1. Autopsy

Autopsy, Auto-Self, psy-view, means "self-View". It is a special surgical operation, performed by specially trained Doctors called Pathologist, Medical Examiners or Forensic Medicine or Legal Medicine Specialist, on a dead body.

There are many advantages to getting an autopsy. when the law wants to know the Cause of Death & at times, when something interesting for the family to know.

There are many benefits associated with performing an autopsy (postmortem examination) that involve the decedent's family, healthcare providers, the community and public health. Autopsies are divided into 2 categories: medical, authorized by the decedent, decedent's family or healthcare surrogate, and forensic, authorized by statute.

In forensic autopsies, the postmortem examination establishes the cause and manner of death.

Under the laws most of all other nations, autopsy can be ordered by the government like Coroner, Procurator Fiscal, Police or Magistrate. A coroner is a political position, while a medical examiner is a physician, usually a pathologist. Exactly who makes the decisions, and who just gives advice, depends on the jurisdiction. Autopsies can be ordered in every state when there is suspicion of foul play, Accidents, Suicides & Murders.

Regardless of whether an autopsy is for medical or forensic purposes, an informed decision regarding the autopsy begins with knowledgeable pathologists, clinicians, and healthcare institutions. Legal considerations surrounding the autopsy should be considered and included in autopsy discussions. Pathologists need to be concerned with issues of authorization, performance, disfigurement, organ retention, failure to diagnose, and unauthorized release of the autopsy findings (report). The fear of medical negligence lawsuits based on autopsy performance or nonperformance is also of importance to both clinicians and healthcare institutions.

The climate surrounding the Autopsy decision depends on the following factors, first ,it often involves tension among several compelling interests: the goals of the physician (medicolegal, scientific, educational, or clinical), second, the wishes of surviving friends and family (informed by prevailing religious and societal norms), and the third, the interests of society (as articulated by the law). Before discussing the mechanics of requesting an autopsy, it is worthwhile to take a closer look at some of these interests.

One constant aspect of the law regarding autopsy is the distinction between 2 classes of autopsy -- medicolegal or forensic autopsies and medical /Clinical or Pathological autopsies.

Every Country/state has some government apparatus (Procurator Fiscal, Police, Magistrate, coroner's office or medical examiner's office) that is charged with the investigation of "unnatural" deaths. This is generally felt to include the death of any person not under a doctor's care. It always includes cases of death by homicide, suicide, or accident. Society, and therefore the state government, is felt to have a compelling interest in such cases. Consequently, although Legal Authority makes every reasonable effort to respect the wishes of family members, no permission from next of kin is required for the performance of medicolegal autopsies. If families do have religious objections, they may argue their case in court, but the interests of society are usually given priority.

Laws governing consent for autopsy in the World vary somewhat from state to state or Country to Country, but all address the same crucial issues, as follows:

- Who is authorized to give consent for the autopsy?
- Who is authorized to perform the autopsy?
- What limitations (if any) are placed on the autopsy?
- What is the disposition of the tissues that are examined?

Although all valid autopsy permits will address these questions, individual institutions are given some latitude in how they accomplish this.

Notice that the questions surrounding tissue disposition are addressed generally. Specific questions about which tissues are retained, how long they are retained, and how they are eventually disposed of are not addressed in detail; rather, they are left to the discretion of the Doctor/pathologist.

Likewise, the issue of autopsy limitations is addressed in a general fashion, and a space is provided if the next of kin wants to list any specific limitations. There are permission forms which are much more elaborate and deal with the above issues in much greater detail. Some countries Consent forms run in Few pages.

Though the consent for organ donation or use of tissue for research purposes must be obtained separately from consent for an autopsy, some permission forms will provide space for all 3 on the same page.

The permission form must be completed by the deceased's legal next of kin, signed, and witnessed. Under extreme circumstances, if written permission cannot be obtained in a timely manner, then the next of kin can grant permission by phone or fax, again, with an appropriate witness.

However, in certain Countries like UK/USA,

The Number of Doctors required to conduct Autopsies and Method of Autopsies are predetermined,

1. Two doctor case if legal proceedings likely (homicide, road accident).

2. One doctor examination in most non-suspicious cases (accident, suicide).
3. Autopsy **or** external examination only (death obviously natural) at the discretion of the pathologist.
4. External examination ("View & Grant" Preferred) if Fiscal considers an autopsy is not
Necessary

Medicolegal autopsies will be considered first.

1. THE MEDICO-LEGAL AUTOPSY

In a Death Investigation Autopsy plays an important role & equally important are the Circumstances surrounding Death & the Crime Scene,

The aims of death investigation are to answer the following questions:

1. Establish Identity (identification of the deceased)
2. Possible place of Death (place of death)
3. estimate the possible time of Death (time of death)
4. **what cause his death & the Factors contributing to his death** (cause of death)
5. Is Death due to Accident, Suicide, Homicide? (manner & mechanism of death)
6. Collection of Evidence Material, Physical, Material, Biological & Trace Evidence (Evidence)

a. The medico-legal autopsy:

The medico-legal autopsy differs from the hospital autopsy in two major respects:

- besides understand the Causes of Death, it is also important to find answers for What happened, When, Where, How, Why?.
- A complete external examination, Internal Examination with special dissection techniques and collection of evidential materials, all documented in the form of Report.

b. Crime Scene:

- Attendance by police officers, Magistrate, CID, family doctor, police surgeon, forensic pathologist, Photographer,forensic scientists.
- The aim is to collect the maximum of information with the minimum of disturbance.
- Potential for professional conflicts.
- Photography, videos, trace evidence.
- Uphold Chain of Custody

c. Circumstances:

- Social - from Family, relatives, friends, police.
- Medical - from GP, hospital notes. Often indicates the likely cause of death.
- Psychiatric - from GP, hospital notes. May indicate possibility of suicide.
- Technical Evidence-CCTV, Mobile phone, Computer, Social Media Activity.

The Medical Autopsies [Clinical/Pathological]

The postmortem examinations in the hospital setting (medical autopsies) provide confirmation, clarification, and correction of antemortem diagnoses. These in turn Convince the Treating Doctors in understanding the extent of the Disease or outcome of Therapy or procedures & at the same time it reassures the families who have suffered the death of a loved one. Reassurance can take the form of comfort that medical care was adequate or alleviate guilt associated with the death.

The Clinical or Pathological Autopsies can also be of great importance to the medical community. Postmortem investigations allow for the evaluation of new diagnostic tests, surgical techniques, devices, and drugs. The discovery of contagious infections, heritable diseases, and environmental toxins is possible. Advances in the fields of public health and epidemiology further the well-being of society. Postmortem discovery of occupational diseases and environmental hazards provides benefit to the community. Autopsy also provides an extension of medical knowledge and a means to document the health of society by establishing valid mortality statistics, such Autopsies also help the Clinicians to frame the modalities or reconsider the Modality of Treatment or Management of Diseases or Conditions.

In most states, autopsy can be ordered when there is some public health concern, i.e., a mysterious disease or a worry about the quality of health care. In most states, an autopsy may be ordered if someone dies unattended by a physician (or attended for less than 24 hours), or if the attending physician is uncomfortable signing the death certificate to know the actual cause of Death or when there is serious allegations on the treating Doctor for Dereliction of Duties or Reckless management of patient leading to Death.

People authorized to perform/attend an autopsy.

The autopsy is usually done by a pathologist/Physician or Forensic Medicine Specialist or Legal Medicine Expert in all Forensic Autopsies. In Hospital Autopsies, the Hospital pathologist get easy access to pertinent medical records and to the attending physician(s) for consultation before and after the autopsy. Under these circumstances, the autopsy is usually performed without charge to the family, whereas in circumstances where the Family insists on Understanding the Cause of Death than Nominal charges are made.

Occasionally, the family may object to the involvement of the hospital and its pathologists in the autopsy. In such instances they have the right to arrange for their own autopsy. In fact,

some states in US/UK require that the next of kin be expressly told of their option to have the autopsy done by an outside pathologist or at a different facility. Such arrangements must be made by the next of kin and usually involve a fee for the transport of the remains (if necessary) and the performance of the autopsy.

Some states may also require that the next of kin be informed of their right to have a physician of their choice present as an observer during the performance of the autopsy.

Disposition of tissue

In most Countries, cases in which permission for an autopsy is granted, the disposition of the tissues removed and examined is left up to the pathologist. All or some of the tissue may be returned to the body cavity for burial, retained for teaching or research purposes, or disposed of as biohazardous material. However, in certain Nations, the next of kin may decide against any of these options, and they must be specifically told of their right to do so. Although all autopsy permits must address this question, it becomes particularly important when dealing with families whose religious beliefs require the burial of the body in as intact and complete a state as possible (e.g., Orthodox Jews, Muslims, Native Americans). The Disposition of Tissue are well explained under the Human Tissue Acts of the respective States/Countries.

SECOND CHAPTER

1. History of Autopsy

The history of autopsy dates back to ancient civilizations, evolving from early dissection practices to a critical component of modern medicine for determining causes of death and understanding diseases.

Pre Historic

The practice of autopsy can be traced back to ancient Egypt around **3000 B.C.E.**, where early physicians conducted examinations of the deceased to learn about human anatomy and identify causes of death, particularly in murder cases. The Removal of Organs & its Examination was first reported in around 3000 BCE by Egyptians, Mummification was practice during these period.

During the Third Millennium BCE, cause of Death was understood by opening the body, much to the opposition from ancient societies, because they considered that such process prevents the after life of the deceased.

Notably, **Herophilus** and **Erasistratus** in Alexandria performed some of the first documented dissections around **300 B.C.E.**, marking a significant step towards understanding human anatomy. Erasistratus and Herophilus of Chalcedon, who lived in 3rd century BCE were known Autopsists. The Ancient Roman's legal practice had established clear parameters for autopsies in an around 150 BCE. Julius Caesar was the subject of an official autopsy after his murder by rival senators, that was reported in 44 BCE.

In Middle Ages

During the Middle Ages, autopsies were largely prohibited in Europe, but this changed during the Renaissance. Andreas Vesalius (1543) conducted a public dissection of the body of a former criminal. It is still displayed at the Anatomical Museum at the University of Basel. He asserted and articulated the bones, this became the world's oldest surviving anatomical

preparation. His work, *De humani corporis fabrica* (1543), provided accurate descriptions of human anatomy, allowing for better understanding of diseases. Ibn Tufail has elaborated on autopsy in his treatise called *Hayy ibn Yaqzan* and Nadia Maftouni, discussing the subject in an extensive article, believes him to be among the early supporters of autopsy and vivisection. The Arab Physicians Avenzoar & Ibn al-Nafis practiced Dissection of Human remains for Medical & Scientific Reasons.

The Development of Forensic Medicine

In the 13th century, **Song Ci**, a Chinese physician, wrote *The Washing Away of Wrongs*, which is considered one of the first forensic manuals, detailing procedures for investigating deaths. This work emphasized the importance of systematic examination in determining causes of death. In Europe, the practice of forensic autopsy began to formalize, with legal authorities often requiring autopsies in cases of suspicious deaths.

It was Giovanni Battista Morgagni (1682–1771), known as the father of anatomical pathology, wrote the first exhaustive work on pathology, *De Sedibus et Causis Morborum per Anatomen Indagatis* (The Seats and Causes of Diseases Investigated by Anatomy, 1769).

Modern Practices

By the 17th century, autopsies became more standardized, and the practice was increasingly recognized for its value in medical education and legal investigations. Autopsies are now performed for various reasons, including clinical, forensic, and educational purposes, and they play a crucial role in understanding medical errors and disease processes. Carl von Rokitansky and colleagues at the Second Vienna Medical School ((mid-1800),began to undertake dissections as a means to improve diagnostic medicine.[35]

Rudolf Virchow(19th-century medical researcher),established and published specific autopsy protocols. He also developed the concept of pathological processes.

the Scotland Yard ,during the 20th century,created the Office of the Forensic Pathologist, a medical examiner trained in medicine, charged with investigating the cause of all unnatural deaths, including accidents, homicides, suicides, etc.

Present time Significance

Today, autopsies are essential for determining the cause of death, especially in cases of sudden or unexplained deaths. They can provide valuable insights into public health issues and contribute to medical research. Despite their importance, the number of autopsies performed has declined in recent decades, raising concerns about missed opportunities for learning from past medical cases.

Throughout history the autopsy practices reflects a journey from Pre historic or ancient practices shrouded in mystery to a Logical scientific procedure that enhances our understanding of diseases & actual cause of death. The practice of Autopsies has further evolved in identification, collection of evidences and determining the manner of deaths by sophisticated Forensic Scientific Techniques.

Nowadays, the autopsy plays a critical role in the audit and quality assurance of clinical care & Death Investigations.

THIRD CHAPTER

2. Religion & Autopsy

The Different Religions and their Cultures have their own traditions, beliefs, and practices surrounding death, hence they have reasonable conflicts with the traditional Scientific Postmortem Examinations.

Unlike Western Countries have less rigid traditions, religious adhesions & beliefs as compared to the Other Countries across the World pertaining to the traditions,beliefs & practices surrounding death,with dominant religious issues. This Religious influence have grossly affected scientific & medical Discovery in the past.

Religions like Islam and Judaism outright object, in that bodily intrusion violates beliefs about the sanctity of keeping the human body complete, although religious doctrine does not in of itself strictly forbid autopsies.

Hindus have no intrinsic objection to autopsies, but their belief is that all organs must be returned to the body, and those who practice Sikhism believe that the funeral must not be delayed. Christian do not object, but autopsies are not advocated. Buddhism, various Christian sects (eg, Anglican, Church of England, Church of Wales, Episcopal, Church of Scotland, Greek Orthodox, Roman Catholic, Baptist, Methodist), Church of Jesus Christ of Latter-Day Saints, Free Church (Salvation Army, Quakers), and Jehovah Witness doctrines do not state an intrinsic objection to autopsies. Shinto, Taoism, and Confucianism do not prohibit autopsies.

Religious objections to autopsy occur in both medicolegal- and hospital (clinical)-based autopsies. However, in medicolegal cases, as part of the Inquest, autopsy is ordered by a legal authority (Police/Magistrate, Procurator Fiscal, medical examiner or coroner), and permission from the next-of kin is not sought although expressed opposition from the next-of-kin is viewed and dealt with on a case-by-case basis. A number of cases in which an

autopsy was protested on religious grounds have been shown to have hampered or obstructed investigation of deaths in certain countries, including those of a suspicious nature.

Hinduism

The main practice of Hinduism is in the Indian subcontinent, Fiji, Guyana, Trinidad, Mauritius, Suriname, Bali, Australasia, Northern America, and Southeast Asia. Hinduism is more a philosophy rather than a religion and is believed to have originated around 5000 BC in the Indus Valley.

Buddhism, Jainism, and Sikhism grew out of Hinduism and hold some of the same fundamental beliefs including those regarding cremation. It is believed that cremation ushers the soul into the next world or its rebirth into the next life. Hindus believe in a cycle of rebirth and redeath. The central tenet is that of a unitary life force or Supreme Being called *Brahman* that has "no form nor shape, is timeless and eternal, and is believed to pervade everything (animate and inanimate), and everything is it."[-] Hindus also believe in *karma* (actions leave an imprint on the mind and soul) and that humans are ignorant of the fundamental unity of the cosmos and therefore should seek actions that lead to enlightenment of the immortal soul, referred to as *Atman* or *Self*.

For Hindus, the purpose of life is to exit the cycle and enter a state of extinction of passion. Family members must provide a smooth journey to death, because death is not viewed as a finite event. The soul leaves the body during death but is still aware. Therefore, Hindus believe that an autopsy may be disturbing to the soul.[-] A disturbed spirit could reenter the body and not continue life, or it could become evil. In order to appease the soul, mourners pray, and a funeral is held by a priest before cremation. The ashes are spread into a holy body of water.[-] However, Suami Bua stated "In the Vedic Age, dissection and mutilation of body were considered detrimental to the fulfillment of life. Yet, if we consider that once the spirit leaves the body, the lifeless body has no karmic obligations, then it may be okay."[-] In summary, Hindus avoid autopsies but comply if necessary by law.

Jainism also believes in karmic philosophy with the main goal of attaining freedom from a cycle of life, death, and rebirth. Their belief (*Nirvana* or *Moksha*) is that by practicing the right faith, knowledge, and conduct, the soul can attain liberation or enlightenment from pleasures, materialistic possessions, and other sins. Jains also believe that life on earth is not finite but instead a continuum of the cycle of life, death, and rebirth.

