Exhumation

5

The removal of a body from a grave (exhumation) requires legal authority, often in the form of a court order. Next of kin may also have a prior right to be heard. Exhumation may be deemed necessary either in cases where a court order was not issued in a timely fashion around the time of death or if new evidence justifying exhumation has since come to light. Since it is often the case that particular questions require clarification, it is important to establish in advance whether exhumation is an appropriate approach to answering these questions.

The utility of exhumation varies greatly depending on the period of time a body has spent in an inground grave (burial time). It may be possible to detect poisoning many years after burial—depending on the preservability of the poison—particularly in the case of heavy metals. Hair analysis also offers the possibility of confirming regular use of medications such as ß-blockers.

Many relevant factors are unknown prior to exhumation, and in most cases, it is impossible to safely determine them retroactively. Exhumations are typically performed to clarify cause of death and determine identity in cases of intoxication, suspected homicide, medical malpractice, or accidents, including traffic accidents. The authorities concerned are often interested in those findings which can be reasonably expected from exhumation, depending on both the nature of the diagnostic question being asked and the specific length of time since burial.

5.1 Macroscopic Findings on Exhumation

The conditions prevailing in an earthen grave can differ significantly and may vary to a considerable degree according to the climate zone and time of year. Although groundwater level is avoided when the depth of a grave is determined, water may nevertheless accumulate in the case of prolonged rainfall, with the result that a body may need to be recovered from a water-filled casket (Fig. 5.1).

It is often possible to make numerous findings after exhumation despite factors such as autolysis, putrefaction, possible animal predation, fungal colonization (Fig. 5.2), mummification, adipocere, and artifacts (e.g., caused during body recovery). There is no linear correlation between postmortem interval and the detectability of findings, which depends far more on ambient conditions and the diagnostic question being posed. A body may have undergone decomposition to an extent that it is no longer possible to make a targeted assessment.

In the case of a naturally mummified body, putrefaction, autolysis, as well as possible animal predation and mummification processes take place simultaneously. When this is the case, mummification, that is to say, the drying out of tissue, inhibits other decomposition processes. Brain tissue often takes on a pulp-like consistency within days or weeks, making a differentiated assessment impossible (Fig. 5.3).

However, important findings such as extensive intracranial or intracerebral hemorrhage may be

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Fig. 5.1 Exhumation from a water-filled casket following prolonged rainfall

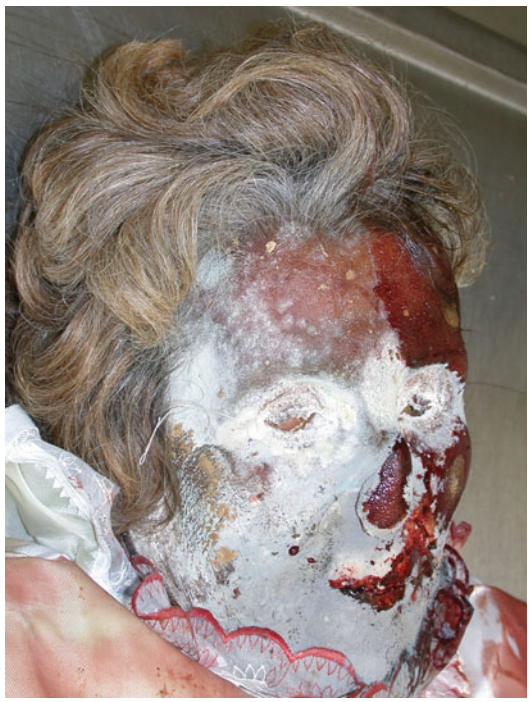


Fig. 5.2 Extensive whitish-gray fungal colonization following a burial time of 7 months

detectable for longer periods of time. Lack of water tends to slow down autolysis and putrefaction; this can mean that the internal organs of a body may undergo complete decomposition, while the outer layer, in particular the skin, remains preserved by the mummification process, especially in cool, dry ambient conditions. The surface of the body is dry and rigid and has a light brown-ocher color (Fig. 5.4).

