of Reiter's Hypothesis

The above scenario is based on a series of assumptions that need to be examined further. To begin with, additional experiments would be needed to demonstrate that the methodology employed by Dr. Reiter yields reproducible data and that the hair specimen was free of contaminating exogenous lead. The narrow widths of the peaks in the Pb profile are, furthermore, at variance with what is known about the transport of lead within the human body and the rate at which it occurs. After entering the body, lead appears initially in the circulating blood and if the exposure to lead was brief, the blood Pb level rises to a maximum quickly and then drops much more slowly with a decay time of about 35 days, while the internalized lead is either excreted or re-distributed among other body compartments, e.g. the soft organs, hair, and the skeleton, where its residence time is measured in years.[14] The rate of transport of lead from circulating blood to the growing

hair has, moreover, been studied in experiments in which healthy human subjects ingested stable lead isotopes and their lead metabolism was monitored for many months.[15] These studies show that the rate at which lead is transported to hair is slow, and was estimated to be several months. Such long equilibration times are clearly inconsistent with the postulated short rise and decay times of a few days implied by the narrow peaks in the Pb profile.

Dr. Reiter's contention that the medication Beethoven obtained from Dr.Wawruch was tainted with lead is not only unsubstantiated, but seems highly unlikely. Dr. Wawruch was a well-qualified and experienced physician and professor of pathology at the University of Vienna. By the 19th century, the danger of ingesting lead was widely known, so much so that the ancient nefarious practice of adulterating wines with lead (for example) was strictly prohibited.[16] The conjecture that Dr. Wawruch had dressed Beethoven's paracentesis incisions with lead putty is also unsupported by evidence and is, moreover, at variance with Dr. Wawruch's report that the lips of the puncture wounds were kept 'meticulously dry' in order to avoid infection.[17, 18]

How can the Pb profile obtained by Dr. Reiter be explained? No details were provided about how the hair specimen was prepared or cleaned before its Pb profile was measured. When dealing with a hair specimen that is 180 years old, this is a matter of considerable concern, for hair is known to be particularly susceptible to contamination by extraneous, particulate lead. The reason for this is that the principal constituents of hair proteins (keratins) carry numerous strong binding sites for lead atoms.[19] This is also why attempts to distinguish between endogenous and exogenous lead have been unsuccessful.

Particulate contaminants adhering to the hair appear to offer the most likely explanation for the narrow peaks in its Pb profile.

Conclusion

In view of these considerations, the suggestion that Beethoven was lead-poisoned, let alone killed by Dr. Wawruch's actions, appears to be based on questionable experimental data that were analyzed with the aid of unsupported and arbitrary

assumptions. While it is not the object of this review to establish Beethoven's actual cause of death, a brief summary of what is known is germane to the present discussion.

Even if the serious reservations regarding the interpretation of the Pb profile could be overcome, Beethoven's medical record is inconsistent with fatal lead-poisoning. While the early symptoms of lead disease are relatively non-specific, the later, ultimately terminal symptoms involve the patient's central nervous system.[16] They include paralysis, blindness, and insanity, none of which were present in Beethoven's case. The symptoms Beethoven did exhibit during his last several years, on the other hand, are entirely consistent with advancing liver disease.

Beethoven's medical history can be reconstructed in remarkable detail thanks to his prominence and the consequent abundance of contemporary primary sources. Among these are the reports written by Beethoven's physicians, the conversation books which deafness obliged him to use from 1818 on, and finally, Beethoven's own letters to friends and family and the memoirs written by them. By scouring these sources for references to Beethoven's hearing loss and to his other ailments, as well as his eating and drinking habits, it has been possible to obtain a fairly complete picture of his developing deafness and of his other afflictions. Probably the most comprehensive collection of these citations was assembled by the pathologists Bankl and Jesserer in a remarkable volume, and their year-by-year account of Beethoven's terminal disease, which is in essential agreement with that of other authors, is briefly summarized in the following paragraph.[20], [21], [22], [23] A similar consensus regarding the causes of his deafness and digestive disorders has not been achieved.[24]

