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Chapter

Postmortem Examination

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Abstract

This chapter titled "Postmortem Examination" will highlight the importance of a postmortem examination, provide a basic overview of what a postmortem examination should involve, and guide the reader through the steps required to perform a complete autopsy. Subsections of special procedures as well as additional testing methods are included for those who are interested in extending their examinations to answer selected questions in selected scenarios. This chapter can act as a guideline to those who are unfamiliar with the process of an autopsy, or a review, and reinforcement to those who wish to build on top of their previous experience.

Keywords: autopsy, dissection, techniques, body, postmortem

1. Introduction

The history of postmortem examination, commonly known as an autopsy, dates back to ancient Egyptian days, where there was considerable interest in the relationship of wounds and fractures to anatomy, but little interest in the nontraumatic diseases. It was not until the 20th century when leaders of medicine in North America, including Sir William Osler (1849–1919), emphasized the importance of the autopsy in medical education. The objectives of an autopsy would include the establishment of final diagnoses and of the causes of death, and the unique opportunity for physicians to correlate their clinical observations with pathologic changes of disease. The autopsy establishes a standard for evaluating the accuracy of pre-mortem diagnoses and outcome of therapy. It provides critical data for quality assurance and makes room for quality improvement. It also provides the surviving family the basis for genetic counseling for hereditary diseases, thereby directing preventative care for living family members, which is particularly true in cases of sudden death. Family members can be comforted by obtaining information on the causes of death of their loved ones, obtaining answers to questions surrounding terminal events, and irrational guilt can be alleviated [1–5].

2. Basic postmortem examination

2.1 Identification

The first step to any examination is to determine the identity of the individual. This can be carried out by law enforcement (who are usually the first responders to the death scene), or by the presiding Coroner or Medical Examiner. Thus, by the time the body arrives in the morgue, the identity has been determined.

Establishment of identity can occur through various methods. The degree of certainty is best classified as definitive, presumptive, or speculative. Definitive

identification is legally sufficient, and it is based on the objective comparison of antemortem and postmortem information. This includes visual recognition (most widely used method of identification), fingerprints, dental record comparison, radiographs/unique anthropomorphic features and/or surgical devices (somewhere serial numbers can be obtained), and deoxyribonucleic acid (DNA) analysis. Presumptive identification is when positive identification has more likely than not been established. This includes recognition of clothing, unique tattoos, scars, birthmarks, or items at scene such as various papers, medication bottles, or identification bearing the decedent's name. Speculative identification is an initial guess, which carries the lowest degree of certainty. In many instances, not one but many methods based on the circumstances surrounding the death, investigation of the scene, and examination of the body are used to accumulate sufficient evidence that points to the decedent's identity [6]. Various special techniques such as artist's sketches and reconstruction methods (forensic sculptors, computer programs) can also be employed in selected circumstances [7, 8].

2.2 External examination

External examination begins by obtaining measurements of height and weight without clothing, and any other features that may help with documentation (such as arm span, foot length, center of gravity from umbilicus to heel, etc.). Medical interventions should be documented, such as endotracheal tubes, intravascular catheters, penetrating tubes or wires. The descriptions should preferentially involve assessments of proper positioning of interventions through markings that are visible externally, as well as externally visible injuries associated with the interventions.

The overall appearance and assessment of nutritional status are also documented. Postmortem changes are assessed, which include the degree of rigor mortis, the distribution of livor mortis, and any other postmortem changes that may be present (decompositional changes of various degrees).

The rest of the external examination can be carried out in various orders depending on personal practice, but a logical way would be to start from the top of the head. The quality and distribution of hair over the head are recorded, together with observations of the scalp including skin conditions and/or injuries. The facial features are then documented, including descriptions of the eyes, ears, nose, mouth, and palpation of the bones of the face to identify any fractures underneath. Description of the eyes should include the color of the irides, and examination of the sclera and palpebral conjunctivae for any discoloration (e.g., scleral jaundice) and/or petechial hemorrhages. Evaluation of pupillary sizes after death is not indicative of their ante-mortem appearance due to early changes after death [9].

