SPECIAL ARTICLE

AN INQUEST ON THE DEATH OF CHARLES FRANCIS HALL*

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Abstract On November 8, 1871, the American explorer Charles Francis Hall died in his cabin on the S.S. Polaris anchored to the shore of northwest Greenland. He had suffered from gastrointestinal and central-nervous-system symptoms that recurred over a two-week period until his death. He accused many of the ship's company of poisoning him.

In August, 1968, an autopsy was performed on the body at the Greenland burial site. Samples of hair, bone and fingernail were analyzed for arsenic by neutron-activation analysis, which showed markedly increased levels in the portion of the hair and fingernails grown during the last two weeks of Hall's life.

HISTORIANS of arctic exploration have often viewed the death of Charles Francis Hall with suspicion. When Hall died in November, 1871, he was in command of the United States North Pole Expedition (commonly known as the "Polaris Expedition"); his ship, the U.S.S. Polaris, lay wintered-in off the northwest coast of Greenland, only 500 miles from the North Pole. After establishing winter quarters, Hall had sledged northward on a strenuous 14-day reconnaissance mission. On his return he boarded the ship and drank a cup of coffee. Almost immediately he was taken ill and for two weeks thereafter was confined to his cabin, suffering severe stomach pains initially, probable paralysis of the left side and apparent dementia. Dr. Emil Bessels, the expedition naturalist who also served as surgeon, attributed Hall's illness to "apoplectical insult," but Hall himself frequently insisted that he was being poisoned, accusing Bessels and other expedition officers of the crime. He died on November 8 and was buried ashore two days later. Soon afterward his journals disappeared.

In 1966, while doing research for a biography of Hall, one of us (C.C.L.) examined a transcript of the Navy Department investigation of the Polaris Expedition.[1] The Board of Inquiry had concluded that Hall's death was natural, but the testimony of the Polaris officers and crew indicated that the situation aboard the ship made murder at least possible. There were serious animosities among the officers. The ship's captain, Sidney Budington, had told Hall that the expedition should retreat southward but Hall had over-ridden Budington's opinions. Both Budington and Dr. Bessels had openly questioned Hall's ability to command the expedition, and Bessels had treated Hall with considerable insolence. Considering the close and tense atmosphere of a wintered-in ship, it was believed that the circumstantial evidence and Hall's accusations justified an autopsy. Hall was buried so far north that the chances were good that his body would be well preserved.

In the autumn of 1967, permission was received from the Danish Ministry for Greenland to travel to Northwest Greenland and there to exhume and perform an autopsy on Hall's remains. In August, 1968, two of us (C.C.L. and F.K.P.) with two other men flew from Resolute Bay, N.W.T., to the burial site of Charles Francis Hall at what is now called Polaris Promontory. On August 8, 1968, Hall's remains were disinterred, and the autopsy was performed.

THE AUTOPSY

At the low cairn marked as Hall's grave by both a wooden and a bronze tablet, the silt and shale soil were dug away to a depth of some 1½ feet, where the white pine coffin lid was revealed. On digging into the soil beside the coffin, we found it to be encased in permafrost, which prevented its removal from the surrounding earth. The lid was pried off with only moderate difficulty. When the coffin was opened – and even before – there was an obvious unpleasant odor of decay, rather unexpected after so long an internment.

In the upper half of the coffin was seen the shape of a body wrapped in an American flag, the stars molded over the face. The other end of the coffin was filled with a sheet of opaque ice. With forceps the flag was gently – and without difficulty – peeled back from the head portion. The face was intact except that the eyes were empty sockets, and the tip of the nose was shrunken and darkly discolored. The head of the hair and beard was a rust brown. The skin appeared normal and of a fairly natural texture although somewhat tanned. The upper half of the body was dressed in a dark blue jacket and vest overlying light, white-cotton underwear. The lower half of the body was encased in ice.

