The Mummies from Qilakitsoq – Paleopathological Aspects

J. P. HART HANSEN

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The preservation of the eight Eskimo bodies found near Qilakitsosq, dating from around A.D. 1475, is due to mummification. The bodies, their garments and their loose belongings desiccated by a combination of dry air and low temperatures.

The scope of the anthropological, medical and odontological investigations was restricted because the four best-preserved bodies were conserved with the garments *in situ*. Thus, more extensive examination could not be carried out and only noninvasive methods such as X-ray examination were permissible. The remaining four bodies were partly decayed. Only in a single body could internal organs be identified. In this 18–22-year-old woman severe anthracosis was found.

Immunological investigations employing the Western blot technique and immunohistochemistry were negative. Bacteriological investigations showed the presence of *Clostridium perfringens* in an abdominal cavity as the only potentially pathogenic bacteria in the mummies. Most probably the find was made by chance.

It was not possible to establish either the cause or the manner of death for several of the mummies. There are indications that the smallest child, mummy 1, was buried alive, which was not unusual in ancient Greenland when a mother died leaving an infant child. The four-year-old boy, mummy 2, suffered from Down's syndrome and Legg-Calvés-Perthes' disease and thus had a lowered resistance to infections and other disorders. Mummy 8 probably died of a nasopharyngeal carcinoma. In the other mummies the cause of death has not been established with any certainty. Infectious diseases, starvation, hypothermia, drowning, and poisoning have been mentioned in this connection.

Nor was it possible to decide with any certainty if all or any of the bodies had been buried simultaneously or at intervals of decades. Indications of several burials were found in both graves. Only in one case could the time of death (July/August) be established with some certainty.

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Mummified ancient bodies from the Arctic are few. It might be expected that the dry, cold arctic climate would enhance natural mummification, but so far relatively few bodies have been discovered. The special conditions of the circumpolar regions will often make safe burial impossible and the body will disappear because of exposure to the weather and animals.

Naturally mummified Eskimo bodies have, however, been discovered before in Alaska. Thus, a frozen female body dating from about A.D. 400 was found on a beach on St. Lawrence Island in 1970. The body had most probably been washed out of the bankside because of erosion. It was extremely well preserved and examination revealed that she must have succumbed to suffocation after being trapped in a landslide or earthquake (Zimmerman & Smith 1975; Masters & Zimmerman 1978).

Another extraordinaty find was made in Barrow, Alaska, in 1982 when two Eskimo bodies and three skeletons dating from A.D. 1510 (+/÷ 70 years) were discovered. They had been crushed and killed in a winter house by overriding sea ice, and the bodies were frozen. An excellent interdisciplinary investigation was carried out (Newell 1984; Zimmerman & Aufderheide 1984).

In Western Greenland graves with mummified bodies have been encountered from time to time. They all seem to date from a later period than the Qilakitsoq mummies. No radiocarbon dating has been performed. The graves most probably date from the period from the sixteenth century up to the introduction of the Christian burial custom some time in the eighteenth century (Meldgaard 1984).

Two important finds of mummified bodies have been made in rock caves in South Greenland. Inhabitants on the island of Uunartoq north of Nanortalik knew of caves containing many dead bodies (Bak 1971). Local legends say that the bodies were of Eskimos who were not able to flee the settlement of Qerrortut when Norsemen planned to attack at some time in the fourteenth or fifteenth century. They hid in the caves close to the settlement and starved to death. An American anthropologist, Martin Luther, visited the area in 1930 on a study tour financed by the the Association of American Meat-Packers. Luther obtained permission from Copenhagen to open ancient graves and bring back a few skeletons to Harvard University, but he discovered the caves at Uunartoq and removed about fifteen mummified bodies (Hooton 1930). A few af these mummies are still preserved in the Peabody Museum at Harvard University in Boston, U.S.A.

In 1934 the Danish archaeologist Therkel Mathiassen visited the site and found the disturbed remains of stone graves in the caves. Only one grave was found intact. It held three infants, all a few months old (Mathiassen 1936).

Mummified bodies have also been found beneath the Pisissarfik mountain at the settlement of Iffiartarfik in the Kapisillit Fjord in the Nuuk/Godthåb district. In this area Norse and ancient Eskimo ruins have been found. Many graves lie on the mountainside among fallen boulders, and they were investigated in 1945 and 1952 (Meldgaard 1953). The bodies of three adults and seven infants and children were found with well-preserved clothing and garments. The bodies were also well preserved. The find has not been radiocarbon dated but is most probably from the sixteenth or seventeenth century (Meldgaard 1984). An interdisciplinary research project on this find is in preparation.

Artificial mummies are not known from Greenland or other parts of the Eastern Arctic. Artificial mummification has been practiced throughout the world in various periods (Cockburn & Cockburn 1980). As early as 4000 B.C. the Egyptians embalmed their dead. Artificial mummification is also know from Australia, China, South America and North America. It was practiced by the inhabitants along the west coast of Alaska and the Aleutian Islands. A few artificially mummified bodies from the Aleutian Islands have been subjected to investigations (Zimmerman *et al.* 1971; Zimmerman *et al.* 1981). The purpose of artificial mummification was to achieve immortality. It is likely that naturally mummified bodies provided the model.

Mummification

The preservation of the bodies, their clothing and their belongings in the two graves at Qilakitsoq is a result of the particular local conditions. The deceased humans as well as their belongings were desiccated; they were mummified by a combination of low temperature and dry air.

The annual mean temperature at the site is well below freezing point. The climate is arctic. The fluctuations may, however, be considerable with temperatures below −40° C in the winter and up to +15° C in the summer. The temperature in the graves, however, can hardly ever have reached more than +5° C. The graves faced north and the overhanging rock protected the capstones on the graves from direct sunlight. Probably there were no more than a few hours each year of direct sunshine on the stones.

The projecting rock also sheltered the graves from direct snow and rain so that only minimal amounts of water came into contact with the bodies. Any water and moisture was drained off through the stones at the bottom of the graves. In addition air could pass between the stones around the bodies thus enhancing evaporation and the desiccation process. The air in the area is very dry with low humidity.

