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The Death of Adolf Hitler—Forensic Aspects

ABSTRACT: The death of Adolf Hitler is one of the unsolved mysteries of the twentieth century. Numerous historians and journalists have attempted to piece together the details, but despite the interest in the forensic literature regarding the identification of the body, there has not been much scientific debate about the alleged cause of death—cyanide poisoning, gunshot injury, or both. The available literature concerning Hitler's cause of death is incomplete because the toxicological analysis has not been performed and because the skull bone fragment with a gunshot wound possibly from Hitler's corpse has not been properly examined. This has given basis for various theories, which are reviewed. We believe that mtDNA analysis of the skull fragments and of Hitler's jaw, now filed in Moscow, and samples from maternal relatives of Hitler are crucial linking the skull fragment with the gunshot wound to Hitler.

KEYWORDS: forensic science, Adolf Hitler, cause of death, forensic data

Although there has been considerable interest in the identification of Hitler's body, there has been less on the actual cause of death.

Several attempts have been made by journalists to determine exactly what happened. In 1947, Hugh Trevor-Roper published his book *Last Days of Hitler*, in which he refers to the eyewitness accounts of Germans who lived in the bunker during the last days (1). The Soviet government kept the Hitler file secret until 1968, when a journalist, Lev Bezymenski, published in German and in English the official results of the Soviet investigation (2). In 1995, Hugh Thomas, published his book entitled *The Murder of Adolf Hitler. The Truth about the Bodies in the Berlin Bunker* (3), raised the issue of the circumstances of the death of Hitler and its forensic investigation.

Additionally, two journalists, Ada Petrova from Russia and Peter Watson from Britain, published a book in English about the KGB's secret files (referred to as the Myth Files) showing photographs of the skull fragments found in 1946; these were found in the garden of Hitler's Reichskanzlei (4). The journalists commissioned Professor Victor Zyagin of the Federal Centre of Medical Forensic Examination in Moscow to deliver an "independent verdict" on the skull fragments (4). In 1998, Ulrich Völklein, a German journalist, published a book *Hitlers Tod. Die letzten Tage im Führerbunker* (Hitler's Death. The Last Days in the Führer's Bunker) in which he invited Professor Klaus Püschel, Director of the University of Hamburg's Institute of Forensic Pathology, to give his opinion on the cause of Hitler's death (5).

In these books, several opinions on the cause of Hitler's death have been put forward, including: cyanide poisoning as proposed by Soviet forensic scientists in 1945 (2); a gunshot wound, proposed by another Soviet forensic scientist in 1946 (3,4); and a combination of the two theories (6). An additional theory proposed by Hugh Thomas was that Hitler was strangled (3). In this paper, we review the theories chronologically and attempt to assess them in the light of the forensic data available at the time of their proposal.

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The Authentic Autopsy Report of the Forensic Medical Commission of the Soviet Army

In 1968, Lev Bezymenski, a Russian writer, published in West Germany a book entitled "*Der Tod des Adolf Hitler*" (The death of Adolf Hitler) (2). The book was subtitled "Unknown documents from Soviet Archives." These documents allowed forensic scientists to evaluate the claim of the Soviet experts to have identified Hitler's body with "a fair degree of certainty." In 1972, Reidar F. Sognaes from the School of Medicine and Dentistry, University of California, Los Angeles, discovered five head X-ray plates originally taken of Hitler in 1944 following an assassination attempt. These X-rays revealed several characteristic dental conditions. Together with Ferdinand Strøm, Sognaes compared this X-ray evidence with the dental features described in Bezymenski's report and with other information obtained from the U.S. Archives recorded between 1945 and 1946. After careful study of various pieces of descriptive, diagrammatic, and photographic evidence, Sognaes and Strøm provided definitive odontological proof that the body recovered by the was that of Hitler (7,8).

Despite the scientific agreement regarding the odontological identification, the enigma concerning the cause of Hitler's death remains to be solved. For this it is important to review the autopsy findings as detailed in Bezymenski's book (2).

Document 12 refers to the autopsy of a male body disfigured by fire—Hitler's body—(Berlin-Buch 8.V.1945 Mortuary CAFS 1 No. 496) performed by Dr. Faust Shkaravsky, a forensic pathologist who in 1945 was Chief Expert of Forensic Medicine with the First Byelorussian Front. The autopsy report is included in full on pages 44–51 of Bezymenski's book:

"A. EXTERNAL EXAMINATION

The remains of a male corpse disfigured by fire were delivered in a wooden box (length 163 cm, width 55 cm, height 53 cm). On the body was found a piece of yellow jersey, 25 × 8 cm, charred around the edges, resembling a knitted undervest. In view of the fact that the corpse is greatly damaged, it is difficult to gauge the age of the deceased. Presumably it lies between 50 and 60 years. The dead man's height is 165 cm (the measurements are approximate since

the tissue is charred), the right shinbone measures 39 cm. The corpse is severely charred and smells of burned flesh. Part of the cranium is missing.