The Sikhism belief is that there is one God without form or gender. Sikhs believe that by living a virtuous and dutiful life by following the teachings of gurus (teachers), meditating on God at all times, and doing acts of service and charity, this will lead to the realization of this God and thus break the cycle of birth and rebirth.

Judaism

Judaism is predominately practiced in Israel, North America, and Europe, and it is based on the Torah, which consists of the 5 books of Moses.

Jews believe that the body belongs to God. Therefore, it is questioned whether the person has the right to decide what is done with it following death. Although not encouraged in Judaism, many rabbis agree that if the person willed or sold his body to medicine, the autopsy should be permitted, as this person did not view this as a desecration. Some still implement conditions requiring inclusion of only body parts that would lead to an unknown diagnosis, or conditions which limit the amount of time until burial (ie, prohibiting use in an anatomy class because this would delay burial by several weeks). There are many rabbis who agree that a Jewish person does not contain the right to donate his body in such a way.

Jewish people believe that the dead body should be treated with respect. The prohibition to desecrate the dead is known as *nivel ha'met* ("desecration of the dead"). It is based on a passage from the Torah, which describes treatment of a hanged criminal: the corpse should not be left on the tree; it should be buried the same day. Additionally, the Torah states that the human body must be respected because man was created in the image of God. "Let Us make man in Our image..." (Genesis 1:26) It is accepted that the body itself is not physically an image of God, but the body contains the soul, or *neshama*, which was created in God's image. Therefore, the body remains holy even following death.

In recent history, rabbis have debated whether autopsies should be permitted or not, with no real conclusions. In 1922, Polish medical schools required for admission that Jewish students provide Jewish bodies to dissect. Polish rabbis were questioned and unanimously prohibited autopsy for several years. However, autopsies continued to occur on Jewish bodies, despite these rabbinic conclusions.

In Israel, the controversy about autopsies sparked a serious public and political uprising which lasted several decades. The opening of Hebrew University's medical school was delayed for 22 years because of the issue of human cadaver dissection. In 1928, a professor who suffered from an infection willed his body to medicine and was autopsied with the approval of the Chief Rabbinate in Jerusalem. Such autopsies continued to be performed (rarely) with the patient's family's permission.

In 1947, Hebrew University opened Hadassah Medical School and asked the Chief Rabbinate to explore the idea of autopsy. An agreement between the Chief Rabbinate of the State of Israel and Hadassah Hospital stated that autopsies are not to be done routinely, because they are a desecration of the human body; however, there are 4 conditions in which they are allowed: (1) the autopsy is required by civil law, (2) three doctors determine that the cause of death cannot be determined without an autopsy, (3) three doctors believe that an autopsy will help save the life of others with similar illnesses, and (4) if a hereditary disease is in question, which may affect relatives. Additionally, autopsies for medical education were permitted as long as the patients voluntarily donated their body for this purpose and

all organs and body parts were eventually buried.

When Israel became a state in 1948, it adopted these conditions as laws. In 1953, the Israel Knesset (Parliament) passed the controversial Anatomy and Pathology Law, which expanded the allowance of autopsies (to include, for example, organ transplantation).

The law of 1953 did not specify if the final decision to perform an autopsy lies with the family or the medical authorities, and a set of amendments was later added for this reason. If the deceased did not leave written consent for an autopsy, the next of kin may refuse. If no family is found, the community organization *Chevra Kadisha*, which helps prepare bodies for burials following Jewish procedures, may object to the autopsy as well. Finally, if the body is unclaimed, it may be donated to medical education. Physicians were still able to proceed with autopsy if 3 doctors deemed that a diagnosis could not otherwise be made, but this led to accusations of physicians abusing this aspect of the law.

In 1962, the new deputy minister of heath Yitzhak Raphael was given the responsibility of reviewing this law. Following several committee and even more subcommittee meetings and hearings with many experts, recommendations were published:

- An autopsy can be performed to determine the cause of death if it will save lives or obtain organs for transplantation to a specific recipient(s).
- An autopsy will not be performed if the patient had expressed this choice during their life or if their specific relatives object to it, unless not establishing the cause of death may bring harm to the public or family, or if medical error may be the cause of death (which may lead to more deaths if not uncovered).

Additionally, a control committee was established to contain a rabbi, a Christian clergyman, and a doctor. These suggestions were not fully incorporated into law. Medical professionals enjoyed the freedom they had to perform autopsies without family consent and believed that if this freedom was removed, autopsy rates would drop dramatically.

To appease the public, the laws were rewritten in 1965 in an effort to balance the power of decision making. The revision was widely accepted in the medical community but disliked by religious factions. Hospitals continued to perform autopsies, overriding family members' wishes for certain reasons. Public outcry continued with demonstrations and threats. In one case, the family of an autopsied patient stormed the hospital, causing much physical damage as well as harm to hospital personnel. The Ministry of Health responded by spreading a circular that no patient who refuses autopsies should be admitted to the hospital.

In response, the Chief Rabbinate of Israel published a radical statement: "Autopsy in any form whatsoever is prohibited by the law of the Torah. And there is no way to allow it except in a manner of immediate danger to life..." He added that any autopsy must be approved by a rabbi. This extreme statement incited more uprising among the Israel public and in Jews around the world. Although physicians suffered violent threats, they continued to perform autopsies against family wishes. People were afraid to be admitted to Israel hospitals for fear of dissection. By the late 1970s, however, practice had changed and autopsies were no longer being done without family consent, and an amendment to the Anatomy and

Pathology Law was passed.

In general, autopsies are currently permitted by Jews. The overriding principle is *pikuach nefesh,* or the obligation to save a life. A life is considered one at hand, which in this age is any person all over the world, and it includes future relatives of the deceased who may benefit from knowledge about a hereditary disease. Autopsies should be limited to only relevant body parts, and care should be taken to return as much of the body as possible. Additionally, autopsies should be done promptly in order to allow for a rapid burial. Some families may request that a rabbi preside over the autopsy.

Buddhism

Buddhism consists of 3 major divisions with distinct practices and beliefs. Theravada Buddhism is practiced in Vietnam, Cambodia, Thailand, Laos, Burma, and Sri Lanka, whereas Mahayana Buddhism is practiced in China, Japan, and Korea, and Vajrayana Buddhism is practiced in Tibet and Japan.

According to Buddhist theory, "death occurs when the body is bereft of three things: vitality (*ayu*), heat (*usma*), and sentiency (*viññana*)." There is debate whether these criteria coincide with that of modern medicine. Buddhists believe that the body is a shell for the spirit. A main Buddhist teaching point is that one should not be overly attached to his/her body; inevitably, it will deteriorate with age and then cease to function. The spirit remains following death and is reborn. Where it is reborn is dependent on the person's *karma*, which is a result of his/her past actions. Following death, the body should be highly respected, so that the spirit can concentrate on achieving enlightenment. For this reason, the body should not be disturbed for 3 days or until a religious leader has determined that the soul has left the body. At this time, most Buddhists will be cremated.

Because of the benefits of autopsies, such as educating medical professionals and determining diagnoses, Buddhists generally believe that autopsies are a form of compassion that help preserve life. Bringing justice to a criminal is also honorable, so autopsies can be done when there is a question of natural versus unnatural deaths. Although Buddhists believe that the body should be treated with great respect and it is not proper to desecrate the body, these views about autopsy rely on the intent. The intent of postmortem examination is not to harm the body. Waiting until the soul has left the body is the only major contingency when performing an autopsy on a Buddhist

Christianity

Roman Catholicism

The Catholic Church had shifted their belief to devalue the dead body in an era when the thirst for new knowledge ruled.

Vesalius eventually became the personal physician of Roman Emperor Charles V and Spain's Philip II. Although the Catholic Church had begun to accept the idea of autopsies, new Protestant rule made it even easier for such examinations to occur. For example, in 1565, London’s Royal College of Physicians was granted permission to dissect human

cadavers.

On the other side of the world, an autopsy was performed for religious reasons in 1533. Siamese twin girls were autopsied in Espanola (now the Dominican Republic) in order to define if there was one soul or two. The girls had been individually baptized, and the postmortem examination confirmed that there were indeed 2 souls. This was based on the finding of 2 complete sets of internal organs -- most importantly, the liver.

Today, Catholics accept the value of autopsy and generally agree with its use for medical education, organ transplantation, and determination of diagnoses. It is considered an act of charity to perform an autopsy in order to help others.

Protestantism

The Bible states that the body is made "of dust from the ground" and is a "tent" or "clothes." (Genesis 2:7, 2 Corinthians 5:1-5:5) Therefore, Christians believe that the body is a mortal housing for the soul. However, God "breathed into his nostrils the breath of life" in order to make man, which makes the body a "heavenly dwelling." (Genesis 2:7, 2 Corinthians 5:4)

" (Matthew 8:11) The idea of the spirit leaving the body to an afterlife is again referenced in 2 Corinthians 5:8: "We are confident, I say, and would prefer to be away from the body and at home with the Lord."

God is considered to have taken away physical immortality when Adam and Eve sinned in the Garden of Eden. The Bible acknowledges human decomposition in its statement "unto dust thou shalt return." (Genesis 3:19) However, Christians strongly respect the dead body and undergo several rituals surrounding death, as set by the examples of the burials of Sarah and Abraham. Although there are not specific limitations during autopsies of Christians, the body should always be handled with respect

Jehovah's Witnesses

Jehovah's Witnesses do not believe in hell. Righteous souls are resurrected at the time of the Armageddon, of whom 144,000 will go to heaven, and the remainder of the righteous will remain on an earthly paradise representing the Garden of Eden. Evil souls will be annihilated.

Ecclesiastes 9:5, 10 states, "But the dead know not any thing." The soul is mortal. Jehovah's Witnesses interpret death as a state of pure nothingness -- not even sleep. No thoughts are perceived, no work is done; the dead is conscious of nothing. All future life for that person is based on a hope of resurrection. During resurrection, it is believed God will form a new body and soul for that person based on His memory.

Their bodies are the creation of Jehovah God; therefore, the main obstacle for Jehovah's Witnesses regarding autopsies is mutilation to the body. A Jehovah's Witness should agree to the autopsy when required by law, but the next of kin may request that no organs be removed and that the body be treated with care.

The Church of Jesus Christ of Latter-day Saints

The prophet historian Mormon completed a book of golden plates containing the revelations of many prophets.

Mormons believe in 3 phases of life: before the human form we are spirit-children, followed by life as a human on earth, and then eternal life with God. Following death, the body and spirit reunite to be resurrected into the afterlife. There are 2 forms of afterlife: Paradise for the righteous and Spirit Prison for the evil. Spirits from Paradise visit the Spirit Prison, where they can teach the gospel; if the unrighteous repent, they may be able to move to Paradise. Therefore, the purpose of life on earth is to prove that one is worthy enough to spend his or her afterlife with Jesus and God. Death is an honorable part of this life. Mormons are encouraged to be buried, although cremation is not forbidden.

Regarding autopsies (as well as organ transplantation), Mormons are invited to choose what will give them a feeling of peace and comfort. Most will ask the Lord for inspiration in these decisions. The Encyclopedia of Mormonism (1992) states, "It is one of the methods whereby both those who die and those who examine them contribute to improving the quality of life and health of their fellow human beings."

Christian Science

Christian Science is a belief system rooted in the idea that God's creations are spiritual rather than materialistic.

Christian Scientists will first turn to prayer before attempting cure through medications or surgery. When seeking modern medicine, Christian Scientists will often discontinue their involvement in spiritual healing.

Christian Scientists believe in an afterlife -- what we refer to as death is considered to be just a continuation of the immortal spirit. Death is only a belief, and the religion believes that death doesn't actually exist (although Christian Scientists admit that the physical being ends). In another book by Eddy (a chapter called "Is there no death?" in *Unity of Good*), she states "Because God is ever present, no boundary of time can separate us from Him and the Heaven of His presence; and because God is Life, all Life is eternal." She goes on to state that "Human beings are physically mortal, but spiritually immortal."

There are no specific rituals surrounding death. Funeral and burial matters are up to the individual's wishes. There are no prohibitions against autopsies for Christian Scientists, but in general they are averse to participating in Western medicine practices. Because God is believed to be the only true healer, Christian Scientists may not see the benefit of a postmortem examination. Autopsies should therefore only be done in special circumstances in accordance with the deceased person's wishes.

Confucianism

Confucianism (China-Chinese folk religion), Shintoism (Japan), Taoism (China-Chinese folk religion), and Shamanism do not prohibit autopsies.

With regards to death, Confucius was often criticized for not discussing the matter. He believed that we should focus on the present day and not attempt to seek an afterlife, that one should lead a life with his/her own mission from heaven. Modern-day China remains nearly silent about death.

Burial is the custom in Confucianism. The body is washed and dressed in coarse clothes. Food and significant personal belongings are buried with the person in a coffin. A willow branch represents the person's soul and accompanies the funeral procession, and then is then placed in the family's altar, where it installs the soul of the deceased.

Some historians believe that the Chinese conducted autopsies before the time of Confucius, as their medicine was far more advanced than other empires. Confucius taught that the body was sacrosanct and touching the body under certain conditions was unholy, so autopsies did not agree with his teachings. Confucius also taught that bodies belong not to oneself but to one's parents. Taking care of the body is a way of showing respect for one's parents and, therefore, all forms of mutilation to the body was not aligned with cultural values. The Tang Legal Code, China's earliest recorded law code, condemned destruction of bodies.

In modern times, however, followers of Confucianism do not prohibit autopsy.

Islam

The main issues in Islam involving autopsies are not different from other religions: autopsies delay burials, cause harm to the body, and remove body parts. The benefits are the same also: autopsies can lead to scientific advances, important medical diagnoses and enhance education, among many others.

Muslims undergo several rigid traditions following death. The eyes and mouth should be closed and the limbs should be straightened. The body should be faced toward Mecca, if not already. The body is washed and draped in a specific manner. Several family and community members travel to the deceased and participate in the mourning process. Muslims are always buried without embalming and are never cremated. The deceased should be buried as soon as possible, usually within 24 hours, and the burial should be as close to the site of death as possible, preferably within 1-2 miles. Family members do not eat until the deceased has been buried. Females never attend funerals.

It is therefore clear why autopsies are not encouraged in Islam tradition. First, a postmortem examination would inevitably delay the burial. The Sharia, the book of Islamic law, states that the importance is "in order to bring the dead person closer to what God has prepared for him/her," and to bring God's servant closer to Him. A decayed body is considered repulsive to others. Finally, a rapid burial is beneficial to the community: if the deceased was a good person, then it will be a good deed to hasten his or her journey to God; alternatively, it would behoove the community to free themselves of a bad person as quickly as possible.

There are a few reasons that are reasonable to delay the burial. Egyptian Rashid Rida's *fatwa* of 1910, entitled "Postmortem Examinations and the Postponement of Burial" was

published in *al-Manar*, a weekly, and then monthly, journal. Rida was a well known scholar and politician at the time. He described that a risk of a hasty burial is that the person may not truly be dead. This, he realized, was especially true in the setting of drowning or being struck down during a storm. Therefore, it is beneficial to wait on an official medical examination. Finally, it may take time to obtain camphor (*kafur*), which is the special turpenoid solution used to clean the body. Hence, Rida had determined that there are reasons to postpone burial, and this has led to expansion of his ideas to include medical examination for various reasons.

The Sharia encourages retaining the body in its original form and keeping it as close to the site of death as possible, both of which would be violated by performing an autopsy. Transporting the body to the laboratory may cause physical damage and move the body far from the site of death. However, the Sharia contains a few exceptions to this as well. It explains that if a person had swallowed money which belongs to someone else, it is acceptable to retrieve that money out of the deceased person's abdomen in order to pay his debt, thereby preventing harm to his heirs. Additionally, if a woman dies during pregnancy and the fetus is believed to be alive, some sects of Islam believe that it is proper to remove the fetus with an incision.

The Prophet Muhammad stated that "to break the bone of a dead person is like breaking the bone of a living person" (*Sunan* of Abu Dawood) which has been extensively interpreted in the fields of autopsy and organ transplantation. Some believe that this means that the deceased can still feel pain.

Maslaha is the Islamic principle of "public benefit." It states that when the benefits outweigh the damages, the beneficial approach should be taken. This has wide interpretations and definitely has been used to support the practice of autopsies. H. M. Makhluf's landmark *fatwa* was published in 1952 and represents the Sunni school of thought regarding postmortem examinations. He explained that a doctor is only fully educated when he understands the body inside and out, thereby making human dissection necessary for thorough medical education.[9] He also stated that advances in medicine are supported by the themes of the Sharia. This is an interpretation of the Sharia's ideas about not performing religious duties if health will suffer.