The symptoms (jaundice, etc.) Beethoven exhibited in 1821 indicate that he contracted viral hepatitis at about that time and the progress of his liver disease was probably hastened by his continued consumption of considerable quantities of wine, beer and spirits, ignoring, as was his custom, his doctors' directions.[25] (Much later, after all hope of his recovery had gone, his doctors let him have alcoholic sorbets that gave him great relief.) But the accumulated historical evidence also shows that Beethoven was not an alcoholic.[26] During the last five years of his life his condition deteriorated steadily and there were increasing signs of the hepatic failure that was, in the end, responsible for his death. Dr. Wagner performed an autopsy one day after Beethoven died and his report

describes cirrhosis and atrophy of the liver and cited other findings (splenomegaly, pancreatitis, etc.) typically associated with severe and chronic liver disease.[27]

*

Finally, in the absence of credible evidence that Beethoven was lead-poisoned, I conclude that lead did not play a significant role in his illnesses or death and that his death resulted from hepatic failure. It is possible that additional analyses of Beethoven's surviving earthly remains will yield further information bearing on his diverse medical afflictions, but to date the rationale for Beethoven's lead disease remains unconvincing.

Acknowledgements

I wish to thank my wife Styra Avins, Dr. Michael Lorenz, and Dr Walter Gratzer for a number of useful discussions.

NOTES

[1] R. Martin. *Beethoven's hair. An extraordinary historical odyssey and a scientific mystery solved*. New York: Broadway Book Co; 2000.

[2] Walsh W., Statement released at the press conference of 17 October 2000. The text is available at http://www.sjsu.edu/depts/beethoven/hair/hairtestpr.html

[3] Josef Eisinger, *The lead in Beethoven's hair.* Toxicol. and Environ. Chemistry, 90(1):1-5 (2008)

[4] Christian Reiter, *Beethovens Todesursachen und seine Locken*: *Eine forensisch-toxikologische Recherche*. Wiener Beethoven-Gesellschaft Mitteilungsblatt XXXVIII, 1–6 (Jan. 2007): The German text is available at http://www.sjsu.edu/depts/beethoven/hair/Reiter.html.

An English translation by Dr. Michael Lorenz appeared in the Beethoven Journal 22(1), 2–5 (2008) under the title: *The Causes of Beethoven's Death and his Locks of Hair: A Forensic-Toxicological Investigation*.

[5] J. Eisinger, W. E. Blumberg, A. Fischbein, R. Lilis, and I. J. Selikoff. *Zinc protoporphyrin in blood as a biological indicator of chronic lead intoxication.* J. Environ. Pathol. Toxicol. 1(6) 897-910 (1978).

[6] H. R. Hu, R. Shih, S. Rothenberg, B. S. Schwartz. *The epidemiology of lead toxicity in adults: Measuring dose and consideration of methodologic issues*. Environ. Health Persp. 115, 456–462 (2007).

[7] F. Barbosa, J. E. Tanus-Santos, R. F. Gerlach, and P. J. Parsons. *A Critical Review of Biomarkers Used for Monitoring Human Exposure to Lead: Advantages, Limitations, and Future Needs*. Environmental Health Perspect. 113(12), 1669-1674 (2005).

[8] D. K. Harkins and A. S.Susten. *Hair analysis: Exploring the state of the science*. Environ. Health Persp. 111:576–578 (2003)

[9] S. J. Steindel and P. J. Howanitz. *The Uncertainty of Hair Analysis for Trace Metals.* J. Amer. Med. Assoc. 285(1), 83-85 (2001).

[10] S. Seidel, R. Kreutzer, D. Smith, S. McNeel, and D. Gilliss. *Assessment of Commercial Laboratories Performing Hair Mineral Analysis*. J. Am. Med. Assoc. 285:67–72 (2001)

[11] M. R. Harkey. *Anatomy and physiology of hair*. Forensic Sci. Internat. 63, 9-18 (1993)

[12] Andreas Wawruch, *Ärztlicher Rückblick auf L. van Beethoven's letzte Lebensepoche (May 1827)* Wiener Zeitschrift für Kunst, Literatur, Theater und Mode 86, 681-685 (April 1842).