Parts of the occipital bone, the left temporal bone, the lower cheekbones, the nasal bones, and the upper and lower jaws are preserved. The burns are more pronounced on the right side of the cranium than on the left. In the brain cavity parts of the fire-damaged brain and of the dura mater are visible. On face and body the skin is completely missing; only remnants of charred muscles are preserved. There are many small cracks in the nasal bone and the upper jawbones. The tongue is charred, its tip is firmly locked between the teeth of the upper and lower jaws. [. . .].

Splinters of glass, parts of the wall and bottom of a thin walled ampoule, were found in the mouth.

The neck muscles are charred, the ribs on the right side are missing, they are burned. The right side of the thorax and the abdomen are completely burned, creating a bole through which the right lung, the liver, and the intestines are open to view. The genital member is scorched. In the scrotum, which is singed but preserved, only the right testicle was found. The left testicle could not be found in the inguinal canal.

The right arm is severely burned, ends of the bones of the upper arm and the bones of the lower arm are broken and charred. The dry muscles are black and partially brown; they disintegrate into separate fibers when touched. The remnants of the burned part (about two thirds) of the left upper arm are preserved. The exposed end of the bone of the upper arm is charred and protrudes from the dry tissue. Both legs, too, are charred. The soft tissue has in many places disappeared; it is burned and has fallen off. The bones are partially burned and have crumbled. A fracture in the right thighbone and the right shinbone were noted. The left foot is missing.

B. INTERNAL EXAMINATION

The position of the internal organs is normal. The lungs are black on the surface, dark red on the cut surface, and of fairly firm consistence. The mucous membrane of the upper respiratory tracts is dark red. The cardiac ventricles are filled with coagulated reddish-brown blood. The heart muscle is tough and looks like boiled meat. The liver is black on the surface and shows burns; it is of fairly firm consistence and yellowish-brown on the cut surface. The kidneys are somewhat shrunken and measure $9 \times 5 \times 3.5$ cm. Their capsule is easily detachable; the surface of the kidneys is smooth, the pattern effaced, they appear as if boiled. The bladder contains 5 cc. yellowish urine; its mucous membrane is gray. Spleen, stomach, and intestines show severe burns and are nearly black in parts.

NOTE

The following objects taken from the corpse were handed over to the SMERSH Section of the 3rd Shock Army on May 8, 1945: a) a maxillary bridge of yellow metal, consisting of 9 teeth; b) a singed lower jaw, consisting of 15 teeth. [. . . omissis . . .]

Appended: A test tube with glass splinters from an ampoule which were found in the mouth of the body.

signed (Shkaravski)
Chief Expert, Forensic Medicine,
1st Byelorussian Front, Medical Service, Lieutenant Colonel

signed (Krayevski)
Chief Anatomical Pathologist, Medical Service, Red Army,
Lieutenant Colonel

signed (Marants)
Acting Chief Anatomical Pathologist, 1st Byelorussian
Front, Medical Service, Major

signed (Boguslavski)
Army Expert, Forensic Medicine, 3rd Shock Army, Medical
Service, Major

signed (Gulkevich)
Army Anatomical Pathologist,
3rd Shock Army, Medical Service, Major

CONCLUSION

Based on the forensic-medical examination of the partially burned corpse of an unknown man and the examination of other corpses from the same group (Documents Nos. 1–11), the Commission reaches the following conclusions:

1. Anatomical characteristics of the body:
Since the body parts are heavily charred, it is impossible to describe the features of the dead man. But the following could be established:
 - a. Stature: about 165 cm. (one hundred sixty-five).
 - b. Age (based on general development, size of organs, state of lower incisors and of the right bicuspid), somewhere between 50 and 60 years (fifty to sixty).
 - c. The left testicle could not be found either in the scrotum or on the spermatic cord inside the inguinal canal, nor in the small pelvis.
 - d. The most important anatomical finding for identification of the person are the teeth, with much bridge-work, artificial teeth, crowns, and fillings (see documents).
2. Cause of death:
On the body, considerably damaged by fire, no visible signs of severe lethal injuries or illnesses could be detected.