According to the Sharia, people are encouraged to seek medical help when needed and not to exhaust their bodies by performing religious duties. Makhluf even went so far to legitimize voluntary donation of bodies to science. Contemporary Islamic society is sensitive to criticism regarding lack of medical advancement and falling behind Western medicine; therefore, these arguments are taken seriously by the public. However, some believe that animal autopsies should be sufficient.

The Fatwa Committee at al-Azhar of 1982 also based their allowances on *maslaha*: autopsies should be permitted if medical students will learn from them, if justice prevails, and if contagious diseases are controlled. Still, the examination should only take place when necessary and include only relevant body cavities. For instance, in the case of a forensic evaluation for potential murder, if the murderer confesses and is willing to take the proper punishment, then the autopsy is not necessary.

In 1972, the Arab Republic of Syria determined situations in which a postmortem can be performed -- if doctors believe that an examination will be socially useful and the deceased was not opposed when he was alive, or if 3 degrees of relatives do not oppose it. Additionally, the government can overcome objections by the family if the postmortem is used for scientific reasons or to prevent an epidemic.

Egypt's law states that an autopsy can only be performed when there is suggestion that the death was caused by foul play. The Saudi Arabian laws describe a rigid pathway beginning with the doctor's requirement to report a death which is thought to have occurred due to poison or a crime. The doctor must describe the wounds which led him to this belief, and this information will be passed onto a forensic expert, who will perform an external examination of the body as well as any accompanying objects (eg, clothes and personal objects). If the expert deems that a full internal examination is necessary to identify the cause of death, he must obtain permission from the authorities.

In Qatar, the permission of relatives is not necessary if an autopsy is performed for reasons of justice or pathologic diagnosis; however, authorization from the Sharia court is needed for the latter as well as if an autopsy is performed for teaching purposes, in which case the family must consent. A male doctor may not perform a postmortem on a female patient unless it is for teaching purposes or if no female doctor is available.

It is generally agreed that an autopsy on an unidentified person following a severe accident is warranted and does not violate Islamic law. Additionally, when the law of the land requires that an autopsy be performed, the Muslim should comply but inform the coroner's office so that arrangements may be made to proceed quickly. In Islamic countries, when consent from the family is needed, the order of priority is as follows:

Father, son, mother

Brothers and sisters, wife, grandfather, grandsons

Cousins of paternal and maternal uncles

FOURTH CHAPTER

3. Objectives

Forensic autopsy objectives

The goal of all autopsies is to find the cause of death. But forensic autopsies have additional goals or objectives, including:

- Establishing the identity of the deceased person if unknown. Fingerprint and/or DNA testing may help with this.
- Assisting in confirming or refuting the alleged manner of death (like homicide or accident) based on medical evidence.
- Estimating the time since death.
- In case of an Infant, establish Live Birth or Viability

- Collect the Evidence Materials
- Determine the Fatal period.

FIFTH CHAPTER

4. Different Autopsy

There are Four main types of autopsies

1. **Forensic autopsy**

Forensic Medicine/Legal Medicine Specialist/Forensic pathologists ,perform forensic autopsies (medicolegal autopsies) as a part of legal investigations.

this type of autopsy is typically necessary when a death is:

- Unnatural (homicide, suicide or accident).
- Sudden or unexpected (especially in an infant or child).
- Suspicious.

- Unknown.
- Violent.
- Unwitnessed.
- Due to an acute (sudden and severe) workplace injury.
- Related to industrial hazards (like fires and toxic waste).
- Associated with medical or surgical treatment in which there's alleged medical negligence.
- Associated with Surgery/ anesthesia (such as from a surgery or procedure).

The legal authority that requires or directs a forensic autopsy varies across the world. Examples include the:

- Magistrate.
- Police.
- Procurator fiscal.
- Coroner or medical examiner.

2. Clinical autopsy

A hospital pathologist sometimes performs a clinical autopsy (pathological or hospital-based autopsy) in cases of natural death to find and/or better understand the cause of death. They aim to determine, clarify, or confirm medical diagnoses that remained unknown or unclear before the patient's death

The deceased person's next of kin (family members) may ask for this type of autopsy. Or a healthcare provider may ask the next of kin for their consent to do a clinical autopsy.

- ***Anatomical*** or ***academic autopsies*** are performed by students of anatomy for study purposes only.
- ***Virtual*** or ***medical imaging autopsies*** are performed utilizing imaging technology only, primarily magnetic resonance imaging (MRI) and computed tomography (CT).[15]

3. Academic autopsy

The Academic autopsies allow students to practice and develop skills in pathology and become meticulous in later case examinations. Academic autopsies are thus performed by

students of anatomy for the purpose of study, to give medical students and residents firsthand experience viewing anatomy and pathology. Postmortem examinations require the skill to connect anatomic and clinical pathology together since they involve organ systems and interruptions from ante-mortem and post-mortem.

4. Virtual autopsy

Virtual Autopsy is an alternative to routine Dissection of Body during Autopsy, wherein, radiographs are used, for example, Magnetic resonance imaging (MRI) and Computed tomography (CT scan) which produce radiographic images in order to determine the cause of death, the nature, and the manner of death, without applying scalpel on the deceased. Virtual autopsies are performed using radiographic techniques which can be used in post-mortem examinations for a deceased individual. It can also be used in the identification of the deceased. This method is helpful in determining the questions pertaining to an autopsy without putting the examiner at risk of biohazardous materials that can be in an individual's body. It can also hasten the process of Autopsy and also satisfy religious concerns of certain religions.

SIXTH CHAPTER

Autopsy Techniques

- The manner in which an autopsy is performed in order to assess the body externally and internally to Identify & determine the cause and circumstances of death, is called Autopsy techniques. Different Autopsy Techniques are adopted by Autopsy Practioners based on their Training & Experiences. The choice of Autopsy Techniques depends on the Cause & Mode of Death.

General features of Autopsy

- The Incisions adopted must provide ready access to the site of interest while offering an opportunity for excellent reconstruction

- Autopsy Methods vary and may include the removal of organs individually or en masse with subsequent dissection
- Specific dissections may be required depending on the circumstances of death and autopsy findings; techniques vary by autopsy practitioner and some cases may benefit from subspecialist referral

General requirements for an Autopsy

SECTION-1

Prior to autopsy

a. A Request or Order for Autopsy by the Concerned Authority, Magistrate, Police, Coroner, Procurator Fiscal office.
b. Follow local standards regarding Dead Body identification and written consent by first of kin (Pathological/clinical autopsy)
c. Summarize information as available regarding the circumstances of death, if known, including any past medical, occupational and social history, in order to determine the autopsy techniques most likely to yield answers.
d. Information obtained from the Police or the Family members or known Acquaintance of the Deceased on the circumstances leading to the Death.
e. Determine if the presence of police or other specialists (e.g., forensic dentists) is needed
f. Determine whether **radiology** will assist the autopsy
g. Preparation with the Autopsy & Protective Gears
h. Checklist of Evidence packs, Bottles, Syringes, Labels ,Boxes, Preservatives ,Body Diagrams, Recorders.
i. Photographers
j. Decision made on the Autopsy Techniques likely to be adopted in the case,
    - Full 3 cavity examination
    - Limited to particular areas
    - Explore all the Organs System
    - Organs required for Sampling
    - Evidences Selection & Retrieval
    - External / noninvasive only (which may allow radiology and taking of samples via a needle)

SECTION 02.-THE AUTOPSY

A. The Primary skin incisions

a. Anterior body wall incisions
   - Y shaped: most common and with excellent reconstruction results
   - T shaped
   - U Shaped
   - Modified Y Shape
   - I shaped or vertical

b. Scalp Incisions
   - Coronal incision connecting the base of both the Mastoids, behind the ears, in an adult provides ready access for the removal of the crown with excellent reconstruction results as it is behind the hairline

B. Different Autopsy Techniques :

a. Letulle Technique**:**

- Organs removed en mass and subsequently dissected
- Best for observing the pathological and anatomical relationships of structures
- Produces a large, bulky mass with which to work
- In brief
  - After opening the body, remove the distal duodenum to the rectum and dissect the pelvic organs away from the body wall
  - Transect the iliac vessel
  - Free the diaphragm then the retroperitoneal organs (bluntly dissect and pull the kidneys forward) from the body wall around each side to the vertebra
  - Free the neck structures anterior to the cervical vertebrae moving upward to stop once the tongue is free
  - Use the tongue (being wary of damaging the larynx) to strip the organs downward off the vertebrae anteriorly to remove the organs en masse
  - Organs are then usually examined sequentially from the posterior aspect

b. Ghon's Technique:

- Organs removed as organ blocks and subsequently dissected
- Thoracic, coeliac, intestines and urogenital system blocks
- In brief
    - Free the tongue as described for Letulle and strip the organs downward off the vertebrae anteriorly stopping at the lower esophagus
    - Transect the esophagus and descending aorta at this level and remove the thoracic block
    - Tie and cut the duodenal / jejunal junction then the rectum
    - Work from one end of the bowel to the other, cutting across the mesentery close to the bowel wall to remove the intestines en bloc
    - Remove the rest of the abdominal organs with a method similar to Letulle

c. Virchow's Technique:

- Organs removed from the body and inspected one by one
- In brief
    - After opening the body, inspect the abdominal contents and the pleural cavities
    - Open the pericardium and remove the heart, followed by each lung
    - Assess the neck (pharynx, larynx, parathyroid glands, thyroid gland) and remaining organs in the thorax (predominantly the esophagus)
    - Move to the abdomen and remove the spleen, intestines, liver and pancreas
    - Open the stomach in situ
    - Remove the kidneys and adrenal glands from the retroperitoneum, tracing the ureters to the bladder
    - Remove the pelvic organs

        - Inspect and open the large arteries and veins in the abdomen and pelvis

d. Rokitanksy's Technique:
    - Debated as to the exact original technique
    - Organs inspected and incised in situ
    - Considered to provide less information
    - Of benefit if there is a highly transmissible disease

e. In addition to the above Techniques , the Doctor adopts their own modified autopsy technique depending on their training, experiences and the circumstances of the case

f. A thorough documentation of the findings in the form of Sketches, Photographs (with visible identifiers and scale) Diagrams & Digital recordings are essential.

C. After autopsy

a. Consider further investigations

- Histology
- Blood spot card (previously known as a Guthrie card)
- **Biochemistry**
- Microbiology
- Virology
- **Toxicology**
- Genetics
- Other

b. Summarize information to determine the provisional cause of death

c. Compile histology and other investigation results into final report, completed at a later date

01. The External examination

Majority of the Doctors/ pathologists before the Autopsy gather all information and will be eager to find the real answers during the Autopsy. The prevailing mood in the autopsy room is curiosity, scientific interest, and pleasure at being able to find the truth and share it. The procedure is done with respect and seriousness.

The pathologist first examines the outside of the body. A great deal can be learned in this way.

A well Described Gross examination should allow for its reader to visualize and recreate in his or her mind exactly what the Doctor (Pathologist) observed during the postmortem examination; in other words, a well-composed, thoughtful, and detailed description should allow the Author of the report to draw exactly what was observed at autopsy.

The examination begins with confirming the identity of the deceased, noting the location and contents on identification tags.

Any Covering/Clothing over the body to be removed from the body should be examined and documented. In hospitalized children and adults, the contents of any diaper on the body, Chest leads, IV cannula, Catheters, should be examined and documented.

The external examination includes careful examination of the body from head to toe:

First, Examine the body including postmortem changes.

Second, Document Injuries, tatoos, scars, birth anomalies, and other injuries (e.g., abrasions from CPR, ecchymoses from cardiovascular access, etc)

Third, Evaluate interventions (e.g., tracheostomy tube, cardiovascular access lines,Catheters, etc

Anatomic regions of the body

- Head
- Neck
- Torso includes chest and abdomen (anterior) and back (posterior)
- Upper extremity includes the shoulder, arm, elbow, forearm, wrist, hand
- Lower extremity includes the hip, thigh, knee, lower leg, ankle, foot
- Genitalia, perineum, and groins

General Anatomic terminology

Generally, the body can be described with customary anatomic descriptors with the body assumed to be in a standard anatomic position. These terms include: superior, inferior, lateral, medial, anterior, posterior.

For the forearms, which can be in various positions in life relative to the body and standard anatomic position (i.e., arms up in defensive posture, running), better terms to describe lesions include flexor or extensor aspect and radial or ulnar aspect.

Body build

- Small frame
- Medium frame
- Large frame

Body length & weight should always be measured at autopsy & with visual estimation of BMI (i.e., thin, normal, overweight, obese, morbidly obese).

Skin color

- Use objective color, not subjective race or ethnicity
- “White” or “light skinned”, “Brown”, Black” or “dark skinned”
- Avoid using “Caucasian”, “African-American”, “Asian”

If a light-skinned person is tan from sun exposure, you can describe that as “The skin is light with areas of hyperpigmentation on the head, face, extremities, and trunk consistent with sun exposure”.

Postmortem changes

- Rigor mortis: stiffening of the body after death: assessed by flexing and extending joints
- Livor mortis: gravity-dependent pooling of blood in vessels (hypostasis) after death: assessed by firmly pressing for at least 5 seconds and then releasing pressure
- Algor mortis: cooling of the body after death

Common findings

- Pitting edema should be assessed by firmly pressing for 5 seconds on affected soft body parts, such as the medial lower legs and medial thighs.

- Ecchymosis = area of discoloration; unknown etiology

Contusion = ecchymosis caused by blunt force trauma; a “bruise”

Best to use ecchymosis if unsure about etiology of lesion

- Congestion is intravascular
- Hemorrhage is extravascular blood; requires defect in vessel and circulation to defect
- Hematoma is a space-occupying collection of blood; should be measured in cm3

Abrasion = removal of superficial tissue layers (i.e., epidermis of skin or epithelium of mucosa) via blunt force trauma

- Caused by mechanical blunt force trauma applied in a perpendicular (i.e., imprinting) or parallel (i.e., scraping) direction; thermal injury can also cause removal of superficial tissue layers

Tattoos can be important in identification of identity (i.e., unknown decedent) and risk factors for disease (i.e., hepatitis virus infection). They should be described as follows:

- Professional appearing
- Polychromatic or monochromatic
- Anatomic location
- Greatest dimensions
- General description of obvious designs or words or dates

Example description: “On the lateral right shoulder there is a professional-appearing, polychromatic tattoo of a Religion design with the word “Rama”, up to 4 in x 4 in.”

Evidence of Postmortem Tissue Harvest for Donation

- **Bilateral eye tissues**
- Long bones of each upper and lower extremity. Each anterior arm shows a linear incision closed with a running suture extending from the anterior shoulder to the antecubital fossa. Each medial lower extremity shows a linear incision closed with a running suture extending from the lower abdomen to the foot. Hard cylindrical pieces of material are palpated in place **of the harvested bones.**

Example description: “In each Lower extremity there is a recent incision closed with a running suture extending from the Right anterior hip to the proximal thigh (right 37 cm, left 40 cm). In each upper extremity there is a recent incision closed with a running suture extending from the anterior shoulder to the medial elbow (right 95 cm, left 92 cm). Cylindrical segments of hard material are palpably present in the place of long bones underneath each of these incisions. In the torso there are two intersecting linear incisions closed with running sutures extending from the manubrium to the symphysis pubis and across the middle torso. Subsequent internal examination reveals an incision through the anterior chest wall and absent tissues and viscera including left lung, heart, aorta, liver and gallbladder, kidneys, adrenal glands, and a segment of distal small bowel into proximal colon. The residual terminal small bowel and proximal colon margins are stapled. The spleen and pancreas have each been sectioned; nearly 1/3 of the spleen and distal one half of the pancreas are absent. The diaphragm is disrupted and the remaining gastrointestinal tract has been displaced into the thorax. There is scant serosanguineous fluid in the torso.

Evidence of Therapeutic Intervention

- Orotracheal tube terminates in the trachea
- Orogastric tube terminates in the stomach
- Cardiovascular access line in right wrist.
- Foley catheter in urinary bladder and penile urethra.
- Findings consistent with cardiopulmonary resuscitation:
- A circular, brown-red, dry abrasion on the middle chest, ~5-6 cm diameter
- Multiple bilateral anterior rib fractures
- Localized hemorrhage in anterior mediastinum.