This is a process of natural mummification which has taken place, stopping normal post-mortem decomposition. Immediately after death, when the cessation of breathing and circulation stops the nourishment of the organs and tissues, the processes of decomposition start (Camps *et al.* 1976). Factors such as low temperature and desiccation can stop or delay these processes, which otherwise gradually lead to the disappearance of the soft tissues of the body. A deceased adult buried in well-drained soil in Denmark, for example, normally becomes a skeleton in about ten years; for a child, it takes about half the time. Some parts of the body are particularly resistant to decomposition, i.e. the bones, teeth, cartilage, hair, nails, and crystalline lenses.

The processes of decomposition are complicated. Decomposition is primarily real putrefaction with decomposition of organic material due to bacterial activity. Bacteria from the intestines and the respiratory passages spread through the dead body, first along the circulatory system. Blood is an excellent nutritive medium for bacteria. Later, bacteria from the environment and soil may join in. Decomposition is also due to autolysis, caused by the enzymes of the dead body. These are bound to the cells during life but escape after death.

The decomposition of a dead body can take different periods of time. Temperature is a very significant factor. Thus, a dead body decomposes rapidly when the temperature of the environment is high, as in the Tropics, or when the deceased has had fever. Low temperatures delay or completely stop decomposition, which is minimal at temperatures below +4° C. It is the complicated chemical processes of decomposition which are slowed down or stopped by low temperatures.

Water is necessary for the processes. The growth of bacteria and to a lesser degree of fungal organisms depends upon the presence of water. As water freezes into ice crystals it is not available for the processes. If water disappears because of freezing or desiccation bacterial growth and thus putrification are hindered. Alternating periods of freezing and thawing have a particularly desiccating effect. The cell membranes are destroyed so that the water of the cell is released and can evaporate.

Mummification by desiccation is not characteristic of cold regions alone. In fact, the drying process is rather favoured by high temperatures, dry air, and draughts which enhance evaporation. Mummification is normally rare in temperate climates. It may, however, be encountered in certain parts of the body such as the hands, which have a relatively large surface and therefore dry easily. Finds of mummified infants are also known. These infants may have been born clandestinely, done away with, and hidden in a warm, dry attic. In warm and dry desert regions it is not unusual to find mummified bodies in the sand, sometimes more than one thousand years old (e.g. in Nubia). These desert people have died in the open and rapidly dried up because of the high temperature and low humidity of the air. These bodies are preserved for an unlimited length of time.

The bodies

A detailed description of the eight mummified bodies can be pieced together from the papers in this volume, particularly the papers on the anthropological (Balslev Jørgensen 1989), radiological (Eiken 1989), dermatological (Kromann *et al.* 1989) and odontological (Pedersen & Jakobsen 1989) investigations.

The scope of the investigations was, however, restricted because the four best preserved bodies (mummies nos. 1, 3, 4 and 6) were restored with the garments *in situ* so they could be exhibited in the Greenland Museum in the capital Nuuk/Godthåb. This meant that only non-invasive methods could be employed in the investigation of these bodies. Hairs from the heads were sampled and small specimens of mummified tissue and bone were, however, removed for various analyses through a small opening made in the garments in the back in all of them, except mummmy 1 (the six-month-old child).

Due the extreme degree of preservation and its small size, this mummy was left untouched. It was decided that more extensive investigations than X-rays might damage the body without any change of giving new information. Hence, the sex of the child was not determined. Small details in the making of the hood of the skin jacket indicate, however, that the child was a boy (Rosing 1979).

The four remaining mummies (Nos. 2, 5, 7 and 8) were accessible for more thorough investigations after their garments had been removed for conservation. None of these bodies were suitable for exhibition because of extensive decay and destruction. The soft tissues of the bodies had disappeared in some places and some were partly skeletonized. From all of the bodies material could be sampled for investigations.

Only in mummy 7 could internal organs be identified.

Figure 1. Mummy 1. The beautifully preserved body of a six-month-old child. Photo: John Lee, National Museum, Copenhagen.

In the other three bodies the mummified internal structures appeared as uncharacteristic brittle material. In mummy 7 the thoracic wall and part of the abdominal wall had to be removed with an electric saw because of the very hard consistency of the mummified tissue. In the thoracic cavity the desiccated heart and two shrunken lungs could immediately be identified. In the abdominal cavity part of the transverse and descending colon could be seen on the front side of the spine. On the left side a small structure was registered at the normal position of the spleen and on the right side a small shrunken liver below the diaphragm with a small structure looking like the gall bladder. White mould was encountered on all internal as well as external surfaces (Svejgaard *et al.* 1989). Eight mummified flies were also found, some of them embedded in mould. They were determined to be representatives of *Trichocera sp.* and *Neoleria prominens* (Lyneborg 1984).

Figure 2. Mummy 1. Photo: John Lee, National Museum, Copenhagen.