In the case of mummification, skin injuries such as incision and stab wounds as well as gunshot wounds can still be detected after long burial times. Even larger wounds and hemorrhage are identifiable in mummified bodies if subcutaneous soft tissue can be well visualized (Fig. 5.5). Dental findings, including evidence of dental treatment, can be made after significantly longer burial times (Fig. 5.6).

Adipocere. This refers to the transformation of body fats into adipocere. Fatty tissue either undergoes an oily transformation or becomes a greasy waxlike mass that eventually dries out and hardens with time to the consistency of chalk, particularly

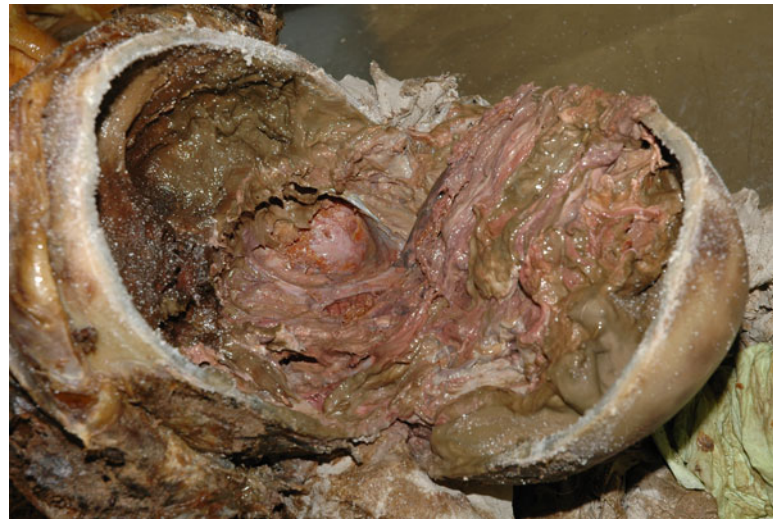
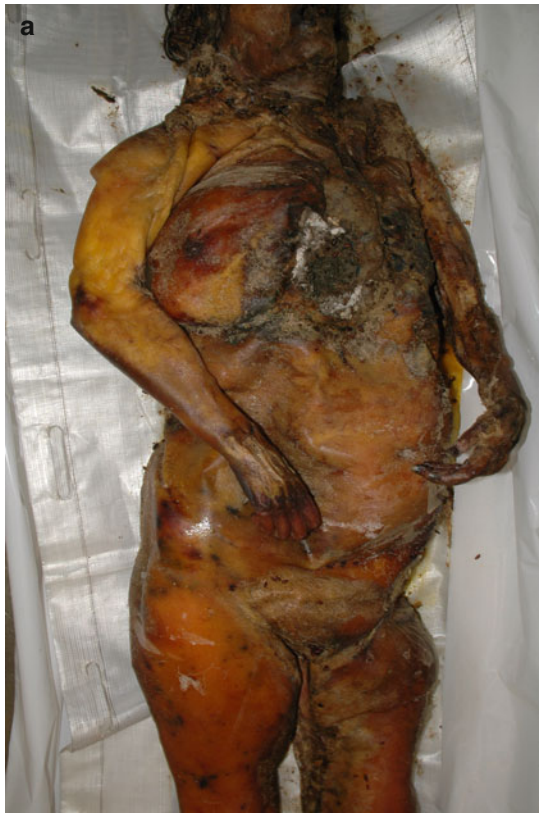


Fig. 5.3 Brain tissue that has undergone pulp-like transformation (burial time, 7 weeks)