Vocabulary

- Bilateral: Doesn’t need to be used when describing a change present in both of two organs (e.g., lungs, kidneys, adrenals, upper extremities, feet, etc)
- Slight versus Mild: Mild is for temperature (weather, salsa)
    - Use: Slight/Moderate/Marked

02. The Internal examination

Skin Incision: The body is opened using a Y-shaped incision through the skin from the acromioclavicular joints on the anterior aspect of each shoulder, to the xiphoid process, and then down the midline to the symphysis pubis and a little beyond over the anterior edge of the pubic bone. from shoulders to mid-chest and down to the pubic region. If the head is to be opened, the pathologist makes a second incision across the head(Coronal Incision), joining the base of both the mastoids behind the ears. The skull vault is opened using two saw cuts, one in front, and one in back. These will not show through the scalp when it is sewed back together.

The Y shaped incision carefully enter the peritoneal cavity by cutting through subcutaneous fat, muscle and deep fascia, extraperitoneal fat and peritoneum. Avoid puncturing the bowel doing this. Extend this incision from the xiphoid process to the pubic bone. In order to wisely expose the abdominal organs, sharply dissect the skin and subcutaneous fat layer from the thoracic cage surface and costal margin to form a large flap extending down to the posterior axillary line on each side.

The chest organs, including the heart and lungs, are inspected. Sometimes the pathologist takes blood from the heart to check for bacteria in the blood. For this, he/she uses a very large hypodermic needle and syringe. The pathologist may also find something else that will need to be sent to the microbiology lab to search for infection. Sometimes the pathologist will send blood, urine, bile, or even the fluid of the eye or samples of brain and/or liver for chemical study and to look for medicine, street drugs, alcohols, and/or poisons.

Then the pathologist must decide in what order to perform the rest of the autopsy. The choice will be based on a variety of considerations. The narration below will use the method of Letulle's or Ghon's Technique, Enbloc or Bloc wise eviseration.

Evisceration principle (Letulle / Ghons Technique).

Evisceration is then executed by a combination of gentle but steady traction on the trachea an esophagus, and blunt and sharp dissection of the prevertebral fascia and diaphragmatic crura from the thoracic inlet to and including the presacral fascia. The bilateral retroperitoneal organs, including the kidneys, adrenals and ureters readily accompany the organ block in the process, because they are anchored in place by their blood supply, and retroperitoneal fascial planes. Furthermore, the fatty soft tissues posterior to these organs are readily separated by blunt dissection and gentle traction. The testicles are removed by dissecting open the inguinal canal, and forcibly extruding the organs into view by scrotal pressure.

Evisceration Details: The viscera from the thoracic inlet to pelvic can be regarded as disposed into two major regions. One is intra-serous, insofar as the organs are lined by a

visceral pleura and peritoneum, and are in serous cavities lined by parietal pleura and peritoneum. The other major region is retro-serous, including the retropleural and retroperitoneal spaces, which contain the aorta, the superior and inferior vena cavas, the azygos vein, the thoracic duct, the esophagus, duodenum, pancreas, adrenals, the urinary system, the rectum, vagina and prostate gland. Evisceration requires four dissection procedures designed to separate all the viscera in one large block from the body cavities:

a. The variable line of reflection of the visceral serosa onto the parietal serosa has to be continuously cut from the thoracic inlet to the lateral
b. pelvic wall, and then medially on each side to the edge of the divided anterior parietal peritoneum at the inferior end of the abdominal wall incision at the symphysis pubis. The continuity of this serosal reflection is interrupted by the diaphragm, which is first eliminated by circumferentially cutting its origins from the infer surface of the costal margins, and from the internal and external arcuate ligaments.
c. The branches of the aorta and vena cava supplying the head, neck, pelvis and upper and lower extremities must be transected.
d. The superior aspects of the respiratory tree and alimentary canal, and the inferior portions of the alimentary canal and genitourinary systems must be transected. The upper transaction is through the thyroid-hyoid membrane and hypopharynx. The rectum, vagina and urethra are transected in the female and the rectum and membranous urethra in the male.

The prevertebral fascia loosely binding the retroserous structures to the vertebral bodies must be separated by blunt and sharp dissection from the cervical vertebra down to and including the sacrum. The continuity of the prevertebral fascia is interrupted by the lumbar vertebra. These muscular origins must be completely severed. The completion of these four procedures mobilizes the entire block organs, which can then be lifted out of the body cavities.

Mobilization of neck organs.

Transect the thyrohyoid membrane and hypopharynx with a scalpel. Take care not to nick the common carotid arteries in the process by identifying the carotid sheath and its contents, and retracting them laterally. Direct the cutting edge of the blade from the lateral edge of the thyrohyoid membrane towards the midline rater than in the reverse direction to avoid puncturing the carotid arteries, which are essential for adequate embalming of the head, and the face, in particular. The epiglottis will come into view after the thyrohyoid membrane is cut. Pull it anteriorly with forceps, and cut the lateral and posterior walls of the hypopharynx behind it, bringing the cutting edge of the blade down to the underlying vertebral body. The neck organs are mobilized by blunt dissection of the prevertebral fascia down to the thoracic inlet.

Removal of the sternum: Sharp dissect the skin, muscle and subcutaneous fat of the cervicothoracic flap from the xiphoid process superiorly to the level of the hyoid bone. Take great care to avoid cutting the skin of the neck. Mobilize the sternum by cutting ribs and the clavicle along a line extending inferolaterally from the midclavicular line at the first rib to the anterior

axillary line at the inferior margin of the thoracic cage. Place towels on each side over exposed cut margins of the clavicle and ribs. The cut ends of the ribs are razor sharp in places and must be covered with a towel to avoid serious injury. This is one of the most common causes of skin cuts sustained during an autopsy and can be prevented. Mobilize the sternum further by cutting the sternal and costal origins of the diaphragm and by blunt dissection of the substernal soft tissues. The sternum is then freed by cutting the internal mammary vessels and the sternal origins of the sternohyoid and sternothyroid muscles.

Mobilization of thoracic organs.

Carefully lyse all adhesions, if any, binding the lungs to the parietal pleura. Circumferentially cut the origins of the diaphragm from the inner surfaces of the costal margins and the arcuate ligaments up to the anterior vertebral surface where the crura of the diaphragm arise. Begin the cutting of the line of reflection of visceral onto parietal pleura at the thoracic inlet, by cutting the apex of the parietal cervical pleural lining the dome of the pleural cavity. The cut is made with scissors pointing towards and ends on the anterolateral aspect of the vertebral column. The right brachiocephalic vessels, the left brachiocephalic vein, common carotid and subclavian arteries hug the underlying domes of the cervical pleural, the head and upper extremities. Continue the medial end of the cut across the cervical pleura inferiorly along the anteriolateral aspect of the vertebral column past the level of the mobilized diaphragm. Direct the cuts inferolaterally on the posterior parietal peritoneum to join the upper ends of the lateral paracolic peritoneal incisions made previously to mobilize the right and left colons.

Exploration of the Peritoneal Cavity and Removal of the Intestines: Palpate the liver, spleen and kidneys. Examine the pelvic organs. Determine the level of the domes of the diaphragms with respect to ribs and intercostal spaces in the midclavicular line. Cut through the transverse mesocolon and adherent omentum to visualize the lesser sac and the body of the pancreas. Examine the small and large bowel in situ by palpation and observation from the ligament of Treitz down to the rectosigmoid junction. This is called “running the bowel”. Make bilateral incisions with a scalpel in the posterior parietal peritoneum in the paracolic gutters from the diaphragm down to the lowest extent of the cut peritoneum at the symphysis pubis. Mobilize the right and left colons by blunt dissection of the fascia of fusion* of the mesenteries of the two colons to the posterior parietal peritoneum. Remove small and large intestine from the ligament of Treitz to the rectosigmoid colon. Place two ties at each end of the bowel to be removed, one pair at the ligament of Treitz, and the other near the rectosigmoid junction. Cut between the ties to avoid bowel content spillage. Cut the mesenteric attachments of the bowel very close to the mesenteric border of the bowel so that the bowel is excised as a straight uncoiled tube.

Mobilization of the pelvic viscera.

Make certain that the lateral paracolic peritoneal incisions are extended infero-medially along the pelvic brim to the cut margins of the parietal peritoneum at the inferior end of the midline

abdominal incision. Identify the ureters passing over the pelvic brim, and avoid cutting them in the process of transecting the external and internal iliac vessels at and below the pelvic brim. Free the anterior aspect of the urinary bladder from the pubic bones by blunt manual dissection of the retropubic space. This manual dissection is continued laterally, posteriorly over the sacrum, and inferiorly around the rectum, urinary bladder and genital organs. The mobilized pelvic block of pelvic organs must be free of all attachments to the anterior, lateral and posterior pelvic walls, when this dissection is completed. It remains to transect the pelvic organs just above their openings through the pelvic diaphragm to mobilize the pelvic block. The mobilized organs are grasped with one hand and, in the male, the membranous urethral below the prostate gland, and anorectal junctions are transected. In the female, the urethra, vagina and anorectal junctions are similarly cut.

03. HEAD DISSECTION: Scalp, Skull & Brain

A. Opening the Skull:

Separate the hair and incise the scalp across the vertex from one mastoid process just behind the ear to another.

Reflect the scalp forwards and backwards past the hairline. Note injury to skull or deeper tissues of scalp.

Cut temporalis and masseter muscles on either side.

Cut the calvarium with the saw in a slightly "V" shaped fashion. Remove the skull cap by inserting and twisting chisel at the sawline.

Examine meninges and note extradural or subdural hemorrhage if any.

Removal of the brain and spinal cord: The brain and spinal cord can be removed en bloc in both approaches. In general, the ventral approach is easier in adolescence and adults. The dorsal approach is easier in fetus, infants and children.

- Ventral approach: The brain and the spinal cord can be removed by a ventral approach after the thoracic and abdominal organs are removed. This is perhaps the most commonly used method. This approach is also of particular value if pathology of the body of the spine.
- Dorsal approach: The brain and spinal cord can also be removed by a dorsal approach. This approach is exceptionally valuable when pathologic changes and trauma to the neck and vertebral arteries are suspected since these structures can be dissected and examined in great details in this approach; it is also useful in identifying spina bifida and in cases with meningocele, meningomyelocele and similar conditions. This approach also allows in situ recognition of tonsillar herniation.

Dislocation of the odontoid process: Put your finger in to the foramen magnum and rotate the head. If you can feel the odontoid process, it is dislocated.

Cervical spinal injury: run your fingers on the dorsal surface of the cervical-medullary junction and the cervical cord while the cord is still fresh. Softening can be felt when there is injury at the cervical-medullary junction. This method is not going to work in fixed bodies and also in cases with the brain and spinal cord removed from the dorsal approach (the atlas has been cut).

Cranial base fracture: The dura should be stripped off. The cranial vault and base should be shaken in frontal-occipital direction and then lateral direction to look for fracture line.

***En bloc* removal of the brain and spinal cord:** The brain and spinal cord should be removed *en bloc*, preferred with neck dissection and dorsal approach, if the following conditions exist:

- History of trauma to the neck (iatrogenic, intentional, and accidental) or shaken-impacted baby syndrome.
- Sign of injury of the neck on external examination during autopsy.
- The lesion is in this region (e.g., brainstem glioma, Chiari malformations)
- The cause of death cannot be explained by the general autopsy, particularly with the history of a feverish illness.
- Clinical history referring to abnormalities of cranial nerves.

CSF: A good volumne of CSF uncontaminated by blood can be taken from the interpeduncular cisterna by using a syringe and a needle. This procedure must be done before the spinal cord is dissected out otherwise the CSF would not be blood free. Attempts in removal of CSF from the ventricles are far less likely to be successful.

Surrounding tissue: The brain maintains an intimate and important relationship with the surround tissue, namely the dura and the cranial bone. This relationship can only be examined during the autopsy. When the body is returned for burial, it would be returned for good in most cases. It is of paramount important to examine the canial bone, the vertebral column and surrounding tissue during autopsy. When the patient has a history of the following conditions, a detailed examination of the cranial base and the vertebral column is always called.

- Intracranial hemorrhage
- Visual disturbance
- Sellar mass
- Aneurysm
- Focal cranial nerve symptoms
- Trauma and suspicion of child abuse
- Cranial base tumor and bone tumor
- Pathologic changes in the vertebral column.
- History of severe infection of the head (such as sinusitis and dental abscess) or the

spine.

The eye and optic nerve: Removal of the eyes and optic nerve is mandatory in cases of child abuse particularly in shaken baby syndrome. The eyes and optic tract should also be removed if there is suspected pathologic changes.

The middle ear: This is particularly important in children with meningitis as the middle ear can be a source of infection. The middle ear should be removed en block with the surrounding bone, fixed, decalcified, and the sliced and submitted for microscopic examination.

Carotid arteries: In case of stroke and particularly an embolic stroke is suspected clinically, the carotid arteries on both sides should be dissected and evaluated for atherosclerosis.

The vertebral arteries arise as the first part of the subclavian artery, transverse the foramen of the 6th cervical vertebra, and ascend through the transverse foramina of all higher cervical vertebrae. The artery pierces the atlanto-occipital membrane and the dura mater to enter the posterior cranial fossa through the foramen magnum.

Delicate portion: The segment of vertebral artery after the transverse foramen of the atlas and before entering the foramen of magnum do not have strong mechanical support and is very vulnerable to injury, in particular, twisting of the neck. A blow to the jaw resulting in a sudden twist of the head can injure this vessels and lead to sudden death. Injury of this segment of the vertebral artery will always result in blood accumulating in the cisterna magnum.

Blood in cisterna magnum: Blood in cisterna magnum is highly suggestive of of damage to the vertebral artery particularly if there is a history of trauma or a suspision of foul play. In forensic examination, a dissection of the vertebral column at the level of the foramen magnum is mandatory.

Fixation and processing

Culture: Appropriate cultures should be taken.

Frozen tissue: Frozen brain tissue, usually from the frontal lobe, should be stored fresh frozen if metabolic diseases are suspected.

For adequate fixation: 6 liters of formalin should be used per brain for optimal fixation. This is often difficult to perform because of its volume. The brain should at least be fixed in 2 liters of 20% formalin for two to, preferably, three weeks. For brains from adults and children older than one year, the brain can be kept from from distortion due to fixation by hanging the brain in formalin. The more common way is to hang it with a string passing through the basilar artery. Alternatively, the dura can also be used if it remains attached to the brain.

Alcohol hardening protocol for fetal and infantile brains (Modified from Rorke and Riggs, 1962): Fully fix the brain in 4% formaldehyde solution. Cut the brain into thick three or four slices. Transfer them to a mixture containing formalcohol (80% alcohol: 37% formaldehyde solution= 9:1) and let it fix for a week. Transfer the sections to 80% alcohol for 5 days and

then to 95% alcohol. The condition of the tissue at this stage determines how long it is kept in the 95% alcohol.

Floating fetal and infantile brain: It is often impossible to hang a fetal or infantile brain in formalin. Fetal and infantile brains contains more water than adult brain and can therefore be floated in formalin in formalin more concentrated that 10%. This can be achieved by adding undiluted formalin to the formalin solution slowly until the brain float. This will avoid distortion due to fixation. As the brain is being fixed in the following two to three days, it will attain the same density as the formalin and sink. By then, the sunken brain will not distort further and it will not be necessary to add additional formalin.

Blood: Brains with hemorrhagic lesion will release a large amount of blood into the formalin. Brain are often not well fixed in bloody formalin. It is necessary to replace the bloody formalin with fresh 20% formalin on the second day after the autopsy.

Volume of blood loss: It is often difficult to estimate volume of the blood clot, the weight, however, is easy to get and would also accurately reflect the size of the hematoma.

Removing blood clots:

- Fresh blood: If there is a ruptured aneurysm of the brain base accompanied by a lot of hemorrhage, the circle of Willis should be dissected out before fixation. Otherwise, the fixed blood clot will greatly hamper the dissection of the vascular structures that make the diagnosis of aneurysms difficult.
- Fixed blood clots: In case if a brain with a ruptured aneurysm or AVM accompanied with a fixed blood clot is received, the blood cand be dissolved away by placing the fixed specimen in detergent solution for a few days.

Paraneoplastic disease: In addition to the brain and spinal cord, the following samples are needed,

- Serum: Stored frozen.
- CSF: Stored frozen.
- Brain, spinal cord, and dorsal root ganglion: Frozen tissue should be procured from suspicious area and frozen in OCT for future frozen section.
- Tumor under question: Frozen tissue in OCT.