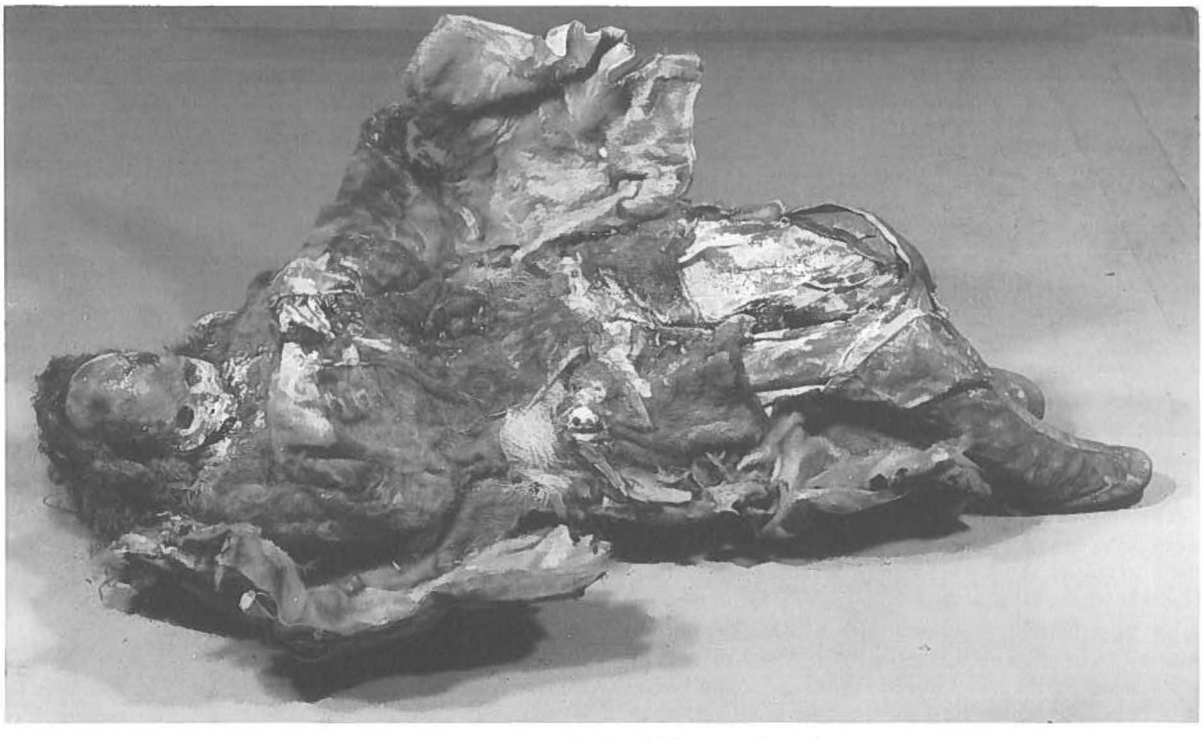

Figure 3. Mummy 3 before conservation. Photo: John Lee, National Museum, Copenhagen.

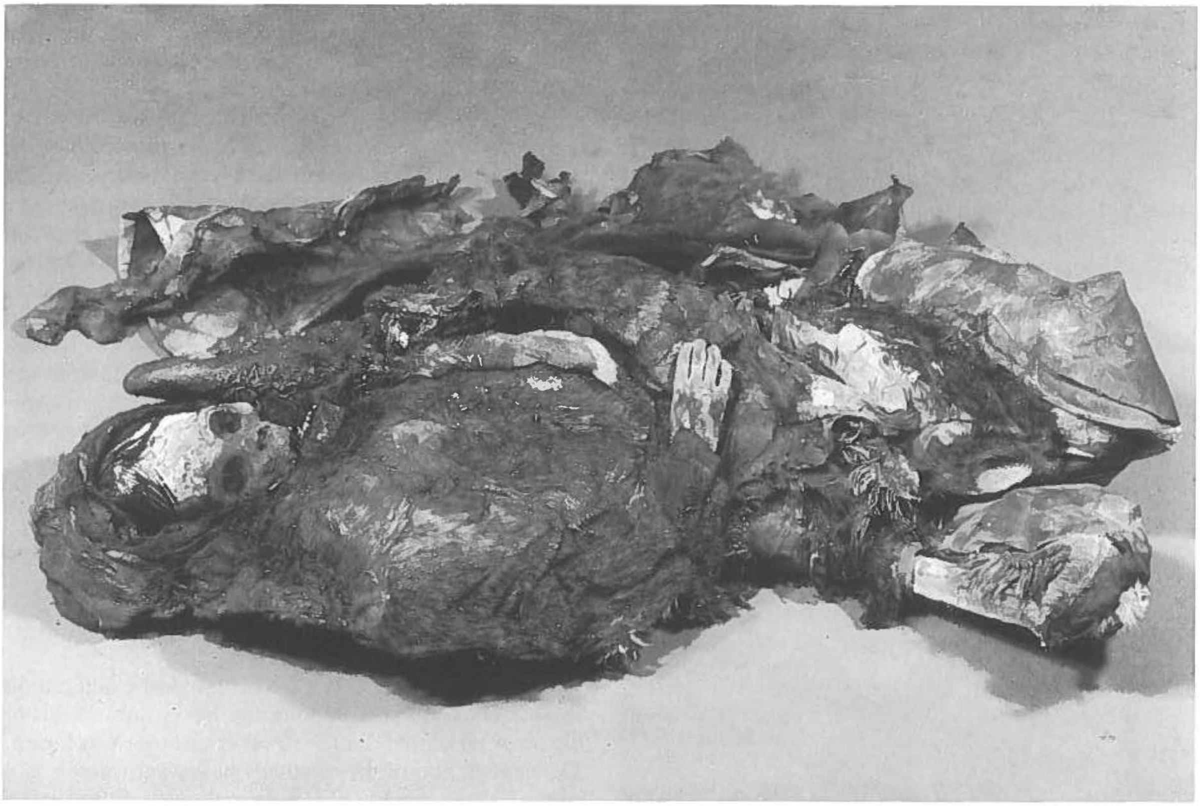

Figure 4. Mummy 7, a young woman of 18 – 22. This body was poorly preserved in comparison with the other mummies. Photo: John Lee, National Museum, Copenhagen.