The presence in the oral cavity of the remnants of a crushed glass ampoule and of similar ampoules in the oral cavity of other bodies (see Documents Nos. 1, 2, 3, 5, 6, 8, 9, 10, 11, and 13), the marked smell of bitter almonds emanating from the bodies (Documents Nos. 1, 2, 3, 5, 8, 9, 10, 11), and the forensic-chemical test of internal organs which established the presence of cyanide compounds (Documents Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11) permit the Commission to arrive at the conclusion that death in this instance was caused by poisoning with cyanide compounds.

signed as earlier”

Of note no mention of chemical tests was made in Hitler's autopsy report. This report didn't indicate the presence of cyanide in his internal organs (see Table 1). Later Lev Bezymenski added “the experts were faced with a most seriously disfigured of all thirteen corpses. Because of this obstacle to the examination two sentences need to be particularly stressed: ‘Splinters of glass, parts of the wall and bottom of a thin-walled ampoule, were found in the mouth’ (Document. 12)—and ‘In the oral cavity [. . .] yellowish glass splinters [. . .] of a thin-walled ampoule were found’ (Document. 13, appendix)” (2). Document 12 is the report of the autopsy

TABLE 1—Hitler's autopsy report.

Autopsy Document	Data from Autopsy Report	Splinters of Zyankali Ampoule	Toxicological Analysis	Conclusion on Cause of Death
Doc. No. 1 Helga Goebbels	brain matter smells of bitter almonds	in the mouth	cyanide present	cyanide poisoning
Doc. No. 2 Heide Goebbels	brain matter smells of bitter almonds	behind the cheek	cyanide present	cyanide poisoning
Doc. No. 3 German Shepherd	smell of bitter almonds at the internal examination	two splinters on the tongue	cyanide present	cyanide poisoning
Doc. No. 4 small black dog	not indicated	not indicated	cyanide present	cyanide poisoning
Doc No. 5 Joseph Goebbels	faint smell of bitter almonds in the lung	in the mouth	cyanide present	cyanide poisoning
Doc. No. 6 Magda Goebbels	not indicated	in the mouth	cyanide present	cyanide poisoning
Doc. No. 7 General Hans Krebs	marked smell of bitter almonds in the brain and in thoracic and abdominal organs	not indicated	cyanide present	cyanide poisoning
Doc. No. 8 Hedda Goebbels	tongue smells of bitter almonds	in the mouth	cyanide present	cyanide poisoning
Doc. No. 9 Holde Goebbels	brain and lung smell of bitter almonds	in the mouth	cyanide present	cyanide poisoning
Doc. No. 10 Helmut Goebbels	brain and lung smell of bitter almonds	in the mouth	cyanide present	cyanide poisoning
Doc. No. 11 Hilde Goebbels	brain and lung smell of bitter almonds	in the mouth	cyanide present	cyanide poisoning
Doc. No. 12 Adolf Hitler	not indicated	in the mouth	not performed	cyanide poisoning
Doc. No. 13 Eva Braun	marked smell of bitter almonds	in the mouth	not performed	cyanide poisoning

of Hitler and Document 13 that of Eva Braun. Although there was no toxicological analysis the Commission concluded that in both cases: "Death was caused by poisoning with cyanide compounds" (2).

Also of note Document 12 (Hitler) contained no mention of bitter almonds. On the other hand Braun's autopsy report indicated that "during autopsy a marked smell of bitter almonds." In addition, splinters of a glass ampoule were found in her mouth (2).

The attribution of Hitler's death to cyanide poisoning was therefore based on the presence in his mouth of splinters of glass from an ampoule and on the autopsy findings: his stomach and the intestines showed severe burns and were "nearly black in parts," suggesting some damage due to the strongly alkaline nature of the hydrolyzed sodium or potassium salts of cyanide (2).

Taking into account the autopsies performed on all the corpses found in the Reichskanzlei, the conclusions of the Soviet experts were based on several findings (See Table 1). The corpse of the German shepherd dog found with Hitler's corpse and the bodies of all the members of the Goebbels family contained cyanide compounds and a smell of bitter almonds was reported, except in the case of Magda Goebbels. In addition, glass splinters were found in their mouths. In the case of Eva Braun, a smell of bitter almonds was recorded but it was not specified from which organs it emanated.

At this point, one should ask whether the Soviet pathologists surmised that Hitler died of cyanide poisoning, or if their conclusions are scientifically correct?

Cyanide acts as free hydrogen cyanide, so that when the salts are ingested they need to release hydrocyanic acid by reacting with water or acid in the gastric contents. This process takes only a few seconds and a fatal dose of cyanide is small (130–300 mg). Cyanide, in the form of the so-called Zyankali capsule, was therefore favoured by prominent Nazis as an easily-hidden suicide pill.

Toxicological tests may be difficult to interpret because of the destruction of cyanide in the body after death and even in stored

blood samples awaiting analysis (9). Knight underlines the importance of handling samples with particular care in order to avoid any hazard to those packing, transporting, or unpacking them and suggests that it is important to deliver the samples to the laboratory as soon as possible (in terms of days) to avoid the spurious formation of cyanide that usually occurs in samples stored at room temperature, and that "the laboratory should be warned in advance that a possible cyanide case is coming their way" and "if it is to be delayed, refrigeration is essential" (9).