Brain weight and size

Head circumference: The head circumference in infants and fetus should be measured. The biparietal diameter is more meaningful if the fetus is under 22 weeks of gestation.

Accuracy: The use of brain weight as a reflection of brain volume is accurate only if there is no severe edema, congestion, or loss of ventricular CSF during the weighing process. In severe brain edema, the brains have a strong tendency to bulge out; these brains often appear too big to fit into the cranial cavity. This phenomenon is particularly prominent in children and infants.

Sex: Male brain is about 10% heavier than female brain.

Brain weight is about 380 g at birth; 970 g at 1 year; 1120 g at 2 years; 1300 g at 5 years; 1400 g at 10 year; 1450 g at 19-21 year; 1430 g at 50 year; 1370 g at 60 year; 1330 g at 80 year. In females the maximum is 1340 g at age 18, which declines to 1140 g at 80.

During gestation, the brain weight to body weight ratio is about 1:7-8.

Cerebellum: In fully-grown human brain, the posterior tip of the cerebellum should parallel the occipital tip. In adult, the cerebellum represents about 12% of the total brain weight. In very young infants, the cerebellum represent only about 5-8% of the total brain weight. The posterior margin of the cerebellum typically falls short from the tip of the occipital lobe.

Blood vessels

Introduction: Blood vessels and dural sinuses must be examined *in situ* carefully if there is epidural and subdural hemorrhage. Hemorrhage into the interpeduncular cisterna (basically a form of subarachnoid hemorrhage) in an adult is very suggestive of a ruptured aneurysm. In premature newborns, hemorrhage in the interpeduncular cisterna and cisterna magna is often, but not always, resulted from extension of an intraventricular hemorrhage as a complication of prematurity.

Internal carotid artery:

- The internal carotid artery is traditionally separated into 4 parts: the cervical part, the intrapetrosal part, intracavernous part, and the cerebral (supraclinoid) part. The later two are also known as the siphon of the internal artery.
- For radiology interest: The internal carotid artery enters the dura around the level where the branch of the ophthalmic artery arise. Rupture of aneurysm below this level should not give rise to subarachnoid hemorrhage.
- Anastomosis: The anastomosis of the internal carotid and external carotid artery through the opthalmic artery represent an important anastomotic pathway. If this anastomosis is normal, even complete occlusion to one of the four major blood supplies to the brain may not necessarily lead to insufficient regional blood flow of the brain.

Circle of Willis: A complete circle of Willis is found in only 25% of human subjects and does not but itself represents pathologic changes.

Atherosclerotic changes: They are common in the major arteries particularly the basilar artery and the circle of Willis. I have derived a grading system of atherosclerosis (Fung's classification):

- Grade 0 (Normal): Vessels are semi-transparent, soft, thin, and collapsed. Blood can be seen through the blood vessels.
- Grade 1: Vessels are less transparent, appears slightly opaque and thickened, but remain soft and not dilated. They do not collapse completely.
- Grade 2: Vessels are ectactic, rigid, fibrotic and have a rigid lumen. No narrowing or obliteration is present.

- Grade 3: Vessels are ectactic, fibrotic, and calcified. The wall is partially thickened and lumen is significantly narrowed or obliterated. The extent and location of obliteration should be documented.

Spinal infarction:

- Spinal watershed areas: The upper thoracic (T1-T4) and first lumbar (L1) spinal segments are among the most vulnerable regions of the spinal cord for infarction. The intercostal arteries do not interconnect with other arteries in the same extensive fashion as the other extraspinal arteries in the cervical and lumbosacral regions.
- Dissecting aneurysm: Occlusion of one intercostal artery in a vulnerable region can result in a spinal cord infarction. This clinical picture is seen with dissecting aneurysms of the aorta or as a result of surgery on the aorta where more than one intercostal artery may be occluded.
- Artery of Adamkiewiczi: this is a major arterial supply to the spinal cord and must be safed during kidney transplantation. Otherwise, the patient will develop spinal infarction.
- The anterior portion of spinal cord at T4 and L1 level are also susceptible to vascular insult.

Blood in spinal subarachnoid space: A small amount of blood in the spinal subarachnoid space is a common feature in infants sustaining respiratory distress.

Batson's plexus: The paravertebral venous plexus of Batson forms and extensive system of venous channels both within and alongside the spinal canal providing direct communication from peritoneal sites and the lower body to the cranial cavity. There are no valves in Batson's plexus and flow may be bi-directional during the Valsalva manoeuvre or a change of body position. This plexus is also a favorable place for metastasis particularly mammary and prostatic carcinoma.

External examination Brain

Dissecting the brain:

- Brain can be fixed in 10% formalin to dissect later or it can be dissected at the moment.
- a fixed brain provides the ability to complete an examination in finer detail with better photography and histology (including immunohistochemistry), which allows for better specialist neuropathological outcomes
- Weight should be taken and excess blood removed prior to fixation
- There are many methods to fix the brain
    - It can be suspended upside down in a large bucket of 10% buffered formalin for at least 4 weeks; suspension methods include resting in a hairnet or with the basilar artery tied with string to the handles of the bucket

    - Formalin should be intermittently replaced (an example routine would be after ~3 days, then every week); high strength formalin (37%) can be used

- Short fixation period (1 - 4 days) may be useful in some circumstances as a compromise

General:

- The brain should be examined in a systemic manner. The first step is to look for missing structures. The brain is a symmetric structure and it is always helpful to compare one side with the other side; it is also important to examine the symmetry of both sides.
- The size, location, macroscopic features of the lesions should be documented. Palpation of the brain is important because early infarction is more likely to appear as softening with minimal color changes. They are far more easily detectable by palpation than visual examination.

Herniations: The types include cingulate (falcine), uncal (hippocampal, transtentorial), tonsillar (cerebellar), upward herniation of the cerebellum, transclavarial (fracture) herniations.

Cingulate herniation:

- **Parasagittal infarction:** Cingulate herniation can compromise the flow of the anterior cerebral artery and lead to parasagittal infarction.
- Degree of aurosal is usually invertly proportional to the degree of deviation of the septum pellucidum and the aqueduct.

Uncal herniation:

- Grooving of the parahippocampal gyrus. Lateral compression of the upper brain stem.
- The posterior cerebral artery can be compressed by a herniated uncus easily. Compromised blood flow of the posterior cerebral artery may lead to infarct of in its territory that include the visual cortex. Blindness can be resulted. When it occur on one side, homonymous hemianopia will occor.
- Kernohan's notch: notch on cerebral peduncle on the side contralateral the uncal herniation. Causes hemiparesis ipsilateral to the herniated side.
- Diencenphalic downthrust: In the case of uncal (tentorial) herniation, this can be assessed by the noting the position of the mammary bodies in relation to a line joining the lateral angles of the inferior horns of the lateral ventricles (Greenhall line). Normally the mamillary bodies lie 1 or 2 mm above this line. A severe downthrust brings them 5 mm or more below it.

Tonsillar herniation:

- Herniation of the tonsillar will lead to compression of the brain stem.
- In neonates, particularly premature infants, the herniated tonsil has a high tendency to undergo necrosis. It may be so severe that the herniated portion of the tonsil disappears and the subarachnoid space of the spinal cord is filled and expanded with necrotic cerebellar tissue. In less severe cases, microscopic fragments of cerebellar tissue can be found in the spinal subarachnoid space.

Upward herniation of the brain stem and cerebellum: this may be resulted from an increase in pressure in the brain stem (e.g. tumor), or a sudden decrease of pressure in the cerebellum (e.g. sudden withdrawal of fluid from the lateral ventricles). In this case, the upper surface of the celebellum will appear convex instead of the usual slightly concave.

Superior cerebellar artery: this artery may be compressed by the upward herniation upon the free edge of the tentorium and lead to infarction of the cerebellum.

Shape:

- The shape of infantile brain is overall more round than adult brains.
- Patients with Down's syndrome may have a box shaped brain.
- Childhood or infant brain with history of prematurity often has elongation along the anteroposterior axis.

Operculum: In mature full term infant, the operculum should be big enough to cover the insula completely.

Melanin pigment is not infrequently seen on the surface of the brain especially in black patients. The two most common sites are the inferior surface of the frontal tip and the anterior surface of the medulla.

Olfactory bulb and tract: It is sometime difficult to tell if the olfactory bulb is congenitally absent or not lost when the brain is removed. If the olfactory bulb is present, there will be a straight sulcus at the place of the olfactory tract. The olfactory bulb can be congenitally absent in only one side.

Fetal cortical convolution: The pattern of convolution in brains and the brain weigh of newborn may reflect the age of gestation more accurately than the body weight. That is, the body weight too high or too low for the gestational age but the brain weight corresponds more accurately for the gestational age.

Epidural hematoma usually produces more flattening of the gyrus than subdural hemorrhage.

Edema (including edema associated with meningitis) in an eldery patient with cortical hemorrhage can be missed easily because of the dilated ventricles.

Brownish discoloration of the cortex in elderly patients is due to lipofusin deposition.

In alcoholic patients, there may be multiple areas of hemosiderin staining on the brain surfaces indicating prior injuries to the brain due to falls.

Hemorrhage in the falx: Small intra-falcine hemorrhages are common in premature babies

and usually do not carry serious clinical significance. They are particularly common in those with induction.

Pontomedullary Junction:

- Forensic medicine: Hyperextension of the neck, frequently seen in shaking baby syndrome and neck injury in motor cycle accidents, the anterior surface of the pontomedullary junction may be coated with a very small amount of blood. Do not ignore these blood. Very frequently, there is a laceration separating the pons from the medulla and can be demonstrated easily by making a cut along the long axis of the brain stem along the mid-line.

Cut sections

Common artefacts: 'Swiss chess' artefact, toothpaste softening, pink haloes (a few mm in diameter, around small blood vessels).

Classical cutting sequence (coronal plane):

- First make a coronal cut at the level of the mammary bodies to separate the brain into a frontal half and an occipital half. The slices the frontal half of the brain into 0.8 cm thick slabs on the coronal plan.
- For the occipital half, examine the cerebral peduncles. Then remove the brainstem by making a cut at the horizontal level of the tips of the mammary bodies. Make sure that this cut is perpendicular to the long axis of the brainstem.
- Slice the occipital half of the cerebrum in to 0.8 cm slabs.
- Remove the brainstem from the cerebellum by cutting the cerebral peduncles. It is easier to approact it from the rostral end. Note: It is better to cut the cerebellum with the brainstem attached in horizontal plan if pathologic changes at the cerebellar peduncles and white matter diseases are suspicious.
- Slice the brainstem into 0.3 cm horizontal slabs.
- Slice the cerebellum into 0.3 cm sagittal slabs.

Premature fetus and neonates: Remove the brainstem by making a cut at the cerebral peduncles. Cut the cerebral hemispheres in coronal plane, the brainstem and cerebellum in horizontal plan.

Other plane: The brain can also be cut in horizontal and sagittal plane. These planes are often very useful for pathologic-radiographic correlation.

"Ribbon effect" or "reverse effect": first described by Larroche. This is not found in adults and is sometimes dramatic in neonatal hypoxic-ischemic injury. This refers to a diffuse reddish-brown color of the white matter while the neocrotic cortex is unusually white. Simply, the adult pattern of darker cortex and lighter white matter is "reversed" in these cases.

The substantia nigra starts to develop pigment at round 3-5 years old and is completely pigmented at about 18 years old.

Hydrocephalus: The anterior tip of the lateral ventricle should not protrude farther than the tip of the temporal tip. Otherwise, hydrocephalus should be suspected.

The thickness of the cortical ribbon is about 0.25 to 0.5 cm. The general trend is that the primary sensory cortex such as the visual cortex is the thinnest. The motor cortex is the thickest. The association cortex is in between.

Pontine tegmentum: The thickness of the pontine tegmentum of the pons should be about half as thick as the basis pontis.

Septum pellucidum is frequently disrupted in fetus with hydrocephalus.

Vertebral artery dissection (in situ or en bloc removal)

- Indicated for circumstances of death suggestive of arterial injury, such as relatively minor neck trauma (e.g., sport, osteopathic manipulation, low speed motor vehicle incident, fall from standing height, unilateral blunt force injury to the mandible) with delayed sudden death or stroke symptoms prior to death
- Consider postmortem angiography as a guide to a site of suspicion or as an alternative to dissection.
- Dissection can involve removal of the entire cervical spine en bloc with subsequent fixation and decalcification before examination or in situ identification of the artery as it traverses from its origin in the thorax, through the lateral pedicles of the inferior cervical spine to the posterior elements more superiorly
    - This latter dissection requires significant time and skill and has a high rate of iatrogenic injury; access is gained through a posterior neck dissection as detailed below .

Removal of the orbital contents

- Most commonly indicated in pediatric nonaccidental injury cases .
- Do not aspirate vitreous humor prior to examination as the retina may be damaged
- Several methods exist
    - One approach is to remove a flap of bone from the anterior cranial fossa with an oscillating saw; the orbital contents are carefully separated from the surrounding bone circumferentially both anteriorly to meet the conjunctiva and posteriorly to include the optic nerve

- Further dissection of the eye is best done after fixation in formalin (at least 48 hours is usually recommended)

Dissection of the middle ear

- Most commonly indicated for systemic sepsis of unknown cause
- Methods range from simple (but destructive) removal of the bone overlying the middle ear (tegmen tympani) to en bloc removal of the middle ear requiring decalcification prior to sectioning with an oscillating saw
    - One example is Cobbler's Cut technique .
- For the simplest method, once the brain has been removed and dura stripped from the middle cranial fossa, chip the bone overlying the middle ear off with a chisel; the area of interest is located posterior and lateral to the foramen spinosum (transmits the middle meningeal artery) and anterior to the ridge of the petrous temporal bone
    - This will provide access to sample any fluid for microbiology but fine anatomical detail will be lost

Facial dissection

- Each part of a postmortem should be considered as essential to justify its intrusiveness; therefore, one must weigh the value of facial dissection versus the ability to reconstruct the face or compromise the embalmer's ability to access facial vessels, especially given the value of postmortem radiology
- Most commonly indicated for assessing trauma to the face
- Standard Y incision of the anterior body can be used by continuing to reflect the skin and subcutaneous tissue with the skin carefully reflected upward, exposing the face; alternatively, a high Y incision can be used
- Depending on the level of inspection required, examination can be limited to the bones of the jaw and facial skeleton, leaving the oral mucosa attached and without breaching the oral cavity; alternatively, it can be extended further upward (including the removal of the eyes in continuity allowing for examination of the bony eye sockets) if necessary

Layer by layer neck dissection

- Complete after brain and thoracic organs have been removed to reduce pressure within blood vessels that may lead to artefactual bleeding within tissues .

- Anterior approach is commonly done in daily practice to assess injury to the neck structures, including if sustained pressure to the neck as a cause of or contributor to death .
- Similar to facial dissection, the standard Y incision of the anterior can be utilized by continuing to reflect the skin and subcutaneous tissue upward, exposing the neck; alternatively, a high Y incision can be used
    - Then, each layer of muscles (platysma, then sternocleidomastoid, then the strap muscles) is separated at their caudal attachments and reflected upward for assessment
    - IJV and common carotid arteries can then be opened longitudinally to assess for intimal tears
    - Tongue and neck are then removed en bloc for further dissection
    - Precervical fascia and underlying cervical spine can now be seen and any abnormalities are exposed
- Tissue bloc is further assessed on the bench by opening the cervical esophagus posteriorly, separating the thyroid for further sectioning, completely separating and stripping the hyoid bone for close inspection (and photography) and opening the larynx
- Document (including photographs) any surface or tissue hemorrhage, deformation or fractures in any structures; the interpretation of possible injuries can be controversial and should be approached with caution.
- Posterior approach is used to document injury to the soft tissues of the back of the neck including subcutaneous bruising or to access to the vertebral arteries in the upper cervical vertebrae (as described above); several methods exist).
    - One approach is with an inverted T incision with the horizontal aspect extending over the scapula
    - After the skin and subcutaneous tissue are reflected, the muscle groups can be reflected laterally; these muscles are typically divided into superficial (trapezius), intermediate (splenius capitis, splenius cervicis and semispinalis capitis) and deep (deep paraspinal and deep subcapital muscles) groups
    - Once removed, the extracranial vertebral artery and spinous processes of the atlas and axis will be seen along with the important atlantoaxial and atlantooccipital ligaments

Dissection of superior vena cava, subclavian and jugular veins

- Indicated for investigation of trauma, origin of pulmonary embolus, upper limb venous obstruction or vasculitis
- SVC can be identified where it enters the right atrium once the breastplate has been removed; from here, the subclavian veins and internal jugular veins (IJV) can be traced and if indicated, opened longitudinally along their course
- Alternatively, the IJV can be identified at the time of neck dissection running in the carotid sheath (that also contains the vagus nerve and carotid artery)

Dissection of lower limbs and pelvis for deep vein thrombosis

- Indicated for investigation of trauma, origin of pulmonary embolus, lower limb venous obstruction or vasculitis
- Measure the widest part of both calves as part of external examination
- Several methods exist; one approach is made through a long vertical incision following the medial border of the tibia
    - This incision is continued medially and horizontally at the level of the popliteal fossa superiorly and Achilles tendon inferiorly
    - Skin and subcutaneous tissue is reflected
    - Exposed calf muscle is removed and serially sectioned in the transverse plane to demonstrate the deep veins in cross section.
- Simpler method involves a transverse incision in the popliteal fossae, which can expose the veins in cross section; by milking the blood from the calf, any clots can be identified
- Large veins in the pelvis can be identified once the abdominal and pelvic organs have been removed; the common iliac vein will have been transected and the large veins can be opened longitudinally along their course both within the pelvis (internal iliac vein) and at their entry point through the femoral canal (external iliac vein)

Demonstration of pneumothorax

- Usually well visualized on postmortem radiology .