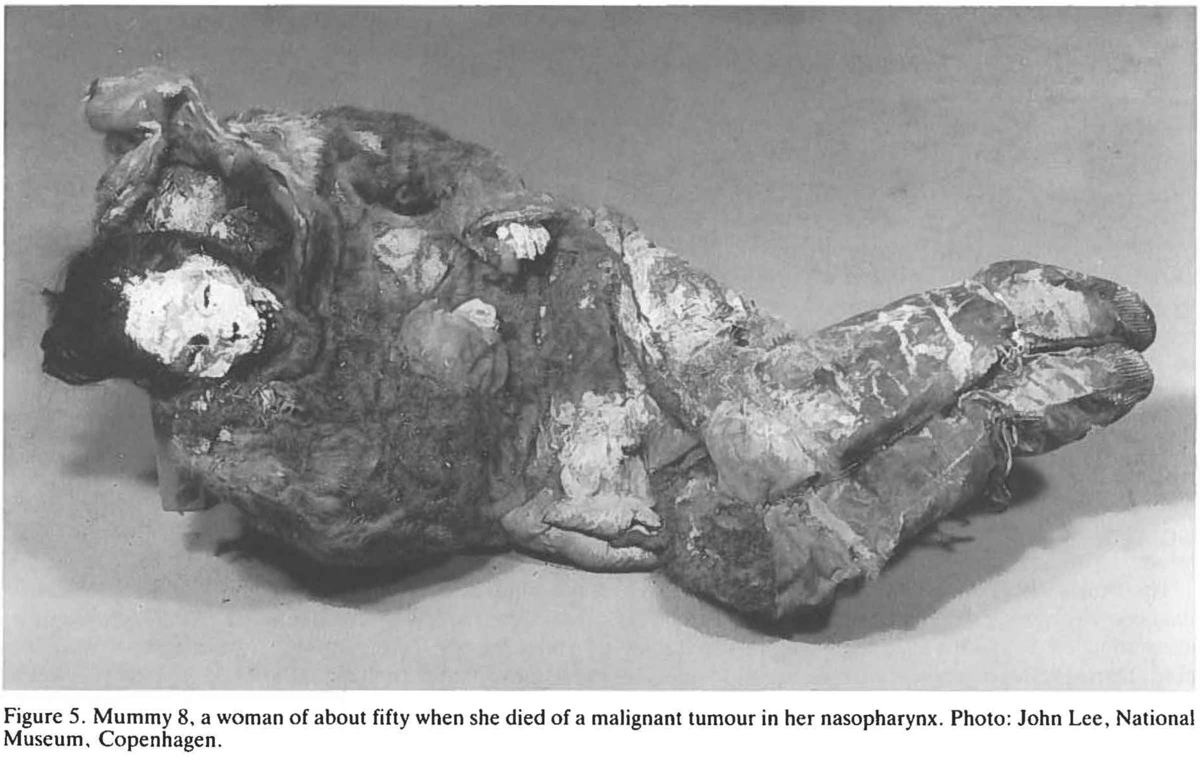

Figure 5. Mummy 8, a woman of about fifty when she died of a malignant tumour in her nasopharynx. Photo: John Lee, National Museum, Copenhagen.

Figure 6. The mummified right lung from mummy 7 after being removed from the thoracic cavity. Photo: Gentofte Hospital.

The two lungs and the heart could easily be removed from the thoracic cavity. It was not possible, however, to remove the abdominal content without using a saw. The abdominal cavity was therefor rehydrated using the original solution of Ruffer according to Zimmerman *et al.* 1971. This procedure made the organs soft and easily removable.

The isolated liver measured 22 × 17 × 2,5 cm. The surface and the cut internal surfaces were without macroscopical changes. The gall bladder was well defined with a wall measuring few mm. The gall bladder itself measured 4 × 2 × 2 cm. No concrements were encountered.

The transverse colon was easy to identify with both flexures. Fat was seen in the retroperitoneal space. The descending colon and the sigmoideum were also discovered. During the removal several faecal lumps appeared with discernible hairs (Lorentzen & Rørdam 1989; Fredskild 1989). After the removal of the colon the small intestine could be identified. The wall was as thin as paper. No content was encountered. The ventricle could be identified too, with a paper thin wall without mucosal relief or any content.

The lungs and the heart were placed in the rehydrating solution of Ruffer. After 24 hours the consistency had changed. The tissues were now soft and permitted the use of knife and scissors without doing any damage to the structures. The rehydrating fluid was strongly dark-brown coloured. After rehydration the heart measured 10 × 7.5 × 2 cm. The pericardium was normal. It was possible to inspect the cavities and valves of the heart and no abnormalities could be registered. In particular, no atherosclerotic changes could be seen in the ascending part of the aorta. The openings of the coronary arteries were easy to locate. Other internal organs could not be identified, neither kidneys, other urinary or sexual organs.

Histological investigations

Tissue samples were taken for histological examination (Myhre *et al.* 1989). Beside rather heavy anthracosis of the lungs no sign of disease or other disorder was found. The explanation of the relatively heavy anthracosis in a young woman aged 18–22 living in the unpolluted arctic air is the fact that it was the duty of the Eskimo woman to tend the lamps and cooking fires (Kleivan 1984). In so doing she inhaled particles of soot. There were no signs of tuberculosis, a disease which in recent generations has ravaged the Greenlandic population (Stein *et al.* 1968).

Immunological investigations

Even if HLA-typing of the mummies turned out to be successful (Hansen 1989) it was not possible to demonstrate antibodies in eluant from mummy skin and muscle tissue using Western blot technique (Shand & Høiby 1987). This was in agreement with the findings of immunohistochemical investigations, which were negative after application of a wide range of stained antibodies to sections of paraffin-embedded tissue.

The following antibodies were applied (Pallesen 1987). The relevant antigen is mentioned in brackets: UCHL-1 (T-cell antigen), LN 3 (HLA-DR antigen), MAC387 (macrophage antigen), Muramidase (polyclonal antibody), Alpha-1-anti-chymotrypsin (polyclonal antibody), CAM5.2 (cytokeratin), AE1 (cytokeratin), Anti-vementin (vementin), Anti-desmin (desmin), Anti-myoglobin (polyclonal antibody), E29 (epithelial membrane antigen), Anti-S-100 protein (polyclonal antibody), and F8/86/3 (factor 8-related antigen).

Figure 7. Section from the root of a lung showing cartilage from the air passages, collapsed alveoli and heavy deposits of inhaled soot (anthracosis). Periodic acid-Schiff (PAS). x 25. Photo: Gentofte Hospital.

Bacteriological investigations

These investigations were carried out by Sebbesen & Thomsen 1984. Material was secured from most of the bodies (skin, heart, lungs, liver, ileum, and colon). Tissue samples measuring approximately 2 × 2 ×2 cm were isolated after impressions had been made of the surface with Rodac plates (5 per cent blood agar). Part of the tissue specimens was homogenized with sterile sand and mortar and suspended in serum broth. It was not possible to sterilize the surface of the tissue samples before homogenization without damaging possible viable germs in the tissue.

For cultivation of the serum broths a semiquantitative technique was used, and the serum broth dilutions were spread on agar plates and 5 per cent blood agar plates for aerobic cultivation. For anaerobic cultivation serum broth dilutions were spread on chocolate agar plates.