There have been reports of a decrease in cyanide concentration in positive samples, if the interval between death and the autopsy is too long. Indeed, the amount of cyanide found during analysis naturally depends on the amount taken and on the time between administration and death. Curry et al. reported that up to 70% of the cyanide content might be lost after some weeks on account of a reaction with tissue components and conversion to thiocyanate (10). Bogusz has reported a case of a patient whose blood sample, measured on arrival at the hospital, contained 13 mg/L of cyanide. Four hours after ingesting cyanide the patient died. The forensic toxicology tests performed two days postmortem revealed no cyanide in the blood, lungs, brain, liver, heart, or kidneys. Cyanide was, however, detected in the small intestine (47 mg/L) and in the colon (0.25 mg/L) (11).

The significance of the effects of heat on the blood cyanide concentration of fire victims has also to be considered. Moriya and Hashimoto have experimentally found that more than 40% and 100% of the original blood cyanide disappeared over 24 h and 3 days, respectively, in persons who died in fires and were left at temperatures of around +20°C. However, the blood cyanide level was found to be fairly stable when the bodies were stored at +4°C or when blood obtained from fire victims was preserved in glass vials at +4°C. The authors concluded that it was impossible to evaluate the toxic effects of cyanide on fire victims solely on the basis of its concentration in blood (12).

It is important to note that the forensic toxicological examination of organ samples taken from the two dogs found buried in the crater with Hitler's corpse also showed the presence of cyanide (2).

Why did the Soviet committee decide not to perform toxicological tests on samples taken from the bodies of Hitler and Braun or if they were performed not to mention them in their report?

Ada Petrova and Peter Watson offer one answer to these questions (4). In 1995 they reported for the first time an interview given by Dr. Nikolai Alexandrovich Krayevski to Lev Bezymenski prior to the publication of his book. According to this information, the main aim of the forensic pathologists was to identify the corpses and not to determine the cause of death. In Petrova and Watson's words (pages 117–118):

“‘Did you know whose corpses were being dissected?’ Bezymenski asked. Krayevski replied: ‘As far as the Goebbels family and General Krebs were concerned, yes. About the two other corpses there was no precise information, but there was talk that they were probably Hitler and Eva Braun. I repeat, it was mere conjecture’. This is an important exchange for it shows that the purpose of the autopsies in the case of Hitler and Braun was different from the others. In the case of the Goebbels family and Krebs (and the dogs, for that matter), the pathologists' main concern was the method [authors' note: cause] of death. In the case of the other two corpses, the priority was with identification” (4).

The Second Soviet Investigation (Operation “Myth File”)

In April–May 1946, a second Soviet commission, headed by the forensic pathologist Pyotr Semenovskiy, continued the investigation. He ordered that a map of the old and new Reichskanzlei and of the Bunker be made, that photographs be taken and that an inspection be carried out of the walls, floor and ceilings to search for traces of blood. He also ordered a thorough inspection of the furniture and of the place where the corpses had initially been found, as well as a search for personal belongings, in the hope of obtaining new forensic evidence about the identification of the corpses and the cause of death (the protocol was signed by Lieutenant-Colonel Klausen, deputy head of the operational department of the Chief Directorate of POWs and Internees of the USSR Ministry of Internal Affairs, Inspector in charge of Special Task, Military-Colonel Osipov and Semenovskiy) (4).

A document dated May 30, 1946 reported on a further excavation of the grave where the corpses of a man and a woman (Hitler and Braun) had originally been found: “At a depth of fifty to sixty cms, two fragments of a skull were found. In one of these fragments there is a bullet hole. The remnants of some cloth and the remnants of a shoe sole, a braided dog collar, and the bones of an unidentified small animal were also found, as were two gasoline canisters.” Later on, the report notes that the earth in the grave showed some staining, as if shrapnel had hit it. A document dated May 31, 1946 records the examination of the skull fragments:

“Earth is attached to the fragments. The back of the skull and the temple part show signs of fire; they are charred. These fragments belong to an adult. There is an outgoing bullet hole. The shot was fired either in the mouth or right temple at point blank range. The carbonization is the result of the fire effect, which badly damaged the corpse. Signed Pyotr Semenovskiy” (Page 85) (4).

Semenovskiy asked permission to carry out a new autopsy on the corpses because he hypothesized that Hitler had died from a

self-inflicted gunshot injury. After the autopsy in 1945 the corpses had in fact been buried again, but the jaws and teeth (a maxillary bridge of yellow metal, consisting of 9 teeth) had been taken to Moscow. When the Soviet military unit occupied the Buch clinic, the remains—not just of Hitler and Braun but of the Goebbels family, General Hans Krebs and the two dogs as well—had been disinterred a third time, moved to Finow, thirty miles from Berlin, and reburied there. Semenovskiy was, however, unable to verify his hypothesis because the Soviet military refused to release the body (3).