The autopsy was performed with the prosector standing in the grave and straddling the open coffin. When a few scalp hairs were picked up with the

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forceps, a piece of the attached scalp broke off with the hair roots, and when a rather long fingernail was lifted, the whole fingertip broke off. Both hands were rather dry and shrunken, the back of the left hand being sufficiently so that the extensor finger tendons and the underlying small bones were partially visible. On peeling back the jacket, vest and underwear as far as possible, we found the skin of the chest to be white except centrally, where there was some blue staining, presumably from the suit dye. A Y-shaped incision was made through the superficial chest wall, but the skin could not be easily removed from the underlying rib cage. Where this was done, however, the underlying muscle tissue was found to be metamorphosed, perhaps by a combination of freezing and drying, to a slightly off-white and very friable material that shredded easily. Entry of the chest cavity was accomplished without great force.

The area normally occupied by the lungs was empty. Only the central part of the chest cavity, the area of the mediastinum, contained tissue, and this was of the same friable consistence as the chest muscle; it too was almost colorless. The thoracic tissues were quite amorphous, with only a suggestion of the whorls of heart muscle. The cartilaginous structures of the trachea and the start of the bronchial tree just past its first major subdivisions were intact and were stained a moderate dark brown. No other structures were identifiable.

Because of the rigid overlying folded arms, only the upper portion of the abdomen was visible and available as a source of entry. Like the chest cavity, this was almost empty. The intestines were represented by a thin, yellowish, parchment-like ribbon. The spaces normally occupied by the liver and pancreas were filled by a small amount of the same whitish structureless material present elsewhere.

The cranium was opened by removal of a roughly triangular section of the forehead with the use of a hand saw. The bone was of a normal, hard consistence and was cut with difficulty since the frozen pillow on which the head lay curled up over the temporal areas. When this piece of bone was removed, the cranial vault was found to be a dark void. Inside, only at the very base of the skull in the neighborhood of the major skull opening, the foramen magnum, was found a small amount of amorphous tissue.

Small portions of all the above material were put into plastic bottles containing formalin, acetone, glycerol and glyceraldehyde. In addition the hair, nail and fingertip and two pieces of the mediastinal tissue were put into a dry plastic bottle. The triangular skull section was encased in plastic wrapping. All this material, in a small heavy-metal tool box, was delivered to the Pathology Laboratory of the Berkshire Medical Center, Pittsfield, Massachusetts, 12 days after the autopsy was done – and almost a century after Hall's death. Here, histologic examination of the body tissues showed nothing but completely amorphous eosinophilic material. A small piece of temporal muscle, however, which had maintained its identity, contained a larval form that was identified as that of an Arctic earthworm.

Neutron-Activation Analysis

Preliminary tests for arsenic performed on the piece of frontal bone by Dr. Arthur J. McBay, of the Massachusetts Department of Public Safety Laboratory, revealed a frankly increased level of arsenic (2 ppm). Therefore, the fingernail, bone, some hair and a sample of soil from the burial site were submitted to the Centre of Forensic Sciences in Toronto for a more detailed analysis for arsenic by one of us (A.K.P.).

The hair and nail samples were cut into small sections and were subjected to neutron activation in the McMaster University nuclear reactor, together with two chips of bone, two samples of soil, a sample of shorter, unsectioned hair and a weighed amount of pure arsenic standard. The gamma activities subsequently produced were measured by means of a 30-ml Ge (Li) detector. The arsenic photopeak contribution to the resulting gamma-ray spectra was measured, and the original amounts of arsenic in the samples were calculated by comparison with the standard reference arsenic photopeak.[2,3]

The arsenic contents of the soil samples were 21.8 and 22.0 μg per gram, the bone chips contained 10.3 and 11.7 μg per gram of arsenic, and the unsectioned hair sample exhibited an average arsenic concentration of 15.3 μg per gram along its entire length. The concentrations of arsenic in the sectioned hair samples are shown in Table 1.