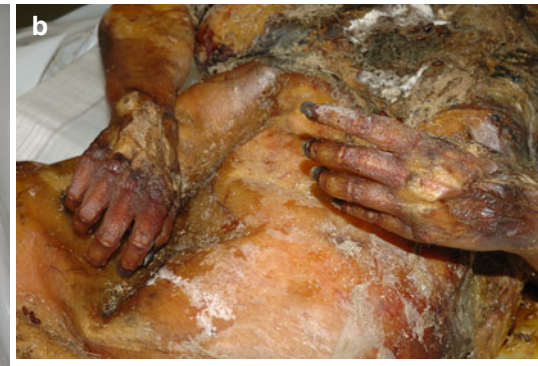


Fig. 5.4 Burial time, 6 years. (**a**) Mummification in dry, cool ambient conditions with brown-ocher-colored drying and stiffening of the body surface. (**b**) Partial involvement of the extremities, including hands and fingers, in the mummification process

under dry-air conditions. Once adipocere has formed, it may be difficult, if not impossible, to detect findings in internal organs; injuries, on the other hand, can remain well identifiable. Table 5.1 lists a selection of macroscopic findings that can still be made even after prolonged postmortem intervals.

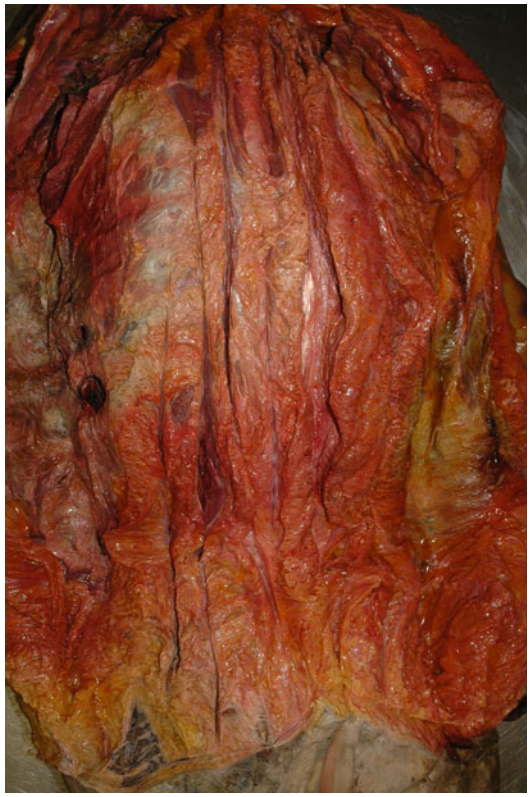


Fig. 5.5 Soft tissue dissection of the back in a partially mummified body (burial time, 1.5 years); anatomical structures can be well visualized

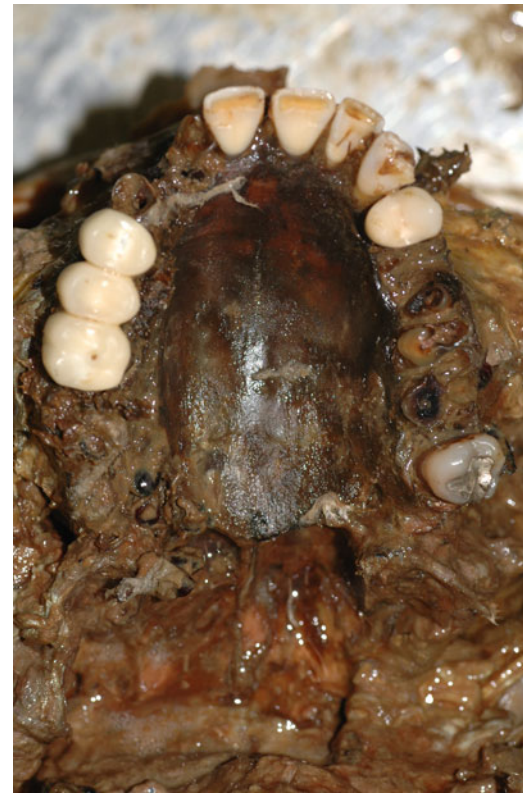


Fig. 5.6 Dental status on exhumation following a burial time of 1.5 years

Even after exhumation, it is possible to differentiate between ante- and postmortem injury and changes to a body. Postmortem artifacts include injuries caused by a primary event (e.g., fire-related artifacts such as heat fractures), postmortem transport, as well as the breaking open of a casket lid and other changes related to the recovery of a body from a grave. Depending on the deceased's prior history, injury may have been caused by previous attempts at resuscitation, e.g., serial rib fractures. Other types of postmortem damage develop according to the postmortem interval, such as autolysis of the pancreas, gastric wall rupture and escape of gastric contents, rectal prolapse due to gas buildup in the abdomen, and hypostatic accumulation of blood. Internal organs gradually lose their color to become dirty reddish brown, e.g., the vascular intima throughout the body. Depending on the position of the body, lesions such as extensive petechiae or ecchymoses may be seen, particularly in the head, neck, and shoulder region in the case of a head-down position.