However, the results of the second inspection of the bunker, during which bloodstains were found on the arms of the sofa, on the upholstery and on the wall (a “spray” of blood), did not provide useful information. One of the bloodstains found in the bunker was of group A2. According to Petrova and Watson, Hitler was group A. They write:

“In Russia, traditionally the cipher system was used—that is, blood groups were typed 1, 2, 3, or 4. This was then placed by the letter system as used in the West—O, A, B, AB. Thus when the forensic experts wrote A2, they simply confirmed that the blood group was A” (Page 85). But although the bloodstains were tested “not once but twice—by Dr Rosanova—and in both cases found to be composed of human blood type A” (Page 98) (4), we have no definitive information about Hitler's or Braun's exact blood groups, or about those of the other persons who were present in the bunker.”

The eye-witness accounts reported by Trevor-Roper (by Hitler's valet, Heinz Linge, by Otto Günsche, his adjutant, Hans Baur, his personal pilot, Johann Rattenhuber, the Head Bodyguard, and Gerda Christian and Elsa Krueger, secretaries to Hitler and Bormann, respectively) (1) seem to agree with the presence of a gunshot wound in the skull fragment found by Semenovskiy.

The English Theory

In 1979, Hugh Thomas, an English surgeon, sifted thoroughly through the forensic evidence and suggested that Hitler was neither poisoned nor shot but died from strangulation. The Soviet autopsy report described the soft tissues on the neck as being charred (2). From this, Thomas concluded that the only possible cause of death was strangulation (3).

Thomas's suspicions were aroused by the fact that the damage described on the skull could have been produced only in temperatures over 1000°C—far greater than any that could have been produced in the open garden of the Reichskanzlei. Thomas stated that fragmentation of the skull was impossible and that the skull fragment must be from another corpse (3). In other words, the deaths of Hitler and Braun had been fabricated in a complicated forensic fraud, and the corpses found burnt outside the bunker were not those of the Führer and his wife.

In an effort to understand this hypothesis, it may be useful to examine reports on heat injuries in the forensic literature. Bohnert et al. showed that the lack of extremities (feet, hands) and the presence of cracks in the skull are frequent occurrences in buried corpses even after exposure to temperatures below 1000°C (13).

A useful means to investigate the influence of heat on the human skull is to observe the changes that occur during the process of cremation, which are described in chronological order by Bohnert et al. (13). The temperatures reached in crematory furnaces are similar to those reached in fires in houses (14,15) and in cars,

although in the latter case they may be higher, depending on the amount of fuel in the tank (13).

Bohnert et al. observed that the changes caused by fire followed certain patterns caused by the combination of the direct effect of heat on the skullcap and an increase in intracranial pressure. After 10 to 15 min, the coffin is sufficiently burnt for it to be possible to see that the corpse assumes the boxer's attitude (13). At this point the scalp has been consumed by fire and, in some cases, as also described by Spitz (15) it is possible to notice fissures on the tabula externa, mostly on the front of the skullcap, where the jet of the flame continuously acts on a limited area of the calvaria.

After 15 to 25 min, the initial fracture lines of the calvaria at the squama frontalis, or coronal or sagittal suture can be seen, regardless of the age of the deceased (13). However, Spitz noted that heat fractures do not generally involve the sutures of the skull, even in young people with open sutures:

“Heat fractures may cross a suture line, but it is unlikely that a suture will gape by steam pressure alone” (15).

After this, the inner table of the skullcap also starts to break. After 25 to 35 min, a fracture of the entire thickness of the calvaria was observed with simultaneous exudation of boiling liquid from the cranium. After 30 to 45 min, the calvaria disintegrated into fragments and the shrunken brain could be seen, while after 45 to 60 min, the base of the skull was exposed. Neither Bohnert et al. (13) nor Hofmann and Merkel, whom they cite (16,17), found a heat-related fracturing of the base of the skull in any of 20 cases observed.

Further information concerning the cracking of the skull due to fire comes from a study of its morphology and arrangement. Herrmann stated that cracks in the calvaria caused by heat are frequently elliptic/circular in shape, sometimes resembling “spider's web fractures,” albeit without the typical radiating fissures (18). In contrast, Spitz described the presence of arched fracture lines on both the calvaria and the long bones in the course of the cooling process after the bones had been exposed to high temperatures (15). These fractures are usually located on either side of the skull above the temples, sometimes bilaterally, with characteristic fracture lines radiating from a common centre.

Moritz, in a personal communication cited by Gordon and Shapiro (19), distinguished two types of thermal fracture of the skull. In one type, the fractures are the result of a rapid increase in intracranial pressure and the fragments are displaced outwards. In the other type, the fractures are caused by rapid desiccation of the bone and exclusively involve the tabula externa of the skull. In this case their lines are frequently stellate or elliptic/circular in shape.