- Once the subcutaneous tissues have been reflected from the anterior thorax, create a pool of water inside the pocket formed between the reflected tissues and lateral chest wall
- Insert an instrument underneath the water surface between the ribs and into the pleural space; if gas is released under pressure, a pneumothorax could be considered
- In the setting of a limited postmortem, a needle thoracostomy is performed similarly to those done with live patients (a large needle attached to a 50 mL syringe partially filled with water and aspirated in the second intercostal space midclavicular line in a supine patient) and could yield evidence for the presence of a pneumothorax
- Decomposition can produce gas in the chest so care must be taken in the interpretation of gas released in this setting
- Findings should be considered along with other signs of clinically significant pneumothorax, such as circumstances of death and other autopsy findings including mediastinal shift, hemithorax volume changes and lung bullae

Demonstration of gas embolus

- Indicated for pulmonary barotrauma / cerebral artery gas embolism (PBT / CAGE) diving fatality where there has been a rapid ascent and rapid loss of consciousness after resurfacing; venous air embolism may occur secondary to trauma, iatrogenic causes (intravenous lines, cardiopulmonary bypass, neurosurgery or gas assisted surgery or endoscopy), childbirth, abortion or rarely from criminal intervention
- For a diving fatality, postmortem imaging must be completed within 8 hours of death due to decomposition or off gassing
    - Off gassing is where nitrogen that has been absorbed into the tissues with diving forms bubbles in the tissues and vessels if the diver ascends rapidly and dies or dies on the bottom and is rapidly brought to the surface
    - This will result in gas artifact that is difficult to differentiate from pulmonary barotrauma and cerebral air gas embolism as a cause of death.
- For demonstration of gas in the heart, the anterior pericardium is carefully opened and the pericardial space is filled with water; the right and left ventricles are penetrated under the water's surface to assess for the presence of gas
    - In order to be sure not to disturb the great vessels, the upper third of the sternum can be left intact until the testing is completed.

    - Significant venous air embolism is ~100 - 250 mL but is much less when arterial

- Demonstration of gas in the cerebral circulation is best seen with postmortem radiology prior to dissection as artefactual introduction of gas into the cerebral vessels is common
    - Bubbles within the vessels of the circle of Willis and deep arteries of the brain might provide evidence for nonartefactual cerebral gas if the brain has been removed after careful clamping of both of the internal carotid and vertebral arteries; however, this is fraught with difficulty and should be interpreted with caution .
- Gas can be produced during tissue decomposition, so care must be taken with the interpretation of gas in this setting

4. Cardiovascular System

HEART, Large Vessels: weight, relative size, configuration, epicardium, myocardium, valve leaflets, endocardium, coronary arteries, circumferential measurements of valve orifices and thickness of ventricular walls, Vascular patency, walls and caliber.

The heart dissection is probably one of the most difficult dissections you will do. Part of the reason it is so difficult to learn is that the heart is not perfectly symmetrical, but it is so close that it becomes difficult to discern which side you are looking at (dorsel, ventral, left or right). Finding the vessels is directly related to being able to orient the heart correctly and figuring out which side you are looking at.

Many cardiovascular diseases can cause sudden cardiac death, either through an arrhythmic mechanism or by compromising the mechanical function of the heart. Cardiac disorders can affect the coronary arteries, the myocardium, the cardiac valves, the conduction system, the intra-pericardial aorta or the pulmonary artery. As many cardiac diseases are genetically determined, reaching a diagnosis of an underlying cardiac pathology may have implications for other surviving family members.

Active Implantable Medical Devices (AIMD): any active medical device which is totally or partially introduced, surgically or medically, into the human body or a natural orifice, and which remains implanted following the procedure, e.g. cardiac pacemakers and defibrillators.

Bundle of His and AV node: parts of the cardiac conduction system.

Cardiomyopathies: a heterogeneous group of myocardial diseases associated with

mechanical and/or electrical dysfunction that usually (but not invariably) exhibit inappropriate ventricular hypertrophy or dilatation. There are multiple underlying causes, many of which are genetically determined. Cardiomyopathies are either confined to the heart or are part of a generalized systemic disorder, often leading to cardiovascular death or other progressive heart failure–related disabilities [5].

Coronary bypass: a surgical procedure performed to relieve angina. Arteries or veins are grafted to the coronary arteries in order to bypass atherosclerotic narrowing and improve coronary blood supply.

CT (computed tomography): a medical imaging technique that uses X-rays.

MRI (magnetic resonance imaging): a medical imaging technique that uses nuclear magnetic resonance.

Sudden cardiac death (SCD): an unexpected death resulting from a cardiac pathology that occurs in a short time period (generally within 1 h of symptom onset) in a person with known or unknown cardiac disease.

Specific health and safety aspects

In medicolegal autopsies and postmortem examinations of individuals who possess an Active Implantable Medical Devices (AIMD) it is important to determine if complications during or after implantation or dysfunction of systems could be related to the cause of death. Correct post-mortem handling of implantable cardioverter defibrillators (ICD) are of utmost importance. Pacemakers and defibrillators can also be useful for the identification of deceased individual [6].

2.3 Radiological examination

Before autopsy, radiological imaging (chest-ray/ CT/ MRI) of the heart may be performed.

The heart is also difficult because the fatty tissue that surrounds the heart can obscure the openings to the vessels. This means that you really must experience the heart with your hands and feel your way to find the openings. Many people will be squeamish about this, and because the heart is slippery, it is easy to drop. Don't be shy with the heart, use your fingers to feel your way through the dissection.

Macroscopic heart examination

The heart should be examined according to the general principles of pathological anatomy.

1) Check the pericardium, open it and explore the pericardial cavity.

2) Check the anatomy of the great arteries before transecting them about 3 cm above the aortic and pulmonary valves.

3) Check and transect the pulmonary veins. Transect the superior vena cava about 2 cm above the point where the crest of the right atrial appendage meets the superior vena cava (to preserve the sinus node). Transect the inferior vena cava close to the diaphragm.

4) Remove the heart from the body.

5) Open the right atrium from the inferior vena cava to the apex of the appendage. Open the left atrium between the pulmonary veins, and then to the atrial appendage. Inspect the atrial cavities and the inter-atrial septum and then determine whether the foramen ovale is patent. Examine the mitral and tricuspid valves (or valve prostheses) from above and check the integrity of the papillary muscles and chordae tendineae.

6) Inspect the aorta, the pulmonary artery and the aortic and pulmonary valves (or valve prosthesis) from above.

7) Check coronary arteries:

- examine the size, shape, position, number and patency of the coronary ostia,
- assess the size and course of the major coronary arteries,
- make multiple transverse cuts at about 3 mm intervals along the course of the main coronary arteries and branches, such as the diagonal and obtuse marginal, and check patency; in cases with an obvious cause of death, a longitudinal opening is also possible,
- heavily calcified coronary arteries can often be adequately opened with sharp scissors. If this is not possible, they should be removed intact, decalcified and opened transversely,
- coronary artery bypass grafts (saphenous veins, internal mammary arteries, radial arteries, etc) should be carefully examined with transverse cuts. The proximal and distal anastomoses should be examined with particular care. Side branch clips or sutures may facilitate their identification, particularly when dealing with internal mammary grafts.

8) Complete transverse (short-axis) parallel, roughly 1 cm thick slices of the heart are recommended from the mid-ventricular level towards the apex. Dissect the basal half of the heart in the direction of blood flow and complete the examination of atrial and ventricular septa, atrioventricular valves, ventricular inflows and outflows and semi-lunar valves.

9) Once emptied of blood, note the following measurements: – total heart weight,

- wall thickness: measure thickness of mid cavity free wall of the left ventricle, right ventricle and septum (excluding trabeculae).

Photographic documentation

The following photographs should be taken:

– anterior and posterior general view,
– one slice of the heart,
– any suspected lesions.

Sampling for histological examination

As a minimum, the following samples for presumed non-cardiac deaths should be taken and fixed:

– two samples of the left ventricle (anterior and posterior walls) with papillary muscles,
– one sample of the septum with the bundle of His and AV node region,
– one sample of right ventricular outflow tract.

For deaths presumed to be cardiac related, the additional samples should be taken and fixed:
– a mid-ventricular slice of the heart,
– any areas with macroscopic abnormalities,
– the most severe focal lesions in the setting of coronary artery disease.

Other cardiac samples (such as valvular tissue, pericardium and aorta) should be taken when indicated. If there is a clinical history or ECG tracing suggestive of a conduction abnormality, a conduction system investigation by serial sections technique should be performed (at least 5 blocks).
If one suspects a rare cardiomyopathy (e.g. mitochondrial, storage, infiltrative, etc), cardiac samples fixation in 2.5% glutaraldehyde or deep freezing is recommended.

The minimal standard histological examination of the heart

Histological examination of cardiac samples mentioned in point 2.6 is recommended for all cases.

For cases of presumed sudden cardiac death, mapped labelled blocks should be performed from the anterior and posterior walls of the left ventricle, the right ventricular outflow tract and the interventricular septum with the bundle of His and AV node.

H & E and a connective tissue stain (as van Gieson, CAB-Chromotrope Aniline Blue) are standardly used. Other special stains and immunohistochemistry can be performed if required.

Results of examinations

In the majority of SCDs a clear pathological cause can usually be identified, albeit with varying degrees of confidence. The level of certainty should accompany the

anatomopathological.

diagnosis (certain, highly probable or uncertain). Whenever possible, the most likely underlying cause should be stated .

Retaining of the entire heart

In some particular cases the heart may be retained after autopsy for a more detailed examination. Cardiac retention should respect the legal restrictions and follow the guidelines of the Swiss Academy of Medical Sciences. If the entire heart is retained, this should be mentioned in the autopsy protocol.

Clinical information relevant to autopsy

The following information should be gathered, if possible, preferentially before the autopsy is performed:

– circumstances of death: time and place (e.g. at home, at rest or during exercise, during sleep, during emotional stress). Was the death witnessed? Resuscitation? Time between the onset of symptoms and death,

– usual pattern of exercise or athletic activity, sport level and type of sport, pre-participation screening,

– past medical history: general health status, previous significant illnesses (e.g. syncope, palpitations, epilepsy and respiratory disease),

– details of current medication, especially cardiac drugs (QT acting drugs),

– history of alcohol or drug abuse,

– family cardiac history: ischemic heart disease and sudden premature death, arrhythmias

– previous ECG (none, normal, abnormal), ECG tracing during resuscitation, serum enzyme and troponin measurement, if done, any results of cardiovascular examination, exercise test,

– laboratory investigations (especially lipid profiles).

Other samples

If a potentially heritable cardiac disorder is suspected, EDTA-blood or a part of the spleen should be frozen. The transfer and genetic analyses should respect the legal restrictions and follow the guidelines of the SAMS.

05. GIT System

GASTROINTESTINAL TRACT: Esophagus, stomach and its contents; intestines; appendix. **Mesentery and Intestine**

Excise the greater omentum close to its attachment to the stomach. The superior mesenteric artery and vein can be examined when the transverse colon and its mesen- tery

are drawn superiorly. By this maneuver the root of the mesentery and its vessels will usually be exposed. In an obese subject it will be necessary to remove fat to bring the vessels to view. Open the vein and the artery. Exam- ine the mesentery by multiple sections across the mesenteric arteries, veins, and lymph nodes. Tie the jejunum with double ligatures for a few centimeters below the ligament of Treitz. Use a sharp, long knife to separate the intestine from the mesentery as close as possible to the intestine. On reaching the ileocecal region, incise the peritoneum of the posterior abdominal wall and lift the cecum and ascending colon free from the surrounding tissues. Separate the transverse colon from its attachments to the stomach, and raise the descending colon away from the posterior abdominal wall. Displace feces from the sigmoid and rectum by stripping upward into the descending colon. Place double ligatures about the sigmoid colon *5* to 6 cm. above the sigmoidorectal junction. Cut between the double ligatures around the jejunum and colon and lift the entire intestine form the body.

a. The rectum is removed along with the bladder as indicated in figure 9 and described under *Urinary Tract*.

b. Remove the mesentery of_ the small intestine by severing its attachment to the posterior abdominal wall. Open the small intestine with blunt scissors or enterotome along the mesenteric attachment, and the large intestine along one of the taenia. The appendix may be examined by multiple cross sections or by a longitudinal incision through the lumen. As the intestine is opened, note the fluidity, color, and other characteristics of its contents. Take sections of representative regions. Do not rub the fingers over the mucosa or wash it with water before the sections are placed in fixative. Record the thickness, consistency, and color of the mucosa and of the wall as a whole.

Esophagus, Stomach, and Duodenum

If there is no pathologic change to indicate the desirability of keeping the liver, bile ducts, and duodenum in one piece, cut across the structures in the hepatoduodenal ligament and remove the duodenum, pancreas, stomach, and esophagus *in toto*. Extend the previous incision in the anterior surface of the first part of the duodenum along the greater curvature of the stomach and up the anterior wall of the esophagus. Note the character of the stomach contents, the thickness, rugae of the mucosa, and other featln'es of the walls. Extend the incision in the second part of the duodenum so as to open the entire length of the third part.

Rectum and Sigmoid

Open the rectum with an enterotome along the posterior midline. Remove fecal material and examine the mucosa and wall. Dissect the rectum from the posterior wall of the bladder and from the prostate to display the seminal vesicles in men. In women dissect the rectum from the vagina.

06. Respiratory System

LUNGS: Weight, relative size, consistency, pleura; cut surface of each lobe; bronchi; hilum; lymph nodes.

Trachea and Bronchi

- Dissect remnants of the pericardia! sac from the underlying structures to expose the trachea and main bronchi. Ordinarily the trachea is transected just below the larynx and is removed along with both lungs.
- In special cases, such as death due to drowning or aspiration of foreign bodies, the tracheobronchial tree, which can be freed from the lung by bisecting the main bronchi immediately after their division at the level of the carina, should be carefully explored. If a foreign body is suspected, radiography, with or without contrast media, can be utilized. Complete occlusion **of** the trachea or of one of the main stem bronchi may be pre- sent when there is obstruction to the flow of formalin introduced from either end. If there is partial occlusion, this can be determined with a probe prior to opening the tracheobronchial tree. The thickness of the bronchial walls, the structure and configuration of the cartilaginous plates, as well as the absence or fracture of any the cartilaginous plates, should be recorded. The mucosa! surface should be examined for its intactness and the presence of ulceration, expecially in individuals maintained on respirators via tracheostomy tubes. Sec- tions of ulcers, especially those penetrating to the level of the cartilaginous plates, focal mucosa! thickening, leukoplakia and small zones of mucosa! hemorrhage should be submitted for microscopic examination.

Lungs

'Examination in situ. The gross examination of the lungs in situ should be approched systematically. Examination of pleura, number of pulmonary lobes, contour and volume of each individual lobe should be noted. Alterations of the pleural surface such as fibrinous or fibrous adhesions, the color of the lung as viewed through the pleura, the presence or absence of pleural plaques, calcifications or nodules should be recorded. Abnormal impressions of the pleural surface, such as might be produced by the superior vena cava or altera tions of the contour of the thorax, especially in cases in which there are fractures of the ribs, should be recorded.