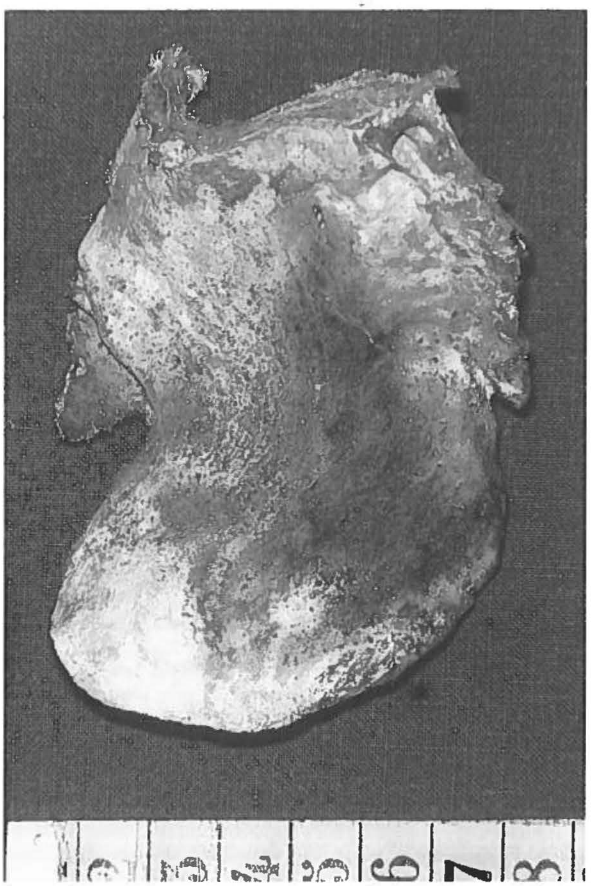

Figure 8. The mummified heart from mummy 7. Both auricles can be seen. Examination after rehydration showed normal conditions. Photo: Gentofte Hospital.

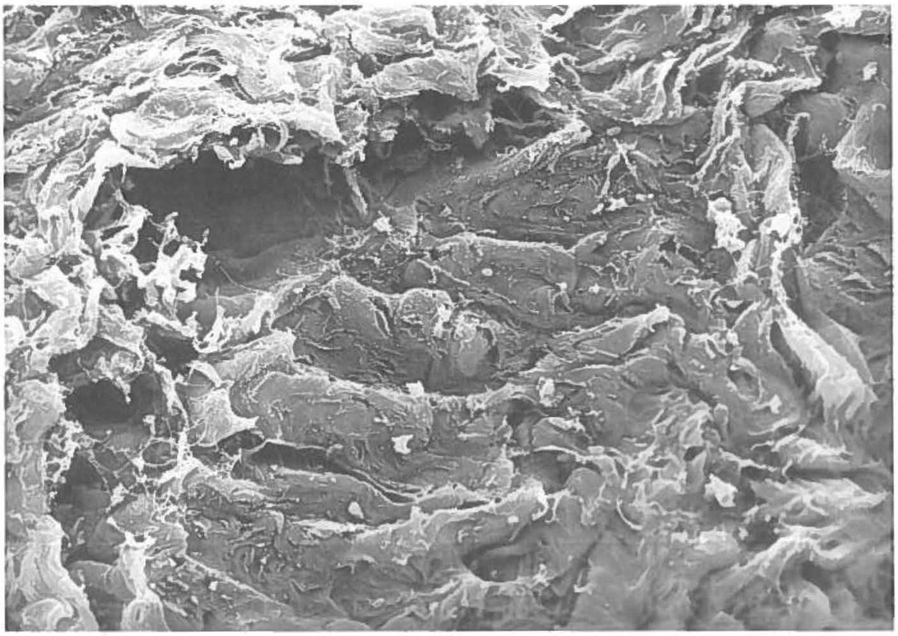

Figure 9. Scanning electron micrograph of the aorta seen from the lumen. The smooth lining of flat cells (endothelium) which in vivo lines the inside of the artery have disappeared and bared the deeper structures of the vessel wall, mainly collagen and elastic fibrils. Magnification 2.000 x. The examination and photo by Bo Hainau, MD, Herlev Hospital, Copenhagen.

Aerobic cultivation was done at 22° C in normal atmosphere and 37° C in 10 per cent carbon dioxide atmosphere. Anaerobic cultivation was done at 37° C in anaerobic jars containing an atmosphere of 70 per cent nitrogen, 20 per cent hydrogen and 10 per cent carbon dioxide. Examination of the plates was carried out after 48 hours and the plates were observed for a period of fourteen days. The morphology of the colonies was described, the bacteria were examined by Gram staining, and movement, spores and suspected pathogenic bacteria were identified.

The results were that up to ten different bacteria were cultured in some of the samples, all of them gram-positive and not different from those found in common soil. Most of the bacteria were found on the surface as well as in the tissue, indicating contamination from the