TABLE 1. *Arsenic Content of Hair Samples.*

PORTION	SIZE (MM)	ARSENIC CONTENT (μG/GM)
Root	2.5	29.4
Next	2.5	21.8
3d	2.5	18.2
4th	2.5	12.4
Next	5.0	10.4
Tip	5.0	10.6

The arsenic profile of the fingernail had the values shown in Table 2.

The next 7.0 mm of the nail were not analyzed.

TABLE 2. *Arsenic Concentration of the Fingernail.*

PORTION	SIZE (MM)	ARSENIC CONCENTRATION (μG/GM)
Root	0.5	76.7
Next	0.5	53.0
3d	0.5	45.4
4th	0.5	32.8
Next	1.0	28.8
Next	1.0	30.8
Next	1.0	20.9
Next	1.0	25.4
Next	1.0	21.5
Next	1.0	20.7

The tip 1.0 mm was analyzed and indicated the presence of 24.6 μg per gram of arsenic.

Assuming average growth rates of 0.4 mm per day for the hair and 0.1 mm per day for the fingernail, these results show that elevated amounts of arsenic had been deposited in the hair and nails grown during the last two to five weeks of Hall's life, with the highest amounts being incorporated into the hair and nails within one week of his death.

A diffusion of arsenic from the roots toward the tips of the hair and nails over a period of 97 years is possible; therefore, the apparent presence of abnormal amounts of arsenic in hair and nail grown before the last two weeks of Hall's life does not necessarily indicate that uptake of some of the poison had occurred more than two weeks before death.

Hall's symptoms were quite in keeping with acute arsenic poisoning.[4,5] On the assumption that arsenic was contained in the cup of coffee that he received on boarding his vessel, the gastrointestinal symptoms (never fully described) could occur very rapidly. The subsequent central-nervous-system symptoms and dementia have been noted in this condition. The exact descriptions of his symptoms, however, vary somewhat from witness to witness since they were not recorded until more than a year after the event.

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MEDICAL PROGRESS

TRANSPLANTATION (First of Three Parts)*

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FROM the clinician's practical point of view the wider application of transplantation as a remedy for disease is being restrained by a number of factors. The available supply of organs in an acceptable physiologic state falls short of the demand. The facilities and financing that would allow maintenance of patients in need of organ transplants, particularly kidneys, are still inadequate and poorly coordinated. But the central obstacle is the rejection reaction, which remains an incompletely solved problem. Nevertheless, it is clear that organ transplants can attain productive life for patients previously near death. An operational solution to the problems of transplantation has already been achieved for many recipients of kidney transplants in that hundreds of patients dying of renal failure, many of them young people in the second and third decades of life, have already been restored to full health for extended periods. The situation with transplantation of other organs – for example, the heart and liver – is less clear.

This report is confined to a discussion of advances since 1964[1] that are particularly relevant to the rejection reaction and may provide useful predictors of future success.

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The Rejection Reaction

The obvious presence of leukocytes about the foreign cells of a transplant originally drew attention to them as possible vectors of the body's response to allografts. Later, the parallel between graft rejection and "delayed hypersensitivity" reactions of the tuberculin type became more evident as it was found that specific sensitivity to a given donor could be transferred to a third party by means of leukocytes but not by serum.[1] No longer does this once clear distinction hold. For example, sensitivity to transplants can be readily transferred in human beings with a subcellular fraction ("transfer factor") derived from leukocytes that has a molecular weight of about 10,000[2] (as discussed below). The involvement of humoral antibody in certain phases of graft rejection has become increasingly plain from several lines of evidence. Thus, a separation of cellular and humoral responses is artificial but will be made as a matter of convenience in the following discussion.

Cellular Responsiveness

Information regarding cellular immunologic responses can be found in recent symposia and reviews.[3-6] We now know that the body's army of immunologically competent cells includes a variety of different histologic types and potentialities.

The "small lymphocyte" appears to be the progenitor of all immunologic responses. Some responses are expressed through circulating antibodies