Culture. Methods for obtaining lung tissue for bacteriological, fungal or viral culture include either the use of a heated metal plate touched to the pleural sur- face, or localized cleansing of pleural surface with acetone or alcohol, thus providing sterile access to subjacent pulmonary tissue. Slice the tissue with sterile instruments and apply the cut surface to glass slides for touch preparations. Gram, Methenamine-silver (for *Pneu- mocystis),* acid fast and fungus stains may be applied. Wet preparations may be prepared by scraping the cut surface. The remining tissue should be ground with an equal amount of saline for various culture methods.

(**l**) ***Viral:*** Remove approximately 1 gram of lung tissue from the suspected areas. If the material is to be delivered to the virology laboratory within 2 hours, store the tissue at 4 **degrees** C. If greater delay is anticipated, quick freeze the tissue and store at - 70 degrees

Note: Respiratory syncitial virus is destroyed by freezing and should be stored at a higher temperature.

(2) ***Tuberculosis****:* If tuberculosis is suspected, the lung should be fixed in a l: l mixture composed of 10 percent formalin and a *50* percent alcohol solution. If inflated with fixative, allow 48 hours for fixation or l week if immersed in fixative. Note: Formalin alone does not inactivate the tubercle bacillus.

Inflation fixation of lung. After obtaining the culture, the site of incision can be repaired so that intrabronchial instillation of fixative can be accomplished. Either one or both lungs can be inflated. The left lung is easier to inflate because of its longer main stem bronchus. Inflation can be carried out by instillation of 10 percent formalin, properly buffered, by means of hydro- static pressure with attachments to a fixed formalin container with the fluid level of the formalin being approximately 15 centimeters above the level of the lungs. This pressure may be varied, but in most instances represents the end respiratory pressure. This technique gives excellent fixation and is the preferred method of examining lung parenchyma. If bronchi are obstructed, then perfusion of the lung with formalin can be accomplished by cannulating either the pulmonary veins or pulmonary arteries. In routine autopsies, the perfusion with for malin should continue for at least 24 and preferably 48 hours. If morphometric measurements are desired, then a week's perfusion may be necessary. After the lung is fixed, sections may be taken at 1.5 cm intervals, using the Gough-Wentworth technique. Slice the fixed lung into sagittal sections, starting posteriorly. If it is necessary to have a quantitative volume determination of either lung or individual lobes, the formalin inflated lung prior to sectioning can be placed in water and the displaced amount of water can be used to determine the volume of the lung or lobe.

a. Special Studies.

(1) *Immunology:* Tissue sections 1 x 1 x .*5* cm should be quick frozen for immunologic studies and stored at -70 degrees C.

(2) *Electron microscopy:* Selected areas for electron microscopic studies should be removed, cut into **1** mm^3 (cubic millimeter) sections and fixed in buffered 3 percent glutaraldehyde or other suitable fixatives. If rapid preservation of lung parenchyma for electron microscopy is necessary, then immediate fixation of a portion of lung parenchyma can be accomplished prior to opening the chest by transthoracic injection of 3 1/2 percent glutaraldehyde into lung parenchyma. The addition of methylene blue will assist in identification of the segment of lung so perfused.

(3) Special studies for vascular changes include the utilization of either latex or gelatin. Cases that deserve special techniques should be referred to centers that have the appropriate equipment and experience in performing these rather complicated procedures.

b. Examination of lung.

(l) Prior to sagittal sectioning of the lung, the carinal, hilar, and bronchial lymph nodes should be examined individually, and alterations in color, firmness, as well as the presence or absence of metastases or granulomas, should be recorded. If distribution of metastases is important, each lymph node group should be identified separately. Although sections of main stem and segmental bronchi are not routinely submitted, they are necessary in diagnosing chronic bronchitis. Cross sections of bronchi can be obtained prior to the sagittal plane cutting. The pulmonary arteries should be examined for atherosclerosis and thrombo emboli.

(2) If a primary neoplasm of the lung is suspected, wider sagittal planes or dissection of a fresh lung by cutting along the bronchial planes will help to determine the site of origin within the bronchus. Sections submitted for microscopic examination should be identified as to their exact origin; i.e., side, lobe, and bronchial segment. Tumors of lung should be described in detail as to their location, including relationship to pleura and bronchi, size, number, consistency and color.

(3) If a fresh Jung is utilized, cut along the bronchial ramifications as a method of examining the Jung parenchyma, then touch preparations of the lung neo- plasm and surrounding parenchyma can be done and collection of intrabronchial material can also be utilized as a positive control for premortem cytology.

f Demonstration of emphysema.

(1) After I inch sections of lung are cut, they may be floated in water in order to determine the degree of emphysema. By floating the inflated and fixed specimens on a liquid solution, the distal air parenchyma is expanded, and the degree of remaining pulmonary parenchyma can be estimated. The volume of individual lobes, their contour and shape can be estimated, and by palpation, zones in which there is alveolar filling can be examined. Regional aeration or consolidation can also be determined on sagittal plane sections.

(2) Utilization of barium nitrate and sodium sulfate solution. In some cases of minimal emphysema, if is necessary to accentuate the alveolar septa, and this can be accomplished by using a saturated solution of barium nitrate and a saturated solution of sodium sulfate. **A** sagittal section of lung parenchyma approximately I inch in thickness is rinsed of formalin, blotted dry, and then immersed in a pan large enough to hold the lung tissue and the barium nitrate solution. Permeation of the lung parenchyma by this solution can be assisted by focal compression and release of the lung parenchyma, comparable to squeezing a sponge. After this has been accomplished, the lung may be blotted dry and then immersed in sodium sulfate solution. The same kneading procedure of the lung parenchyma may be necessary in order to admix the solutions and have proper impregnation of the lung parenchyma by barium sulfate. This lung section may then be rinsed and examined under water with a dissecting microscope to determine the degree of emphysema. Photographic documentation can also be performed at the same time.

g. Determination of Pneumoconiosis. A weighed portion of lung parenchyma in terms of grams of dried lung can be digested by the use of Chlorox, spun down or

filtered, and the particles of dust per gram of dry lung will express the concentration of dust within the lung parenchyma. Sections should be taken from the sub- pleural versus medial, and an upper versus lower lobe in order to provide representative counts of different portions of the lung parenchyma. Iron stains may assist in counting the number of ferruginous bodies.

h. Photographic documentation of lesions within the lung can be performed at different stages of the autopsy. Massive air trapping as can be seen with total occlusion of a sublobar bronchus, or atelectasis secondary to occlusion of a more proximal bronchus, may best be demonstrated by photography in situ. Photographs to demonstrate emphysema should be taken while the lung is suspended within an aqueous solution. Restoration of color to a formalin fixed lung section can be accomplished by the addition of *95* percent alcohol for a period of I to 2 hours.

Examination of the Larynx, Pharynx, Hypopharynx, Tongue, Thyroid, and Parathyroid

a. When there is extensive disease of these structures it is advantageous to remove all the neck organs as a unit. To accomplish this, the skin, together with the attached platysma muscle and portions of the pectoral muscles, is dissected from the underlying tissue and retracted as far superiorly as possible. The muscles of the neck will be exposed and enlarged cervical lymph nodes can be noted. Further dissection will reveal the submaxillary glands in the submaxillary triangles. The thyroid gland is brought into view by dissection and lateral retraction of the infrahyoid muscles. With blunt dissection each common carotid artery is dissected from the carotid sheath and retracted away from the larynx and trachea along its entire course in the neck. Avoid cutting the carotid arteries during this procedure because of their importance to pro- per embalming of the head. These vessels are ligated with long strings and then severed at their origins from the aortic arch on the left and the innominate artery on the right. The patency of the internal carotid arteries can be tested by injecting them with physiological solution of sodium chloride after the brain has been removed.

b. The extrinsic muscles of the tongue are cut through their attachment to the mandible and styloid process with the amputating knife. The stylopharyngeus muscle is severed from the styloid process at the same time. The soft palate and uvulva are cut from their attachments. The mobilized tongue is drawn inferiorly and the posterior wall of the pharynx and esophagus separated from the underlying tissues. The lower respi- ratory tract, including the trachea, bronchi and lungs, may be left attached to the upper air passage or the trachea, while the proximal portion of the esophagus may be transected. In this way the tongue, the pharynx, the pharyngeal muscles, the larynx, the trachea, the thyroid, the parathyroids, and the proximal portion of the esophagus are removed *en bloc*. After examination of the surface of the tongue, multiple transverse sections are made.

Dissection of the parathyroid glands is facilitated by removal of the neck structures *en bloc* so that there will be landmarks. The parathyroids are sought from the posterior aspect. The prosector is more likely to find all parathyroid glands if he is seated and has a spotlight directed on the field. Some pathologists prefer to fix the specimen in

formalin before attempting to locate the parathyroid glands, because they are firmer and a deeper yellowish brown than in the fresh state. The upper parathyroid glands are usually found embedded in the deep cervical fascia between the esophagus and the posterior aspect of the upper portions of the lateral lobes of the thyroid. The lower parathyroids are usually found in the deep cervical fascia along the inferolateral aspect of the lateral lobes of the thyroid. Occasionally one or more parathyroids are embedded in the thyroid gland or are located inferior to the gland in the upper anterior mediastinum. The normal parathyroid glands are yellow-brown structures that are distinct in color and consistency form the surrounding softer yellow fat and firmer gray lymph nodes. In cases in which the para- thyroid glands are of unusual interest, all the tissue from this region should be saved for microscopic examination in the event that all the glands are not identified grossly. After the parathyroid glands are removed, the thyroid gland is dissected from the larynx and multiple sections are made through it.

c. The upper air passage should be examined for evidence of obstruction before it is opened. Next, the hypopharynx, including the epiglottis and the pyriform sinuses, should be examined. The upper portion of the esophagus is opened posteriorly and dissected away from the posterior wall of the larynx. The larynx is then opened longitudinally along its posterior aspect to reveal the vocal cords.

The Oral Cavity

The oral cavity is one of the most overlooked areas in postmortem examinations. Pathologic conditions related to the major disease process responsible for the patient's death or to chemotherapeutic agents used in treating his illness may be present in the oral regions. Metastatic or metabolic diseases, or debility resulting from a prolonged chronic, terminal illness, to mention just a few, may also be reflected in these tissues. Such conditions should be described and discussed in the final autopsy report. However, rigor mortis often tenders adequate examination here very difficult and therefore prosectors may be discouraged from conducting thorough oral examinations. But important conditions relating to the cause of death may be found here. On occasion, falling out of bed or seizures in terminally ill patients have resulted in the displacement or fracture of prosthetic appliances. These may block the larynx or compress the epiglottis resulting in death by asphyxiation. Without a thorough examination of the oral cavity, this could easily by overlooked. One non-mutilating method of gaining access to the oral cavity locked in rigor mortis is by the use of the Molt mouth prop which is designed to force and hold the mouth open. After the neck organs are removed (see para 26), the oral cavity posterior to the teeth can be visualized.

c. A thorough examination of the oral region should include visual and digital examinations of the labial mucosa by everting and and palpating the upper and lower lips. The buccal mucosa, buccal alveolar mucosa, lingual and palatal alveolar mucosa, hard and soft palate, the dorsum, ventral and lateral borders of the tongue and the floor of the mouth, should be examined visually and by palpation. Examination for palpable minor salivary glands and lymph node enlargments should be included. The

cortical plates of both the maxilla and the mandible should be thoroughly palpated for thinned areas of erosion, crepitis, perforation, sinus tracts, etc., which may indicate the presence of central lesions of the jaws. If portable x-ray or panoramic radiograph equip ment is available, a fast radiograph could be most useful in exposing such central lesions. Any tissue deviation from normal, either in the soft tissues or within the bone should be sampled for histologic examination. At times there may be a neoplastic process involving the periodontium, teeth and pulp of one or several teeth, with bone destruction and root resorption. The ideal procedure for good gross and histologic examinations of such lesions would be an *en block* resection. If the prosector is not experienced in this procedure, the hospital oral surgeon or senior residents in the oral surgery department could be invited to the morgue for consultation or to actually perform the resection. The importance of this procedure is that it retains the relationship of the intraosseous lesion to the roots of the involved dental structures and the surrounding contiguous bone.

07. Hepatobiliary System

LIVER: Weight, surface, consistency, color and markings of surface and parenchyma.

GALLBLADDER AND DUCTS: Contents; mucosa.

LIVER: Capsule, architecture (including location and degree of fibrosis), changes in liver cells (degeneration, necrosis, storage of normal or abnormal metabolites), changes in biliary system (canaliculi, cholangioles, interlobular ducts), changes in reticuloendothelial cells (Kupffer cells, portal macrophages), changes in vessels(central veins, portal vein and hepatic artery branches), degree of inflammation in lobules or portal areas and types of inflammatory cells. *Gallbaldder:* mucosa, tunica propria muscularis and serosa.

Gallbladder, Bile Ducts, and Nearby Vessels

The gallbladder, bile ducts, and nearby vessels are usually examined *in situ:* Open the second part of the duodenum and locate the ampulla of Yater; Squeeze the gallbladder and note whether or not bile issues from it. Pull the duodenum anteriorly to expose the retroduodenal distal portion of the common bile duct. **Nick** the duct, and with a small scissors, open it proximally into the cystic and hepatic ducts and distally into the ampulla of Yater. Note the circumference of the common bile duct, and look for stones, tumors and strictures. Open the gallbladder, note its contents, examine the mucosa and wall, and collect the bile in a clean dry glass container, saving this for toxicologic study if needed. Within the hepatoduodenal ligament, the hepatic artery is usually to the left of the common bile duct, and the portal vein is posterior; these should be opened and explored. Near- by lymph nodes should be

examined and sampled. The prosector may find it more convenient and instructive to dissect this region from the posterior aspect after removal *en masse* (see para 60-73), especially if the portal vein and its tributaries are obstructed by tumor or thrombus, or if a portacaval shunt is present.

Dissection of biliary tract

- Indicated for checking the patency of the biliary system in the setting of malignancy, systemic sepsis, trauma or after adjacent abdominal surgery
- Several methods exist
    - Can be dissected with the organs in situ or from the posterior aspect after the abdominal organs have been removed as a block
    - One approach identifies the ampulla of Vater in the duodenum, which is then probed and opened longitudinally to its insertion into the gallbladder and common bile duct
- May be aided by the cannulation of the biliary system and injection of dye (such as methylene blue) or with the assistance of a suitably experienced surgeon

liver

After dividing the duodenohepatic and gastro-hepatic ligaments. remove the liver by dividing its attachments to the diaphragm and cutting the hepatic veins (usually 3) where they join the inferior vena cava. Explore the hepatic veins for obstruct1on. Weigh and measure the organ and describe the exterior surface. Slice with a long knife, each parallel slice about 2 cm thick: Describe the color, consistency, and architectural pattern. Pay special attention to the hilar region. Take representative blocks.

08. ReticuloEndothelial System

SPLEEN: Weight, size, consistency; capsule, cut surface; color, dry or moist, markings; character of pulp. **LYMPH NODES:** Size, consistency, appearance on cut surface.

LYMPHATIC SYSTEM: Capsule, architecture, follicles, stroma, pigment, reticulo-histiocystic components.

a. **SPLEEN:** Capsule, malpighian bodies, red pulp, trabecule, vessels.

Spleen

Examine the anterior surface of the pancreas, the splenic artery, the vein on the superior surface of the body and tail of the pancreas. Lift the spleen, divide the vessels at the hilum, and remove the spleen. Weigh the organ and measure its length, breadth, and thickness. Expose the parenchyma by a single incision extending from the greatest convexity toward the hilum. Further incisions parallel to the first should be made 3-5 mm apart (particularly, if the patient is suspected of having Hodgkin's disease). Touch imprints should be made if a hematologic process is present or suspected. If enzyme studies are con- templated, air dry the imprints for fixation and do not fix in methanol.

Lymph Nodes

Any enlarged lymph nodes should be incised and the cut surface examined. Take note of any replacement of the lymph node by tissue foreign to the node (malignancy or infectious process). Touch imprints may be made to help to elucidate the cause of any enlargement. If en- zyme studies are contemplated, air dry the imprints for fixation and do not fix in methanol.