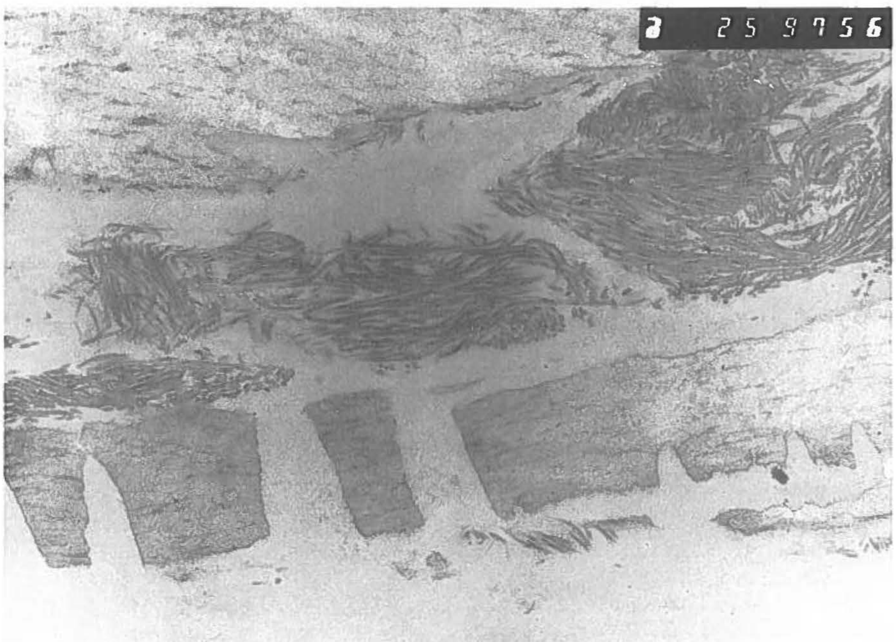

Figure 10. Transmission electron micrograph of the aorta. The slender cross-striated fibrils are collagen. The thick fibre exhibits the striation parallel to the long axis which is typical of elastin. The sequestration of the fibre is probably due to the process of mummification. Magnification 25,000 x. The examination and photo by Bo Hainau, MD, Herlev Hospital, Copenhagen.

Figure 11. Skin specimen with tattooing. The epidermis has disappeared. In the dermis deposits of black soot can be seen. The tatooings of the Qilakitsoq mummies were made by the so-called sewing technique. A thread made of caribou sinew was blackened with soot. With a needle the thread was drawn beneath the skin through dermis. The tattooer pressed the thumb on the spot to press in the pigment. Periodic acid-Schiff (PAS). x 100. Photo: Gentofte Hospital.

surroundings. In tissue taken from the pelvic cavity growth of *Clostridium perfringens* was found. This bacterium was not found on the surface.

In conclusion, *Clostridium perfringens* was the only potential pathogenic bacterium found. *Clostridium perfringens* is commonly found today in faeces from humans and animals and in soil contaminated with faeces. In poorly oxygenated tissue these bacteria can cause gas gangrene, which in former times was fatal. The importance of this finding is difficult to evaluate. Most probably, it was a chance finding. Gas gangrene does not seem to have been recorded in Greenland in historic times.

Cause of death

It has not been possible to establish either the cause or the manner of death for several of the mummies. This is partly because thorough internal investigation was not permissible in the cases of the best preserved mummies, which had to be fit for museum exhibition. These bodies would have provided the best possibilities for identification of structures and possible pathological changes.

In some of the cases there are, however, firm indications of the cause of death. In other cases it is only possible to conjecture. Many likely causes could not be put to the test because access to internal examination was limited. In some cases the organs were poorly preserved. When considering the possible causes of death, one must keep in mind that the individuals may have died on the same occasion from the same cause, or at different times for different reasons, perhaps at intervals of several years.

Mummy 1, the smallest child, showed no sign of disease or trauma under external examination and X-ray. The child may have been killed by being buried alive with its deceased mother (Meldgaard 1953). This procedure was in fact not unusual in ancient Greenland. In the small, isolated arctic communities it was not always possible to save a child whose mother had died. Instead of letting the child die gradually of hunger because no other woman could be found to nurse it, the father would kill the child. Often it was suffocated and buried with the mother so they could travel together to the Land of the Dead. In other cases the child was buried alive with the dead mother.

In the present case the child was found on top of the other four bodies in grave I. The lower four bodies were completely covered by hides and the child was placed upon these without any covering itself. This indicates that the child was placed into the grave as the last act before the grave was covered with stones.

In *mummy 2*, a boy of about four, the roentgenological examination offers certain indications of the cause of death (Eiken 1989). Most probably this child suffered from Legg-Calvés-Perthes' disease, which must have caused pain and difficulty in walking normally. Moreover, the shape of the pelvis indicates that the child suffered from Down's syndrome. This syndrome is well known also in Eskimos. Most probably the boy had great need for support and was only able to limp or perhaps just crawl around. His mental development was probably poor in relation to his age. Rarefaction of his bones indicates that he was disabled and probably immobilized for some time. Surprisingly, however, the boots of the boy showed that they were normally worn. The soles were even repaired below the heels. This seems to contradict the above. But explanation may be that the child was given the boots of another child after death. This supposition is supported by the fact that the right and left boot were on the wrong feet. No signs of rickets were found.

A disabled child like this boy must have had great difficulty surviving in ancient Greenland. Resistance to contagious diseases and hunger will have been poor. Children suffering from Down's syndrome also have a higher death rate than normal children as a result of congenital heart diseases and blood cancer. No internal malformations or diseases could be discovered in the boy. The poor state of preservation of the body has, however, limited the extent of the investigations.

It is also well known that in ancient Greenland children and also adult invalids were sometimes killed, either violently by strangulation or drowning, or by exposure, given the limited resources of the small communities (Mylius-Erichsen 1905, Hansêraq 1933). However, it was not possible to find any sign of strangulation or other violence in the boy, and death from exposure, cold or thirst cannot be proven. Thus, the boy may have died a natural death as a result of congenital or acquired disease and general low resistance. It can not, however, be ruled out that he was killed in one or another way.

The custom of killing disabled and sick persons when provisions and resources were low was not regarded as evil but rather as an act of compassion. This is analogous to the behaviour of many old and disabled persons who left their homes and settlements on their own initiative and sought death in order not to be a burden to their families, particularly during periods of hunger (Egede 1939).

The findings made during examination of *mummy 3* included a kidney stone (Hueg 1983) and a bone fragment from the temporal bone of either a seal or a polar bear (Møhl 1983), probably located in the gastrointestinal canal (duodenum). The kidney stone may have caused a malfunction of the kidney. The bone fragment must have been taken in with the food and was following the natural route through the body when death occured. However, it is not possible to exclude the possibility that the fragment may have torn a hole somewhere in the gastrointestinal canal or caused volvulus by lodging in the intestinal passage. Both are possible causes of death.

Mummy 4 had a distended abdomen. This immediately gave rise to speculations that she was pregnant at the time of death. Roentgenological examination however ruled out this possibility. The distension of the abdomen was most likely caused by post-mortem intestinal gas production. An ovarial cyst is however a possibility, though such a cyst very rarely causes death.