Examination of the neck should include documentation of any abnormal markings and injuries that may suggest self-harm and/or criminal actions. If injuries are suspected, a layered neck dissection procedure should be performed in a bloodless field (see Section 4 below).

Examination of the extremities aims to look for any deformities that may suggest acute or previous injuries, and scars or markings that may add to the social history (such as scars on the wrist in cases of self-harm, or track marks in cases of intravenous drug use). In certain criminal investigations, fingernails can be clipped and submitted for further testing that may link the victim to the assailant.

Examination of the torso follows, with documentation of overall size and shape that may suggest underlying diseases (such as a barrel chest in chronic obstructive

pulmonary disease) and/or injuries (such as a flail chest in multiple rib fractures). Examination of the torso also includes the back, which is ideally performed with the body positioned prone on the table. Again, documentation of any abnormalities that may suggest disease or injuries is done, and the anus is also examined for any abnormalities.

The body is then positioned supine, lying on a block between the shoulder blades, and the internal examination can begin.

2.3 Internal examination

There are several ways of incising into the skin to expose the underlying structures. The most commonly employed skin incisions include the Y-shaped incision, the modified Y-shaped incision, and the I-shaped incision. The Y-shaped incision goes from the tips of the shoulder on each side obliquely down, joining at the middle of the chest, roughly between the nipples, and the incision is then continued down vertically along the midline of the front of the body, stopping at the pubis. The modified Y-shaped incision is when the top most incisions start from behind each ear down the sides of the neck toward the middle of the chest. The I-shaped incision is a single straight vertical incision that goes from the top of the neck down the midline of the front of the body to the pubis [10, 11].

The skin is then peeled back from the underlying bones, by cutting roughly parallel to the skin surface along the subcutaneous layer of soft tissues. The chest plate is removed by first separating the sternoclavicular joints, and cutting the ribs near the anterior costochondral junctions, preferably cutting through the cartilaginous parts so that the cut edges are relatively dull to reduce risk of injury during subsequent evisceration.

There are several techniques for evisceration (the removal of organs from body cavities) [12, 13]. The technique of Virchow employs removal of body organs one after another. This technique is good for demonstrating pathology in individual organs, but the relationships between various organs may be hard to interpret. The technique of Letulle or the en masse technique is when the cervical, thoracic, abdominal, and pelvic organs are removed as one mass, and then subsequently dissected into organ blocks. This technique is good for preserving vascular supply and relationships between organs. However, the organ mass is sometimes awkward to handle, and an assistant may be required to help with handling. The technique of Ghon or the en bloc technique is where the cervical and thoracic organs, the abdominal organs, and the urogenital system are removed as separate organ blocks. This is a mixture of the Virchow and en masse techniques, allowing the preservation of anatomical relationship sufficiently while enabling one person to execute without an assistant. Finally, the technique of Rokitansky consists of in-situ dissection combined with en bloc removal.

The organs are then examined individually, and any diseases and/or injuries are documented. During examination, sections of organs may be submitted for subsequent microscopic examination (see Section 5.1 below).

3. Special dissection procedures

Selected procedures and techniques that differ from or are added to the routine autopsy are performed in certain situations to better demonstrate the diseases or injuries involved.

3.1 Pneumothorax

Pneumothorax is usually associated with injury to the lung, although pure pneumothorax, although rare, can happen. The pleural cavities, therefore, should be checked for the presence of air in cases of chest injuries.

The skin and muscle on the injured side of the chest are reflected and dissected to form a pocket lateral to the chest wall, just below the level of the axilla. This pocket is then filled with water, and a scalpel is introduced under the water level, incising into an intercostal space through to the pleural cavity. Air bubbles observed exiting through this incision represent presence of pneumothorax. An inverted graduated cylinder filled with water can be held over the pocket prior to the incision into the pleural cavity to collect and measure the amount of air in the pleural cavity if desired [14].