In a case involving a car fire, Hausmann and Betz also described an ovoid heat-induced lesion in the human skull similar to that caused by a bullet but without any evidence of the well-known crater pattern at the point of penetration of the cranium, which was therefore classified as a postmortem artefact (20). Mason described similar findings as “hot-spots” (21). However, Hausmann and Betz were able to reconstruct the tabula externa in the region of the lesion and so distinguish the heat-related lesion from a firearm wound (20).

According to the above publications (13,14,15,20), the possibility that heat breaks the skull into fragments and that this may be difficult to distinguish from fragmentation produced by mechanical impacts cannot be completely excluded. Even gunshot injuries should be kept in mind. All these conditions weaken the theory advanced by Hugh Thomas, but the hypothesis of head lesions caused by a gunshot wound remains.

The German version of the report of the autopsy performed on Hitler's body (2) states that part of the occipital vault was missing. The English edition also mentions that

“Parts of the occipital bone, the left temporal bone, the lower cheekbones (sic!), the nasal bones, and the upper and lower jaws are preserved. The burns are more pronounced on the right side of the cranium than on the left. In the brain cavity parts of the fire-damaged brain and of the dura mater are visible” (2).

The original autopsy report does not describe the internal examination of the brain and makes no mention of any cerebral haemorrhage or a bullet track in the brain.

We have searched the literature available through several electronic databases for information concerning the possibility that the effects of heat could hide a cerebral haemorrhage but found no specific data on this aspect.

One Step Forward, Two Steps Back?

Finally, do the forensic data support the historically agreed conclusion that Adolf Hitler died after taking poison and then shooting himself? In our judgment, a complete evaluation of the forensic evidence and, consequently, the answer to this question call for at least one more forensic consideration.

With regard to the skull fragments, we know that in 1993 Sergej Minorenko, Chief of Soviet Archives, discovered a cardboard box in which were stored the fragments of a skull bone (4) but we do not know whether or not these were the same fragments that Semenovskiy examined. No further examination was made until 1995, when Ada Petrova and Peter Watson commissioned Professor Victor Zyagin of the Federal Centre of Medical Forensic Examination (the same institute as Pyotr Semenovskiy) to give an expert opinion (4). This was the first time when the fragments were mentioned since the Soviet forensic documents of 1946. Following the examination by Professor Zyagin, Petrova and Watson reported that

“the bones were the back of the parietal and part of the occipital bone; the hole is in the parietal area and the shot was made from below, maybe in the mouth, maybe in the chin (this solves one problem, which has confused many people – namely, how could Hitler have shot himself and bitten into the ampoule when he had a gun in his mouth?) The barrel of the Walther would surely impede any biting action? But by shooting himself through the underside of the chin, Hitler would have been able to place the ampoule in his mouth himself and then bite through the glass of the Zyankali capsule only moments before he squared the trigger. Whether or not it happened, it makes sense. The fragments are burned at the edges, the skull comes from an adult; the conclusion was based on an analysis of the sutures” (pages 126–127) (4).

All these data seem to match the autopsy reports in Lev Bezymenski's book (2), as cited earlier.

On April 26, 2000 in an exhibition entitled “The Agony of the Third Reich—Retribution” in Moscow, presumably the same bone fragments were displayed for the first time in public, together with a photograph of Hitler's jaw (22). No information regarding the samples after that exhibition is available. According to Petrova and Watson, until 1995 the skull bone fragments were on file with the State Archive of Russian Federation (4). The jaw samples taken from Hitler, however, are believed to be on file with the Archive

of the Federal Counter-Intelligence Service in Moscow (4). So, the chain of custody for the putative Hitler's specimens is not well provided as frequently happens with ancient remains. Nevertheless, it might be useful to re-examine the skull fragments, to study their integrity, to compare them with the data from the autopsy of 1945, and to obtain samples for mitochondrial DNA (mtDNA) analysis.

It has been demonstrated that mtDNA analysis can be performed successfully even on 12 000 years old human remains (23) and even on Neanderthal skeletons (24–25). Because of its unique maternal inheritance, mtDNA is also very useful in cases of forensic identification (26–27) and for determining maternal family relationships when a gap of several generations exists between an ancestor and the descendant (28).