In *mummy 5* the hair of the scalp was sparse, resembling the physiological type of baldness in men (Kromann et al. 1989). Baldness is infrequently seen in females, and physiological baldness is rare in Inuit, even in men. The baldness may have been caused by a virilizing tumour of the ovary, and the possibility cannot altogether be excluded that such a tumour may have been of some importance for the occurence of death. Small areas of baldness can be seen in Inuit women in the temples, caused by the widespread habit of arranging the hair with a very tightly knotted top. This type of baldness has been given the name *alopecia arctica s. Groenlandica*. The same type of baldness can be seen today in girls wearing their hair with an excessively tight ponytail.

In *mummies 6* and *7* no changes were observed of relevance to the cause of death. In *mummy 8*, however, a woman of about fifty, extensive destruction of the base of the skull was observed in roentgenological examination (Eiken 1989). This destruction was most probably caused by a malignant tumour spreading in the bone. The changes are identical to those which can be seen in patients with nasopharyngeal carcinoma. This cancer type is particularly frequent among people of Inuit origin in Greenland, Alaska and Canada (Højgaard Nielsen *et al.* 1977). It is also frequent in certain regions of China and North Africa, although it is rare in Europe. In fact, the current incidence is about 25 times greater in Greenlanders than in Danes. Presumably, a nasopharyngeal carcinoma was the cause of death in this woman. This malignant disorder must have caused distressing symptoms during the last period of the woman's life, with blindness and pain. The marks of cuts in her left thumbnail indicate, however, that the woman was able to work to the very end (Kromann *et al.* 1989).

With regard to the establishment of the cause of death it must be taken into consideration that 500 years have elapsed since the death of the people from Qilakitsoq. The disease pattern in Greenland has changed profoundly during this period, particularly during this century. Many serious infectious diseases have been nearly eradicated. Nonetheless, the disease pattern in Greenland today still differs considerably from that of industrialized countries like Denmark (Harvald 1982). For example, the cancer pattern in Greenland differs markedly, with relatively high rates of certain types of cancer, as for example nasopharyngeal and oesophageal cancer, salivary gland cancer, cervical cancer and lung cancer in women, and relatively low rates of other types such as breast cancer, uterine cancer and prostate cancer (Højgaard Nielsen 1986). No doubt both hereditary and environmental conditions play a role for the occurence of cancer and a number of other diseases.

The Inuit have lived in relative isolation for thousands of years. This isolation was only really broken by World War II with the increasing strategic importance of the Arctic and growing exploitation of natural resources. The admixture of non-Inuit genes in the gene pool is constantly increasing and living conditions and the environment are undergoing radical changes. The proportion of European genes in West Greenland today is at least 25–30 per cent (Kissmeyer *et al.* 1971). These changes in heredity and environment are also reflected in the disease pattern.

One characteristic feature of the unique Inuit disease pattern is that coronary thrombosis and both the juvenile and mature form of diabetes are rare (Dyerberg & Bang 1982; Sagild *et al.* 1966). In recent years coronary disease is diagnosed six times more frequently in Danes than in Greenlanders. This is probably because the thrombocytes of Inuit blood have a low ability to aggregate (Bang & Dyerberg 1981). For centuries Greenlanders have been known to bleed easily. Today there is a relatively high rate of cerebral haemorrhages, prolonged bleeding in connection with childbirth and a pronounced tendency to nosebleeding. The occurence of atherosclerosis *per se* in Inuit has not been conclusively investigated. It has been postulated that Inuit do not have atherosclerosis to the same degree as Europeans, for example, and this has been attributed to the traditional hunter's diet. Atherosclerosis has, however, also been found in ancient Inuit bodies (Zimmerman & Smith 1975; Zimmerman & Aufderheide 1984).

The bones of Inuit are relatively deficient in calcium. This fact is well known from investigations of Inuit skeletons up to 1500 years old from the entire Arctic – Greenland, Canada, Alaska and the USSR – as well as of living persons (Thompson *et al.* 1982; Mazess 1974; Mazess & Mather 1975). The absolute blood calcium content in Greenlanders is lower than in Danes (Jeppesen & Harvald 1983) but the content of vitamin D, which is essential for the formation and development of bone tissue, seems to be sufficient in Eskimos living on a traditional diet (von Westarp *et al.* 1982). As a result of the sufficient vitamin D content rickets is not found in Greenlanders, whereas the low calcium content of the blood tend to rarify the bones with an increased risk of fractures. In several of the mummies the skeleton was rarified (Eiken 1989), and small compression fractures of the lumbar vertebral bodies were encountered. Greenlanders who have moved to Denmark show a higher calcium level in the blood, probably due to calcium-rich dairy products. In this context the increased occurrence of lactase insufficiency in Grenlanders has to be kept in mind (Gudmand-Høyer *et al.* 1973).

Among the possible causes of death, infectious diseases are important. For centuries Greenland has been virgin country for many infectious organisms (Bertelsen 1943). Given the secluded location of Greenland and the small, scattered settlements with little contact with the outside world infectious diseases often had a devastating effect. An infectious organism responsible for influenza or measles, for example, brought into the country from the outside by whalers or explorers, for whom it may have been harmless, could spread in the community, killing the greater part of the population in a short time. Many epidemics are on record from historical times, i.e. diseases like smallpox and typhoid fever. Serious epidemics of measles and hepatitis are known from recent decades, and tuberculosis is still remembered as the great killer in the first half of this century (Skinhøj *et al.* 1977; Stein *et al.* 1968). It has not proved feasible to apply any method to material from the mummies which could prove or disprove with reasonable certainty whether infection was the cause of death.

Life in ancient Greenland was harsh, at least at times. The dark period of the year, often with low temperatures, was a threat if provisions had not been stocked during the period of the year with abundant hunting. Families and whole commuinities could be wiped out by starvation, and during such periods of hunger individuals were more at risk from cold and exposure than normally.