Dr. Michael Lorenz has translated Dr. Wawruch's account of Beethoven's last weeks and has provided an exhaustive commentary: *Medical Review on the Final Stage of L. van Beethoven's Life.* Beethoven J. 22(2) 87-100 (2007)

According to Dr. Reiter, Dr. Wawruch considered the massive accumulation of fluids (edema) that Beethoven developed after the pneumonia, was a "side effect" of the medication he had provided. Dr. Wawruch made no such inference in his own account, but reports Beethoven's massive edema and jaundice over his entire body eight days after the pneumonia episode, commenting that his chronic liver disease was progressing rapidly.

[13] Once Dr. Wawruch deemed the first paracentesis necessary, he called on the surgeon Johann Seibert, to perform it. After the incision was made and the fluid spurted out, Beethoven shouted with joy to him: "Professor, you remind me of Moses striking the rock with his staff!" In spite of his suffering, Beethoven's spirit was clearly unbroken and when a few days later, the 40 volumes of Arnold's works of Handel arrived, he was overjoyed and praised Handel as the greatest and ablest composer that ever lived. *Thayer's Life of Beethoven (Revised and edited by Elliot Forbes)* Princeton Univ. Press (1967), Vol. II. pp1023-1024.

[14] M. B. Rabinowitz, G. W. Wetherill, J. D. Kopple J. D. *Kinetic analysis of lead metabolism in healthy humans.* J. Clin. Invest. 58, 260–270 (1976)

[15] Allan H. Marcus, *Multicompartment Kinetic Models for Lead. II. Linear Kinetics and Variable Absorption in Humans with Excessive Lead Exposures.* Environmental Research 36, 459-472 (1985)

[16] Josef Eisinger. *Lead and Wine. Eberhard Gockel and the Colica Pictonum.* Med. History 26:279–302 (1982)

[17] Andreas Wawruch, *op. cit*. p683 (p89 in Lorenz's translation)

[18] The professional qualifications of Dr. Wawruch and Dr. Seibert and the contemporary medical practices have been reviewed in considerable detail by Dr. Michael Lorenz and his commentary appeared in Beethoven J. 22(2) 87-100 (2007)

[19] Keratins are structural proteins that are unusually rich in the sulfur-containing amino acid cysteine, whose sulfhydril groups (S-H) have a strong chemical affinity for Pb atoms. The strength of the bond formed between sulfur and lead (Pb-S) is also responsible for the toxic effects of ingested lead, because many different human enzymes are proteins that contain cysteine residues. In the presence of lead, these enzymes commonly bind Pb ions causing the enzymes to malfunction.

[20] Hans Bankl and Hans Jesserer, *Die Krankheiten Ludwig van Beethovens: Pathographie seines Lebens und Pathologie seiner Leiden.* Vienna: Verlag Wilhelm Maudrich; 1987

[21] A. K. Kubba and M. Young, *Ludwig van Beethoven: a medical biography*. Lancet 347, 167-70 (1996)

[22] P. J. Davies, *Beethoven in Person: His Deafness, Illnesses, and Death*. Westport, Conn., Greenwood Press, 2001.

[23] F. M. M. Mai, *Beethoven's terminal illness and death*. J. Royal Coll. Physicians Edinb. 36, 258-263 (2006)

[24] P. D. Shearer, *The Deafness of Beethoven: An Audiologic and Medical Overview.* Am. J. of Otology 11(5) 370-74 (1990)

[25] Beethoven's alcohol consumption during his final months is discussed by Michael Lorenz in his commentary to Andreas Wawruch, *op. cit*., p98.

[26] Bankl and Jesserer, *op. cit*. 75-79

[27] Bankl and Jesserer, *op. cit.* 83-87