Petrova and Watson reported that at least four children of Hitler's maternal cousin were still living in 1995 (4). On page 164 the authors mentioned that the daughter of Hitler's maternal aunt had four children, the last of whom was a boy, born in 1940. The gender of the other three is not indicated. So, it could be possible to compare the mtDNA types between the genetical material from the direct descendent of Hitler's mother's family and the skull fragments. In case the jaw samples taken at the Hitler's autopsy would also be available, it should be interesting to compare the genetical material from them and from the samples obtained from the relatives in order to strengthen the hypothesis that the autopsy was carried out for Hitler's body. Furthermore, this would offer an opportunity to study if the skull fragments and the jaw are from the same person. Unfortunately, other kinds of biological samples obviously do not exist because the bloodstains found in the Hitler's bunker during the second Soviet investigation, are no longer available. Moreover, Hitler's corpse was destroyed in 1970.

mtDNA analysis of the skull bone fragments and samples obtained from Hitler's maternal relatives could either exclude the possibility that the fragments were from Hitler's corpse or indicate that in all likelihood they were. If the mtDNA sequence of the skull bone samples is different from the maternal reference, then the samples cannot come from a maternal relative. The theoretical probability of exclusion is 100% but in actual practice the probability of exclusion is less than 100%, considering laboratory errors or contamination with extraneous DNA. That can lead to false exclusions (29). In the case of exclusion, there was no evidence for a gunshot wound on Hitler's skull. But in the event that the mtDNA sequences were identical, there are three possibilities: (1) the remains are indeed those of Hitler, (2) the remains are not from Hitler but from another maternal relative, or (3) the remains are from an unrelated individual with, by chance, the same mtDNA sequence of the maternal relative (29). Moreover, if a mtDNA match was found, and the existence of a gunshot wound could be morphologically established, the manner of death would still remain undetermined. But even if there is no resolution for the questions whether the gunshot wound was self-inflicted or whether the cyanide was swallowed first, we believe that the DNA analysis would provide more scientific reconstruction of the events surrounding Hitler's death.

We are conscious that investigation of old specimens presents extreme technical difficulties because of the very small amounts of and degraded nature of residue mtDNA and the wide risk of contamination (30–33). We are also aware that only few laboratories in the world could analyze biological samples adhering to the international recommendation for drawing meaningful conclusion in forensic and ancient mtDNA research (34–36). The importance of performing the analyses by two laboratories in parallel should also be emphasized. The control samples from the Hitler's relatives should be analyzed in a third independent laboratory. To date, protocols to determine the correct mtDNA sequence in foren-

sic and ancient samples have been published by several authors (30,34,35,37,38). Recently, the problem of "phantom mutation" suggesting phylogenetic analysis to detect errors in mtDNA data has been discussed (39–41). Moreover, we are not aware whether any forensic laboratory has already accepted the challenge of examining Hitler's remains, the permission to which, however, depends on the Russian authorities. We nonetheless believe that this forensic contribution, independently of the results, would be one step forward in understanding what happened in the Berlin bunker in the last week of April, 1945.

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References

1. Trevor-Roper H. The last days of Hitler. London: Macmillan, 1947.
2. Bezymenski L. The death of Adolf Hitler. Unknown documents from Soviet Archives. London: Michael Joseph, 1968.
3. Thomas H. The murder of Adolf Hitler: The truth about the bodies in the Berlin bunker. New York: St Martin's Press, 1995.
4. Petrova A, Watson P. The death of Hitler. The full story with new evidence from secret Russian archives. New York, London: W.W. Norton & Company, 1996.
5. Völklein U. Hitlers Tod. Die letzten Tage in Führerbunker. Göttingen: Stedl Verlag, 1998.
6. Trevor-Roper H. The last days of Hitler. London: Basingstoke, 1971.
7. Sognaes RF, Strøm F. The odontological identification of Adolf Hitler. Definitive documentation by X-rays, interrogations and autopsy findings. Acta Odont Scand 1973;31:43–69.
8. Keiser-Nielsen S, Strøm F. The odontological identification of Eva Brau Hitler. Forensic Sci Int 1983;21:59–64.
9. Knight B. Forensic pathology. London: Edward Arnold, 1992.
10. Curry AS, Price DE, Rutter ER. The production of cyanide in post mortem material. Acta Pharmacol Toxicol 1967;25:339–44.
11. Bogusz M. Disappearance of cyanide in blood and tissues after fatal poisoning. Forensic Sci 1976;7:173.
12. Moriya F, Hashimoto Y. Potential for error when assessing blood cyanide concentrations in fire victims. J Forensic Sci 2001;46:1421–5.
13. Bohnert M, Rost T, Faller-Marquardt M, Ropohl D, Pollak S. Fractures of the base of the skull in charred bodies—post-mortem heat injuries or signs of mechanical traumatization? Forensic Sci Int 1997;87:55–62.
14. Richards NF. Fire investigation—destruction of corpses. Med Sci Law 1977;17:79–82.
15. Spitz WU. Medicolegal investigation of death. 3rd ed. Springfield: Thomas, 1993;309–13.
16. Hofmann E. Lehrbuch der gerichtlichen Medicin. Vienna: Urban and Schwarzenberg, 1878.
17. Merkel H. Diagnostische Feststellungsmöglichkeiten bei verbrannten und verkohlten menschlichen Leichen. Dtsch Z Gerichtl Med 1932; 18:232–49.
18. Herrmann B. Neuere Ergebnisse zur Beurteilung menschlicher Brandknochen. Z Rechtsmed 1976;77:191–200.
19. Moritz AR. Personal communication. 1946. Cited in: Gordon I, Shapiro HA. Forensic Medicine. A guide to principles. Edinburg London and New York: Churchill Livingstone, 1975;117.
20. Hausmann R, Betz P. Thermally induced entrance wound-like defect of the skull. Forensic Sci Int 2002;128:159–61.
21. Mason JK. Heat and electricity. In: Mason JK, editor. Forensic medicine. London: Chapman & Hall, 1993;112–3.
22. Reynolds M. Moscow display on Hitler may end mystery. The Los Angeles Times 2000 Apr 28, p. 1.