Table 5.1 A selection of pathomorphological findings correlated with burial times

Macroscopic finding on exhumation	Burial time
Epidural/subdural hematoma	2.8 months
Cerebral contusion	2.1 months
Hematothorax	2.5 years
Blood aspiration	1.7 months
Cardiac tamponade	3 years
Intestinal bleeding	1–2 years
Strangulation marks	Months
Electrical burns	2 months
Conjunctival hemorrhage	2.6 months
Meningitis	3.5 months
Coronary sclerosis	7.5 years
Coronary thrombosis	10 months
Pulmonary thromboembolism	13 months
Pneumonia	2 years
Liver cirrhosis	1 year
Oligodendroglioma	39 days
Cerebral hemorrhage	66 days/73 days
Aortic aneurysm rupture	193 days
Deep vein thrombosis	75 days

Table 5.1 (continued)

Macroscopic finding on exhumation	Burial time
Fresh myocardial infarction accompanied by cardiac tamponade	97 days/64 days
Myocardial scars	304 days/1,581 days
Left ventricular hypertrophy	240 days/128 days
Cor pulmonale	267 days/128 days
Prostatic venous plexus thrombosis	202 days/27 days
Bronchial carcinoma	202 days/13 days
Caseous pulmonary tuberculosis	236 days/10 months
Lobar pneumonia	37 days
Pleural mesothelioma	157 days/210 days
Fresh pulmonary embolism	168 days/13 months
Status following hepatic rupture	49 days
Cavernous hemangioma of the liver	38 days
Cholecystolithiasis	478 days/7.5 years
Ascites	50 days
Perisplenitis cartilaginea	176 days/6 weeks
Gastric cancer	168 days
Pseudomelanosis coli	71 days
Esophageal varices	39 days
Ventricular ulcer	170 days/157 days
Inguinal hernia	112 days/127 days
Inguinal testis	60 days
Renal cysts	240 days
Full urinary bladder	236 days
Prostate hyperplasia	478 days/2.5 years
Decubital ulcer over the sacral bone	111 days
Dermal scarring	478 days/7.5 months
Tattoos	72 days
Parasternal rib fractures due to resuscitation	114 days
Crural ulcers	30 days/9 weeks

Modified from Karger (2004), Ulm (2008) and based on additional information in the literature

5.2 Histological Findings on Exhumation

Histological and histopathological findings following prolonged postmortem intervals have been the subject of several investigations in the past (Table 5.2). The detection of usable microscopic findings depending on the postmortem interval, especially in the context of exhumation, is by nature temporary and reliant on many factors. Thus, methods of forensic–histological diagnosis are limited in the presence of autolysis and putrefaction, being only of modest use, for example, in autopsies on bodies taken from mass graves. In the case of mummification, on the other hand, tissue and organoid structures, as well as potential pathological findings, can be seen microscopically for a significantly longer period of time as compared with in the presence of autolytic and putrefactive processes. However, microscopically, numerous problems of differentiation are encountered, for example, when distinguishing tubular necrosis in the kidney from purely autolytic changes. Detecting acute myocardial infarction can also be challenging and is only possible for a limited period of time. Finally, structures are prone to various autolytic processes in the postmortem period. Leukocytes and nuclei of granulocytes are seen as exceedingly resistant to autolysis and putrefaction. Evidence of bronchopneumonia could be shown following exhumation even after 392 days. Others have diagnosed confluent bronchopneumonia after a postmortem interval of 95 days. However, there is no specific sequence or timeline for changes to internal tissues and organs resulting from autolysis and putrefaction, nor can a fixed time or period of time be determined for single organs. In general, the uterus is considered to be an organ relatively resistant to putrefaction.