Death from starvation, cold and exposure is difficult to trace in anthropological material like this. However, it is unlikely that the mummies died of starvation, at least not all of them. The intestinal content, which could be examined in mummy 7 (Lorentzen & Rørdam 1989), showed that this person had a varied and abundant diet up to her death. There seems to have been enough food at the time of her death, which also seems to have occurred in the summer period when food is normally available. None of the bodies seemed lean; on the contrary mummy 7 was rather stout. The garments and the loose skins and hides were all without traces of chewing or eating and this also contradicts the theory of death by starvation. When humans or their dogs starved in ancient Greenland pieces of skin were often cooked and chewed by the hungry humans and eaten by the dogs (Janssen 1913: 107; Rosing 1963: 151).

Another possible, and fairly frequent cause of death in Greenland is drowning. So the theory of drowning was put forward immediately after the opening of the graves (Rosing 1979). It was supposed that all eight dead persons had sailed together in an umiak, the traditional Greenlandic skin boat for transporting many people and goods. This type of boat was always rowed by women while the men followed in their kayaks. In the present case the umiak could have been sailing near the settlement of Qilakitsoq when an iceberg in the fjord capsized and raised a huge wave. This may have capsized the boat and thrown the women and children into the sea, where they drowned. The men would have survived the big wave in their more manoeuvrable kayaks. The drowned would either have been taken from the sea or washed ashore, and they might then have been buried together in the rock cleft.

It has not been possible to find firm evidence to support this theory. Even today it can be difficult to find absolute proof of drowning in drowned person.

Since the beginning of this century it has been believed that the occurrence of diatoms in the lungs was a proof of drowning. Diatoms are one-celled plants which can turn inorganic material into organic using solar energy. Diatoms are most often found in natural water, but can also be isolated from earth, and they circulate in the air (Foged 1982). Material from all the mummies except the smallest child (mummy 1) was examined for diatoms and a large-scale investigation was launched (Foged 1982) involving meat from animals and fish and material from Danes who had recently drowned or died from other causes. Diatoms were recovered from all the mummies investigated. Most of the diatoms were of the type found in fresh water, not in sea water, which was surprising considering that most of the diet must have had its origin in the sea (Tauber 1989). The Greenlandic material was compared to Danish material and no difference could be found. Thus the results of the investigation neither supported the theory of drowning as the cause of death for the Qilakitsoq mummies, nor did they indicate that the occurrence of diatoms in tissues from drowned persons could with any certainty be utilized in support of diagnosis of drowning (Foged 1983).

It must also be mentioned that a comparative geological investigation could not demonstrate, in the garments of the mummies, one single grain of some very characteristic minerals which were abundant on the local beach (Ghisler 1989). Thus the bodies can hardly have been landed on the beach. Further, it was stressed by an old hunter from Uummannaq that not one single fragment of the boat was found in the graves (Hart Hansen *et al.* 1985). The hunter emphasized that in cases of fatal boat accidents skin from the doomed boat was used to cover the bodies in the grave. Such boats, umiaks and kayaks, as well as other material and implements responsible for fatal accidents could not be used by living persons according to customs.

Another theoretical cause of death is poisoning. Deadly epidemics and single fatal cases of food poisoning (botulism) are well known from the whole arctic area even to-day (Kern Hansen & Bennike 1982). In Greenland deadly cases of poisoning from eating mussels are on record, but no cases of death from eating poisonous plants are mentioned (Berthelsen 1940).

Did they die simultaneously?

It has not been possible to decide with any certainty if the mummies died and were buried simultaneously or if they died from from different causes and were buried at intervals – perhaps of decades.

In the graves some indications were found that there had been one burial initially in each of the graves, which were later filled up on one or several occasions. Thus in grave I a big flat stone was found standing vertically, most probably placed in its position after the burial of the first woman, as the stone was standing on a heap of hides entombed with the woman. The stone may have been meant to increase the height of the grave for later burials and to ensure that the opening of the grave would not be too big when the covering stones had to be placed. In grave II the bottom woman was difficult to find as she was covered with hides and plants. There were many small stones and the grave seemed nearly filled up with loose skins, hides and stones when the two uppermost bodies were removed.

On initial roentgenological examination of the four-year-old boy (mummy 2) seven deciduous teeth were discovered lying together on the back above the lumbar spine, seemingly under the garments. It was initially believed that the teeth had been placed in a small, partly decayed skin purse resting on the surface of the skin, perhaps as a kind of amulet. Four other teeth were found firmly trapped in the mummified soft tissues at four different parts of the trunk and neck. It was discovered that the teeth were all from the boy himself and that they had fallen out after death, since they all had roots. It was also registered that the garments and the soft tissues of the lower part of the back were partly decayed and that the teeth were in fact located inside the soft tissues below the skin surface, not in a purse.

It is most probable that the different positions of the child's teeth, which must have loosened and fallen out years after death and burial, were caused by movement of the body. All the teeth were firmly trapped in the mummified tissues. This indicates that the teeth reached their final position before mummification was complete. After mummification it would have been impossible for the teeth to relocate. Tissues and the garments must still have been soft and decaying when the teeth moved round the body. Most probably, the child was moved from or in his grave, perhaps in order to have other bodies buried in the same grave, or for burial in another grave with his mother or other relatives. This may have happened long after death, after the loosening of the teeth and before completion of mummification. The total process of mummification may have lasted decades, given the particular conditions of the grave.

It had been envisaged that modern scientific methods could help in deciding if the dead persons had died and were buried simultaneously or perhaps at intervals of decades. Carbon 14 dating is too inaccurate in this context. It was also hoped that longitudinal X-ray-fluorescence-spectrometry on hairs from the heads of the mummies might provide some clues as to the contemporaneity of the bodies. This method can show changes in the concentration of different elements and these concentrations are known to fluctuate depending upon the character of the diet. In the event of identical diet, identical changes would be demonstrable in hairs from the individual mummies. Characteristic patterns could not, however, be demonstrated, and the results neither supported contemporarity or the opposite (Hansen *et al.* 1989).

It was only possible to recover food items from the intestines of one of the mummies (mummy 7) (Lorentzen & Rørdam 1989). The content of the faecal lumps suggested that this person most probably died during the summer (July/August). Had it been possible to collect such material from several of the mummies it would have been possible to compare the food content in order to find out if the individuals had shared the same diet, and whether they could have died at the same time of the year or not.

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