3.2 Posterior leg dissection

Deep vein thrombosis in the calves is frequently seen associated with cases of death by pulmonary embolism, and is a frequent complication of immobilization and/or trauma. With the body positioned prone, the calf is incised vertically from the heel to the popliteal fossa, and the skin is then reflected. The tendon of Achilles is severed, and the attached calf musculature is then reflected and dissected gently from the underlying tibia and fibula from the heel upward. Transverse sections through the reflected musculature are then performed, and thrombi, if present, will thus be transversely sectioned, and their relationship with the attached vessels can be visualized. Antemortem thrombi typically maintain their sausage-like shape even if they become dislodged from the vessels, and show a concentrically layered cut surface (an indication of antemortem organization) [14]. Postmortem clots are typically soft and collapsible in nature, and do not show concentric laminations on cut surfaces.

3.3 Layered neck and facial dissections

Examination of the neck structures can aid in determining injuries in the neck that may have medicolegal implications. The neck should be examined at the end of the autopsy following removal of all other organs including the brain so as to create a dry/bloodless field to minimize the possibility of introducing blood seepage into the neck structures during dissection.

The routine Y-incision is extended from the tips of both shoulders upward along the posterior-lateral aspects of the neck and behind the ears toward the level of mid-ear. The skin is then undermined and reflected from the shoulder regions to the ears, proceeding to the level of the mandible on both sides. Layerwise reflection of the muscles of the neck is then carried out and injuries of the anterior neck are documented. Examination of the posterior neck takes on a similar approach, which is most easily done with the body positioned prone. A single vertical incision from the protruding C7 spinous process up toward the midline occiput is coupled with a horizontal incision at the mid posterior neck, effectively creating a cross-shaped incision, where the skin can then be reflected back to expose underlying musculature. The posterior neck muscles are then reflected in a layerwise manner and examined for injuries.

Sometimes it is necessary to examine the soft tissues of the face, and the anterior skin flap can be further reflected by undermining the facial skin from the level of the mandible. Subcutaneous severing of the external auditory meatus will mobilize the skin for better visualization of the facial skull, and will not interfere with the cosmetic appearance of the face as long as midline attachments of skin to subcutaneous tissues are maintained at the midline of the face.

3.4 Exploration of middle and inner ears

The middle and inner ears are encased in the petrous portions of the temporal bones, located at the base of the skull.

Following the removal of the brain, the dura is stripped from the middle fossa, and the petrous regions are dried. Bone cutters are used to excise the petrous ridge from all four sides to produce a roughly rectangular segment. The inner surface of the tympanic membrane is exposed and can be examined for evidence of inflammation. Findings of purulent inflammation should be reported and swabs may be submitted for culture. The entire petrous block can be decalcified and submitted for microscopic examination if so desired [14].

3.5 Air embolism

Air embolism should be suspected in cases involving an open wound to the neck area, diving misadventures, chest trauma, or cases associated with childbirth or abortions. An interrupted blood column at autopsy in cerebral or cardiac vessels is often artefactual and thus is not regarded as evidence of air embolism.

The pericardial sac is opened anteriorly, and the edges are grasped with tools such as forceps or hemostats to create a pocket. Water is poured into the sac and the heart is submerged. A scalpel is then used to incise into the right side of the heart under the water level. Bubbles will arise if air is present. For measurement, an inverted graduated cylinder filled with water can be placed in the water prior to incising the heart [14].

3.6 Exploration of the sphenoid sinus

The presence of water in the sphenoid sinus, although recognized to be present in any body that has been immersed in water, is one extra finding that can lend support to cases of drowning, which remains a diagnosis of exclusion. A large-bore needle attached to a syringe is used to perforate the sphenoid bone on either side of the sella, while it is directed downward and medially at a 45° angle. An average of 2–3 ml (sometimes up to 5 ml) of water may be aspirated [14].

3.7 Removal of the spinal cord

The spinal cord can be visualized or removed for further examination by either an anterior or posterior approach, traditionally by sawing through the pedicles (anterior approach) or the laminae (posterior approach) to expose the underlying spinal cord following the routine autopsy and removal of the brain. Alternatively, an intervertebral disc in the lumbar spine can be transected, as well as another intervertebral disc in the thoracic area. A Stryker saw is used to cut out the segment of vertebral bodies between the two transected discs. The exposed dura is visualized, and can be slit vertically and reflected sideways. The exposed portion of the cord/cauda is then loosened by severing the nerves within the spinal canal, and slow downward traction toward the feet can be applied to retrieve the remaining cord in its entirety [14, 15].