5.3 Chemical–Toxicological Analysis Following Exhumation

Experience with a number of poisons or types of intoxication has been gained in terms of potential toxin detection following prolonged burial times (Table 5.3). This process involves taking very particular specimens, such as the bottom boards of a casket, casket fittings, and soil samples from above, below, beside, and at some distance from the casket. For autopsy purposes, samples of the following, where available, should be taken for chemical–toxicological analysis:

- Blood (cardiac blood, femoral vein blood)
- Liver sections
- Kidney sections
- Lung sections
- Brain sections
- Bile fluid
- Gastric contents

Table 5.2 Detectability of selected histological findings subject to postmortem periods according to data in the literature

Finding	Postmortem period	Author(s)
Electrical burns	3 weeks	Walcher (1937)
Peritonitis, sepsis, septicopyemia	17 days/42 days	Althoff (1974)
Polynuclear alveolar cells	15 days	Althoff (1974)
Early cell infiltration	65 days	Althoff (1974)
Subserous hemorrhage	65 days	Althoff (1974)
Chronic meningitis	52 days	Althoff (1974)
Coronary thrombosis and myocardial fibrosis	90 days	Althoff (1974)
Chronic bronchitis	27 days	Althoff (1974)
Bronchopneumonia	133 days/95 days	Althoff (1974)
	392 days	Naeve and Bandmann (1981)
Immunohistochemical analysis using myeloperoxidase	19 months	Schulz et al. (1999)
Brain metastasis of lung cancer	44 days	Althoff (1974)
Liver metastasis of hemangiosarcoma	27 days	Althoff (1974)
Bronchial anthracofibrosis	80 days	Althoff (1974)
Stenosing coronary sclerosis	133 days	Althoff (1974)
Intimal sclerosis of the coronary arteries	19 months	Schulz et al. (1999)
Ganglion and glial cells	114 days	Walcher (1937)
	1,212 days	Althoff (1974)
Positive evidence of iron in the tissue	1–2 years	Walcher (1937)
Fat embolism	8–10 days (exp.)	Lubarsch (1900)
	4–8 weeks	Walcher (1925, 1928)
	4.5 months	Strassmann (1921–1931)
Coronary thrombosis	8 months	Banaschak et al. (1998)
	3.5 months	Grellner and Glenewinkel (1997)
	3.9 months	Althoff (1974)
	96 days	Stachetzki et al. (2001)
Acute myocardial infarction	6 weeks	Breitmeier et al. (2003)
Detected immunohistochemically using necrosis marker C5b-9(m) and	12 months	Karger et al. (2004)
NP57 (indicates neutrophilic leukocytes)	63 days, 487 days	Ortmann et al. (2000)
	128 days	Ortmann et al. (2000)
Detection of hemosiderin in the dura	8.5 months	Breitmeier et al. (2005)
Liver fibrosis	4.5 months	Breitmeier et al. (2005)
Shock liver	6 months	Breitmeier et al. (2005)
Glomerulonephritis	3.2 months	Breitmeier et al. (2005)
Cervical artery dissection	20 months	DeGiorgio et al. (2007)
Alzheimer's disease	2 months	Gelpi et al. (2007)
	20 months	Omalu et al. (2005)
Previous cerebral contusion	3.5 weeks	Grellner and Glenewinkel (1997)
Cerebral edema	13 weeks	Grellner and Glenewinkel (1997)
Thyroiditis	3.75 months	Grellner and Glenewinkel (1997)
Nodular goiter	7 weeks	Grellner and Glenewinkel (1997)
	13.5 weeks	Althoff (1974)
Thyroid adenoma	3 months	Grellner and Glenewinkel (1997)
Tracheitis	2 weeks	Grellner and Glenewinkel (1997)
Epicarditis	3.75 months	Grellner and Glenewinkel (1997)
Lipomatosis cordis	2.5 years	Grellner and Glenewinkel (1997)
Myocardial hypertrophy	3.5 months	Grellner and Glenewinkel (1997)
	4.25 months	Naeve and Bandmann (1981)