23. Hagelberg E, Sykes B, Hedges R. Ancient bone amplified. *Nature* 1989;342:485.
24. Krings M, Stone A, Schmitz RW, Krainitzki H, Stoneking M, Pääbo S. Neanderthal DNA sequences and the origin of modern humans. *Cell* 1997;90:19–30.
25. Ovchinnikov IV, Götherström A, Romanova GP, Kharitonov VM, Liden K, Goodwin W. Molecular analysis of Neanderthal DNA from the northern Caucasus. *Nature* 2000;404:490–3.
26. Orrego C, King MC. Determination of familial relationships. In: Innis MA, Gelfand DH, Sninsky JJ, White TJ, editors. *PCR protocols*. London: Academic Press, 1990;416–26.
27. Sullivan KM, Hopgood R, Gill P. Identification of human remains by amplification and automated sequencing of mitochondrial DNA. *Int J Legal Med* 1992;105:83–6.
28. Jehaes E, Toprak K, Vanderheyden N, Pfeiffer H, Cassiman JJ, Brinkmann B et al. Pitfalls in the analysis of mitochondrial DNA from ancient specimens and the consequences for forensic DNA analysis: the historical case of the putative heart of Louis XVII. *Int J Legal Med* 2001;115:135–41.
29. Stone AC, Starrs JE, Stoneking M. Mitochondrial DNA analysis of the presumptive remains of Jesse James. *J Forensic Sci* 2001;46:173–6.
30. Cooper A, Poinar HN. Ancient DNA: do it right or not at all. *Science* 2000;289:1139.
31. Hofreiter M, Serre D, Poinar HN, Kuch M, Paabo S. Ancient DNA. *Nat Rev Genet* 2001;2:353–9.
32. Capelli C, Tschentscher F, Pascali VL. “Ancient” protocols for the crime scene? Similarities and differences between forensic genetics and ancient DNA analysis. *Forensic Sci Int* 2003;131:59–64.
33. Knight A, Zhivotovsky LA, Kass DH, Litwin DE, Green LD, White PS, et al. Molecular, forensic and haplotypic inconsistencies regarding the identity of the Ekaterinburg remains. *Ann Human Biol* 2004;31:129–38.
34. Wilson MR, Stoneking M, Holland MM, DiZinno JA, Budowle B. Guidelines for the use of mitochondrial DNA sequencing in forensic science. *Crime Lab Digest* 1993;20:68–77.
35. Wilson MR, DiZinno JA, Polanskey D, Replogle J, Budowle B. Validation of mitochondrial DNA sequencing for forensic casework analysis. *Int J Legal Med* 1995;108:68–74.
36. Bar W, Brinkmann B, Budowle B, Carracedo A, Gill P, Holland M et al. DNA Commission of the International Society for Forensic Genetics: guidelines for mitochondrial DNA typing. *Int J Legal Med* 2000;113:193–6.
37. Tully G, Barritt SM, Bender K, Brignon E, Capelli C, Dimo-Simonin N et al. Results of a collaborative study of the EDNAP group regarding mitochondrial DNA heteroplasmy and segregation in hair shafts. *Forensic Sci Int* 2004;140:1–11.
38. Parson W, Brandstatter A, Alonso A, Brandt N, Brinkmann B, Carracedo A et al. The EDNAP mitochondrial DNA population database (EMPOP) collaborative exercises: organisation, results and perspectives. *Forensic Sci Int* 2004;139:215–26.
39. Budowle B, Polanskey D, Allard MW, Chakraborty R. Addressing the use of phylogenetics for identification of sequences in error in the SWGDAM mitochondrial DNA database. *J Forensic Sci* 2004;49:1–6.
40. Bandelt HJ, Lahermo P, Richards M, Macaulay V. Detecting errors in mtDNA data by phylogenetic analysis. *Int J Legal Med* 2001;115:64–9.
41. Bandelt HJ, Quintana-Murci L, Salas A, Macaulay V. The fingerprint of phantom mutations in mitochondrial DNA data. *Am J Hum Genet* 2002;71:1150–60.

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