3.8 Examination of the cervical spine/vertebral artery

Examination of the cervical spine may be warranted in cases of traffic deaths, falls, diving deaths, and suspected shaken baby cases. One radiological study showed that cervical injuries in road crash victims can be above C3 (50% of cases)

or below C3 (22% of cases) [16]. Injuries range from severe fractures and dislocations to a few deep hemorrhages in the musculature. Injuries to the vertebral artery can sometimes occur when hyperextension/flexion and rotational forces are in play, with the most vulnerable regions being the third section [17].

The body is placed face down, and a head block is placed under the chest, with the head flexed at the neck. A posterior midline incision is made, and the musculature dissected in a layered fashion down to the vertebral column. The atlanto-occipital joint capsules are incised into, so that the articular surfaces can be examined. The atlas is disarticulated and removed. Laminectomy is then performed on the cervical vertebrae, and the dura mater can be incised and the spinal cord examined prior to removal. The exposed underside of the base of the skull can now be examined for fractures [14].

To begin the vertebral artery examination, the brain should be examined for basal subarachnoid hemorrhage, and if present, the basilar artery can be clamped with a hemostat. The skull cap can be replaced to ensure stability. The vertebral arteries can then be accessed from its branching point from the subclavian artery (most often the first branch) and cannulated with an 8F catheter, and secured and sutured to ensure no leakage around the catheter. An anterior–posterior x-ray is then obtained, and each cannulated artery is injected with 3–5 ml of contrast medium repeatedly until the vessel is visible on x-ray. The lesion, if present, can be established radiographically, and the entire neck block can be excised by cutting around the foramen magnum superiorly and disarticulating the seventh cervical vertebra inferiorly [14]. Fixation and decalcification can then proceed, and the vertebral arteries and surrounding tissues can then be exposed and examined.

3.9 Fixation of the brain

The brain is a soft structure that goes into decomposition quickly following death, thus making processing and examination difficulty in the fresh state. In addition, many brain findings can be subtle and require the tissue to sbe in optimal condition in order for these findings to be exhibited. Thus, it is advisable for the brain, following removal from the cranial cavity, to be suspended in a bucket of formalin using a string placed under the basilar artery of the circle of Willis, for at least a week and most optimally beyond 2 weeks prior to cutting into the brain parenchyma. The hardened tissue also provides better exhibits for photographing subtle lesions.

4. Other examination/testing

4.1 Microscopic examination

Some conditions (such as myocarditis) are diagnosed only on microscopic examination, with no specific corresponding gross findings. Forensic microscopy should be a part of investigations of sudden unexpected deaths, determination of the premortem nature of diseases or injuries, and interpretation and substantiation of gross findings (such as in cases of infections and/or malignancies). In my experience, samples of major organs (heart, lungs, liver, kidneys, and brain) should be microscopically examined in every autopsy.

4.2 Toxicology/biochemical analysis

Collection of postmortem specimens for toxicological testing has become almost routine for many institutions involved in death investigation, and can be performed

with or without a complete internal examination. The routinely collected specimens include blood from a peripheral source, urine, vitreous humor, and liver tissue [18]. Other specimens that may be of value include bile and stomach contents.

Blood should be collected from a peripheral site such as the femoral vessels to minimize effects of postmortem redistribution of certain drugs. Collection can be achieved by inserting a large bore needle attached to a syringe through the skin, overlying the location of the femoral vessels (medial anterior inguinal regions), or internally by directly visualizing the vessels during the autopsy. Urine can be collected through the skin as well by inserting needle into the suprapubic area. Vitreous humor is collected by inserting needle into the whites (scleral portion) of the eyes, aiming toward the center of the globes.

Fluid specimens should be deposited and stored in glass tubes with sodium fluoride, to preserve the storage stability of drugs such as cocaine [19]. Vitreous fluid is also useful in the evaluation of diabetic complications, in that glucose and ketones are seen to increase substantially in cases of diabetic ketoacidosis [20].

Conflict of interest

The author declares no conflict of interest.

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