Table 5.2 (continued)

Finding	Postmortem period	Author(s)
Myocardial granulation tissue	3.5 months	Grellner and Glenewinkel (1997)
Myocardial fibrosis or scarring	2.5 years	Grellner and Glenewinkel (1997)
	2 years	Nordmann (1939)
Acute pulmonary trauma	5 weeks	Grellner and Glenewinkel (1997)
Pulmonary edema	3 months	Grellner and Glenewinkel (1997)
	2.5 years	Thomas (1979)
Chronic pulmonary congestion	2.1 months	Grellner and Glenewinkel (1997)
	3.5 months	Naeve and Bandmann (1981)
Pulmonary amyloid bodies	3.5 years	Grellner and Glenewinkel (1997)
Shock lung	2 weeks	Grellner and Glenewinkel (1997)
Pneumonia	3.75 months	Grellner and Glenewinkel (1997)
	1.1 years	Naeve and Bandmann (1981)
Immunohistochemical detection of neutrophilic granulocytes with NP57	24 months	Karger et al. (2004)
Lung emphysema	2.5 years	Grellner and Glenewinkel (1997)
	2 years	Nordmann (1939)
	26 days	Raestrop (1926)
Anthracosis	7.5 years	Grellner and Glenewinkel (1997)
Tuberculosis	1.5 months	Grellner and Glenewinkel (1997)
	10 months	Nordmann (1939)
Pulmonary artery sclerosis	2.5 years	Grellner and Glenewinkel (1997)
Pulmonary thromboembolism	1.5 months	Grellner and Glenewinkel (1997)
Pulmonary fat embolism	4.5 months	Strassmann (1921–1931)
	1–2 months	Walcher (1925, 1928)
	1.2 months	Naeve and Bandmann (1981)
Hepatic capsular fibrosis	2.5 years	Grellner and Glenewinkel (1997)
Hepatocellular necrosis	6 days	Grellner and Glenewinkel (1997)
Fatty degeneration of the liver	3 months	Grellner and Glenewinkel (1997)
	10 years	Siegel (1985)
Fatty liver hepatitis	2 weeks	Grellner and Glenewinkel (1997)
Periportal infiltration	16 days	Althoff (1974)
Splenic artery hyalinosis	3.75 months	Grellner and Glenewinkel (1997)
Septic spleen	8 days	Grellner and Glenewinkel (1997)
	16 days	Althoff (1974)
Scarring of the renal cortex	3 months	Grellner and Glenewinkel (1997)
	4.8 months	Naeve and Bandmann (1981)
Renal shrinkage	6 weeks	Grellner and Glenewinkel (1997)
	3 years	Walcher (1937)
(Chronic) pyelonephritis	6 months	Grellner and Glenewinkel (1997)
	5 weeks	Althoff (1974)
Prostatic hypertrophy	2.5 years	Grellner and Glenewinkel (1997)
	2.5 months	Riepert (1993)
Corticoadrenal hyperplasia	3.5 weeks	Grellner and Glenewinkel (1997)
Adipose tissue	2 years	Grellner and Glenewinkel (1997)
Alveolar structure and epithelium	4.8 years	Grellner and Glenewinkel (1997)
	1.25 years	Walcher (1937)
	2 weeks	Althoff (1974)
Amniotic fluid components	4.5 months	Strassmann (1921–1931)
Bone marrow	3 months	Grellner and Glenewinkel (1997)

(continued)

Table 5.2 (continued)

Finding	Postmortem period	Author(s)
Residual brain tissue in adipoceratous cadavers	73 years	Erman (1882)
Brain structures	3 months	Grellner and Glenewinkel (1997)
Myocardium	2.5 years	Grellner and Glenewinkel (1997)
Hepatic cells	2.5 years	Grellner and Glenewinkel (1997)
Neuronal and glial cells	17 years	Grellner and Glenewinkel (1997)
	3.3 years	Althoff (1974)
Pancreas	4.8 years	Grellner and Glenewinkel (1997)
	4 weeks	Walcher (1937)
Renal structures and cells	2.5 years	Grellner and Glenewinkel (1997)
	3 years	Walcher (1928)
Skeletal muscle, including transverse striation	4.8 years	Grellner and Glenewinkel (1997)
Thyroid structure	2.5 years	Grellner and Glenewinkel (1997)
Infectious arteritis of the hepatic artery	9 days	Dedouit et al. (2010)
Reticulum cell sarcoma	16 months	Sierra-Callejas and Pribilla (1978)
Expanded lung tissue in a newborn caused by breathing	4.5 months	Strassmann (1921)
Displaced textile fibers at the site of bullet entry	7 months	Strassmann (1921)
	1 year	Strassmann (1921)
Interstitial lung fibrosis	223 days	Stachetzki et al. (2001)
Keratinizing squamous cell lung cancer	43 days	Stachetzki et al. (2001)
Brain metastasis of small-cell bronchial cancer	73 days	Stachetzki et al. (2001)
Immunohistochemical detection of glucagon	Negative from 14 days post-mortem	Wehner et al. (2001)
Immunohistochemical detection of calcitonin	Negative from 13 days post-mortem	Wehner et al. (2001)

From Dettmeyer (2011)
Sometimes only the postmortem interval is stated in the literature, but not if mummification or autolysis and putrefaction can be assumed

Table 5.3 Toxin detection following exhumation

Toxin	Years prior to detection	Toxin	Days prior to detection
Arsenic	9	Phosphorous	152
Lead	9.5	Hydrogen cyanide	116
Thallium	8	Fluorine	53
Strychnine	6	Aconitine	48
Antimony, barium	5	Mercury	30
Atropine, scopolamine	3	Carbromal	28
Morphine derivate	1.1	Mineral acids	23
Colchicine	0.8	Barbiturates	21
Parathion (E 605)	17		
CO	0.6		
ß-Blockers (hair)	7		
Digitoxin	1.4		
Chlorprothixene	5.5		
Diazepam	2.7		

From Forster (1986), Karger (2004), and own results

- Intestinal contents, subdivided into small and large intestine contents
- Muscular system
- Fatty tissue (particularly in the case of volatile gases such as anesthetics)
- Hair
- Finger- and toenails
- Vitreous fluid
- Synovial fluid (knee joint)
- Cerebrospinal fluid

Gaining information on poison concentrations from chemical–toxicological analysis following exhumation is problematic, since although it is still possible to identify a poison as such, the postmortem metabolization of toxic substances needs to be taken into account. Thus, drawing conclusions about fatal intoxication should be done so with caution and only when all other facts have been taken into consideration.

5.4 Exhumation of Mass Graves

A distinction is made between mass graves intended as a final place of burial and those intended as a temporary measure. Mass graves are usually created when there are large numbers of deceased, and these numbers, combined with external circumstances or time considerations, prohibit normal burial.

Most notably in postwar periods (including civil war), and especially in the case of possible war crimes, there is a desire to remove the deceased expediently. Typically, bodies are randomly placed in large pits and possibly also strewn with quicklime to accelerate the process of decomposition. Mass graves of this kind are usually opened and mass exhumations undertaken as part of criminal proceedings at the International Criminal Court in the Netherlands. In addition to identifying victims, it is also important to establish the cause of death in each individual case. As the time interval between death and exhumation increases, it becomes ever more challenging to assign individual body parts or bones to the relevant individuals.

It is not uncommon in the case of terrorist attacks, serious accidents such as air crashes and ferry disasters, as well as natural disasters like earthquakes, floods, and tsunamis for the sheer number of bodies to vastly exceed normal cooling and storage capacities. In such cases, creating temporary mass graves may be the only option available. However, this type of mass grave is created in a well-ordered manner to facilitate, as far as possible, the later exhumation and examination of the deceased.

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