09. Endocrine system

PANCREAS: Weight, consistency, cut surface:**ADRENALS:** Size, cut surface, Cortex, medulla, tumors, vessels. **PANCREAS:** Acinar parenchyma, islets, ducts, vessels.

THYROID: Acini, stroma, degenerative changes

Adrenal Glands

Free the adrenal glands by dissection and remove extraneous tissue. Weigh the organs if the size is abnormal and examine the cut surface by making parallel sections. Place a part or all of each organ in 10 percent formalin

Pancreas

Examine the pancreas by making multiple cross section or by a single frontal section extending from the inferior border to the superior border. On the cut surface locate the pancreatic duct; note its size and con- tent, and the character of its wall. With small sharp- pointed scissors open the pancreatic duct. Separate the pancreas from the duodenum by dissection. Weigh it and measure the long axis, the width of the head, and the average depth. Select blocks of the head, body, and tail for microscopic study. The islets are most numerous in the tail. This block should be used for routine sections, but the other blocks should be saved in case they are needed.

10. Genitourinary System

GENITOURINARY TRACT: Kidney: Weight,size and consistency; capsule, subcapsular surface, cut surface; cortical markings, width of cortex; pelvis, pelvic fat, ureter; large vessels. Urinary bladder: amount and character of contents; mucosa; wall.**SEMINAL VESICLES:**PROSTATE: or UTERUS, OVARIES AND ADNEXA:**TESTICLES:**

KIDNEYS: Glomeruli, tubules, interstitial tissue, vessels, pelvic mucosa.

PELVIC ORGANS:

(l) Bladder: Mucosa, submucosa, muscularis.

(2) Prostrate: Glands, stroma, hyperplasia, in- flammation.

(3) Seminal Vesicles: Mucosa, infection, concre- tions.

(4) Testes: Tubules, basement membrane, atrophy, spermatogenesis.

(5) Uterus: Endometrium, myometrium, tumors, vessels.

(6) Vagina: Mucosa and submucosa.

(7) Ovaries: Stroma, cysts, corpora albicantia and lutea, vessels, follicles, germ cells

Examination of the Female Genitalia and Breasts

a. In autopsies of women the internal female genitalia are removed with the bladder and the rectum. Examine the bladder and separate it from the anterior surface of the vagina. Open the vagina along each lateral wall with knife or scissors. The incisions can be carried superiorly through the cervix and lateral walls of the uterus to the cornua, which exposes a larger portion of the endometrium for inspection. Record the thickness of the endometrium and myometrium, and the greatest length, breadth, and depth of the uterus. Examine the fallopian tubes by multiple cross sections. Bisect each ovary. Inspect the veins and arteries in the broad ligament. Fix blocks from the vagina, cervix, uterus, tubes and ovaries.

b. The mammary glands are conveniently examined after reflection of the skin and subcutaneous tissues over the thorax. Multiple sections from the posterior aspect extending to within a few millimeters of the skin will expose the mammary tissues. If the nipple is diseased it may be removed.

Semlnal Vesicles

Multiple longitudinal incisions, *2* to 3 mm. apart, serve to expose the wall and the lumens of the vesicles. The thickness, the character of the wall, and the physical characteristics of the seminal fluid should be noted. Place a representative block in fixative.

Testes and Epididymides

a. *R*emove the testes by enlarging the inguinal canal, inverting the scrotum, and cutting the attachment of the tunica vaginalis to subcutaneous tissue of the lower part of the scrotum. *If* there are related pathologic changes in the genital tract, the testes should be mobilized before the pelvic organs are removed, as that the entire length of the vasa and the attachment to both the epididymides and the seminal vesicles are preserved.

b. Open the tunica vaginalis and note the amount and physical characteristics of the fluid it contains. Incise testes and epididymes. If abnormality exists, record the weight and measurements. Observe the thickness of the tunica, the tissues of the epididymis, and the consistency of the testis. With forceps determine the ease with which the tubules "string" from the cut surface of the testis. Place a block from the opposite half in fixative.

Vas Deferens

Examine the vas deferens by multiple cross sections without completely dividing the structure. Note the size and richness of the pampiniform plexus and inspect the thrombi.

Prostate

The prostate is examined by multiple coronal sections *5* to 6 mm apart, extending from the base of the bladder to the apex of the prostate. Inspect the mucosa of the urethra. Place one complete coronal block. including the posterior lobe. in fixative.

Kidneys

With a long knife divide the kidney into anterior and posterior halves by a straight, sharp single incision along the longitudinal axis of the convexity, as indicated in figure 10. With scissors open the pelves and the ureters, the renal artery and vein and their major branches. Record the weight, length, breadth, and depth of each kidney after severing the ureter. Strip the capsule to expose the surface of the parenchyma. If the kidney is small. record the number of pyramids. For histologic study remove a block of tissue 3 to *5* mm thick, including cortcx, medulla, and pelvic mucous membrane from each kidney as shown in figure 11. Measure the thickness of the cortex and the thickness of the entire renal substance and if indicated, the diameter of renal artery and the ureters.

Urinary Tract

Remove urine from the bladder with a syringe and needle if indicated. With a finger or blunt instrument separate the bladder from the extraperitoneal tissues of the retrosymphysial space so that the bladder and prostate are completely free from the pelvic wall. Futher dissec- tion with the fingers posteriorly will separate the rectum from the body wall. A knife or curved scissors may be used to cut the urethra distal to the prostate and the rectum not less than 2 cm above the anorectal junction. Reflect the pelvic organs upward and outward, exposing the great iliac vessels. Free the kidneys and ureters by retracting them toward the midline from surrounding structures and remove them by a sharp dissection along with the bladder, internal genitalia, and rectum from the body in one block.

Urinary Bladder

Note whether the bladder is of normal size and configuration. or dilated or contracted. Open the bladder by a vertical incision on the anterior surface extending from the fundus to within a few millimeters of the internal urethral orifice. Invert and inspect the mucosa and wall. Select a block to include all layers of the wall for fixation.

Prostate

The prostate is examined by multiple coronal sections *5* to 6 mm apart, extending from the base of the bladder to the apex of the prostate. Inspect the mucosa of the urethra. Place one complete coronal block. including the posterior lobe. in fixative.

11. Musculoskeletal System

Bones, Cartilages, Joints, and Bone Marrow

Whenever skeletal or joint disease is known or suspected, roentgenograms should be obtained or consulted to aid in the selection of material. Substantial amounts of bone should always be obtained in any autopsy with bone disease. In many cases it is advisable to obtain the consent of the next-of-kin and to consult with the mortician before removing bones or joints. The mortician may wish to do part of the embalming before or during the autopsy. Bones or cartilage for grafting should be taken only from certain types of cadavers, and the details and technique of selection should be discussed with the clinician who has requested the material.

Ribs

The study of nutritional deficiencies, metabolic derangements and other effects on osseous and cartilaginous growth may require the removal of several costochondral junctions. The specimen should include at least 2 cm of costal cartilage and *5* cm of rib (total of about 7-8 cm). The rib farthest from the cartilage should be used for cross-sections. The rest of the specimen should be used for longitudinal sections. These should be split or sawed longitudinally before fixation.

Calvarium

In certain anemias infections and other diseases, it is desirable to sample the calvarium. This can be done by removing bone from between two closely placed parallel saw cuts.

Digits

The small bones and joints of the hands and feet can be removed through palmar or plantar longitudinal incisions. The skeletal contours can be restored if necessary by inserting wooden substitutes for the resected bones. Special permission is necessary.

Extremities

Both proximal humerus and proximal femur, with a little care and effort, can be inverted into the usual **Y in**cision area so that l/4-1/3 of the length of the upper end of these two bones can be obtained without any special incision. For the humerus, this requires opening the capsule of the joint and inverting the humerus toward the mid-line. For the femur, it requires cutting the inguinal ligament and the superior portion of the acetabu- lum from within the pelvis in order to invert the upper femur into the pelvis. In both cases, the muscles can be stripped from the bone as the bone is inverted into the body area. In both cases, broom sticks or comparable wood sticks sharpened at one end should be driven into the medullary cavity of the bone that remains, and the proximal end tied with string to the scapula in the case of the humerus, and the pelvis in the case of the femur, in such a way that the limb appears normal externally. A segment of cortex and bone marrow can be removed from the bone shaft as demonstrated in figure 18.

Knee Joint

The knee joint can be exposed by anterior curved incision immediately below the patella. Flex the knee in carry the incision through the quadriceps tendon to ex- pose the joint. To dislocate the joint, cut the capsule and cruciate ligaments and free the muscle attachments. Tissue from the articular surfaces joint capsule, bursae, and tendons may be obtained. If the knee joint is to be removed as a unit, a longitudinal anteromedial incision is employed. In the case of a woman, the distal portion of the incision should be well above the hemline of the dress to be worn. The cooperation of the mortician is essential for this procedure, since loss of contour is in- vitable. Prosthesis may be accomplished by driving a wooden rod into the cut end of the shaft of the femur and proximal tibia.

Sternoclavicular Joints

The sternoclavicular joints are readily removed and offer an opportunity for the simultaneous examination of bone and joint. Prosthesis is generally unnecessary except occasionally to restore contour in women.

Vertebrae

The vertebrae can usually be satisfactorily examined either by removing the anterior halves of the bodies by means of a coronal saw cut or by inspecting the blocks obtained in removing the spinal cord by the anterior route. The vertebral column is best removed anteriorly. The entire column can be removed by transecting the inter- vertebral discs at the upper and lower end of the column and then cutting the pedicles with bone cutters after the muscles have been dissected away. In this manner, the entire length of the vertebral bodies can be removed for study and the entire length of the spinal cord together with the nerve routes will lie exposed and available for study and removal. The rigidity of the vertebral column can be restored by a stick of wood sharpened at both ends to be driven into the remaining vertebral bodies and tied with string via a coarse needle that goes around the stick and posterior to the laminae and spinous processes to hold the stick in place as a substitute for the missing vertebra. Wire and metal should never be used-only wood and string or cord, especially if the body is to be cremated.

Bone Marrow

Bone marrow may be obtained by the following methods:

a. Saw through anterior one-third of vertebra to ex- pose the bone marrow. Dig out a block of bone marrow with cartilage knife and place in formalin fixation. Ethylenediaminetetraacetic acid (EDTA) decalcification will give excellent cellular detail and will allow for enzymatic studies such as the Leder stain. EDTA is also suggested if ultrastructural studies are contemplated on this marrow material. Touch imprints should be made if a hematologic process is present or suspected. Do not fix imprints in methanol if enzyme studies are contemplated. If a hematologic problem is not of concern and ultra- structural and enzyme stains are not of concern Zenker's fluid may be used. Place tissue in 90 ml of Zenker's fluid

in which 10 ml of glacial acetic acid has been added for 24 hours. Usually sufficient decalcification of cancellous bone will have taken place to permit embedding and sectioning.

a. Scoop bone marrow from the femur from the incision.

b. Resect a segment of rib and squeeze out bone marrow by compressing the rib with a pair of pliers. Make smears on cover slips and slides and stain by Wright's method or with Giemsa stain after fixation for 2 minutes in absolute methyl alcohol. Dilute the bone marrow with an equal amount of serum to obtain thin spreads.

12. Examination of the Tissues of the Arm and Hand

A cardinal principle in all autopsies is that the skin of the face, the neck, the arms, and the hands must not be incised without *specific· permission*. If the structures within the arm or hand must be examined, it is sometimes convenient to make a complete circular incision through the skin of the upper arm, and invert and roll the skin downward until the region to be examined is reached.

Subcutaneous dissection of trunk and limbs for occult bruising

- Commonly indicated in cases of homicide for evidence of blunt force injury to determine age of injuries as circumstances of death
- Possible bruising should be sampled for histology to confirm
- Reflection may be done in layers, with sequential reflection of the skin, fat and muscles
- Routine anterior body incision will enable assessment of the anterior trunk
- Posterior trunk can be dissected through a midline posterior longitudinal incision, which can be carried over the back of the buttocks if limb examination is also required
- Limbs should have a longitudinal incision on the posterior surface for best reconstruction results .
- Photography of bruising may be enhanced with ultraviolet light

Subcutaneous dissection for intravenous needle marks

- Curved skin incision is made around the area with the needle puncture mark and the skin and subcutaneous fat are reflected to demonstrate the underlying vessel
- In some cases, the puncture mark is obvious (marks may be hidden by cigarette burns or tattoos) and macroscopic assessment of the perivascular tissues for fibrosis can be made
- Cross sections of the vessel and adjacent soft tissue can be submitted for histology and surrounding subcutaneous tissues sent for toxicological testing
- If sending tissue for toxicology, control specimens should be taken from the opposite side of the body and sent in a separate container

2. Special Procedures-Ancillary Investigation

EXAMINATION FOR MICROORGANISMS

Postmortem Investigation

An adequate postmortem investigation of the tissues for microorganisms is as important as the morphological study and may yield the only positive proof of the exact nature of a pathological process. The pathologist is responsible for the collection of the material for culture. If a bacteriologist is available, he should collaborate with the pathologist in the selection and collection of material for cultures.

What To Culture

If indicated, prepare aerobic and anaerobic cultures of the heat's blood on both solid and liquid media. If the lesions suggest a possible bacterial cause, prepare cultures from other tissues too. If a sulfonamide or antibiotic has been administered, collect specimens for culture in large amounts of media containing 0.1 percent agar to reduce the concentration of the drug; hold the cultures for a least I week before reporting them sterile.

How to Obtain Material For a Culture

During the course of an autopsy the surface of the organs becomes grossly contaminated. Precautions must be taken to destroy these contaminating organisms and to secure material for culture from the deeper tissues only. Hold a spatula over a gas burner until it is red hot and apply it to the surface of the tissue from which the culture is to be taken. Hold the spatula on the area until the tissue is seared and thoroughly dry. Do not allow the area to become contaminated by contact with surrounding tissue and fluids before the culture is taken.

Techniques

There are several techniques for securing material for culture:

c. *Heart's Blood*. Plunge a pipette (glass tube drawn to a point and sterilized) or a sterile hypodermic needle (18 to 20 gauge, 3 in.) attached to a 20 ml sterile syringe, through a seared area on the wall of the atrium or ventricle

and draw the blood by suction. If the heart has already been removed from the body, blood sometimes can be obtained from the femoral vein, portal vein, or vena cava.

a. ***Solid Viscera***. With a sterile, sharp instrument break the surface in a seared, dry area and plunge a sterile applicator stick, with its end lightly covered with cotton, into the substance of the organ. Withdraw the stick and replace in the sterile test tube, but do not allow the portion of the applicator held by the fingers to enter the tube. A small amount of sterile broth or normal saline solution must be in contact with the swab in the test tube, otherwise the culture will soon dry and be worthless. If actual tissue is desired, remove a block of about 1 **ml** with sterile forceps and scissors from beneath the

seared sur- face. Place the block in a sterile container and later grind it in mortar with sterile broth. Use the suspension to in- oculate appropriate media.

b. ***Leptomeninges***. If the dura is intact after removal of the calvarium, it may be reflected form the cerebral hemisphere and cultures of the leptomeninges taken with a swab or pipette without searing of the surface. Other- wise, the leptomeninges must be seared with the heated spatula, which may kill the organisms immediately beneath it. To obtain viable organisms the swab or pipette should be inserted through the seared area and directed through the subarachnoidal space into an adjacent unheated, uncontaminated region.

c. ***Deep Freezing for Subsequent Cultures***. Representative fresh tissues frozen at the time of necropsy may prove essential to diagnosis in the event that histologic study indicates a need for cultures.

Special Cultures. Many microorganisms grow poorly or not at all on routine culture media, therefore, the bacteriologist should be given full information concerning the exact nature of the disease and the character of the lesions, in order that he may do intelligent and ac- curate work. The more important diseases requiring special conditions for cultivation and isolation of the microorganism are tuberculosis, tularemia, brucellosis, pertussis, gonorrhea, and influenza. For preservation of material form spirochetal diseases, draw blood or tissue fluid into capillary tubes, 8 to 10 cm in length. Seal the ends of these tubes by melting the glass in a flame. The *Treponema pal/idum* may remain active for as long as 48 hours under these conditions.

Study of Fungi

Direct microscopic examination of pus, other fluid, or material form ulcers should be examined without staining by placing a drop on a slide and pressing it gently under a cover glass to make a thin smear. If necessary, the material may be cleared by placing it in a drop of 10 percent potassium hydroxide on a slide, covering with a glass slip and gently warming the slide.

a. Spinal fluid should be examined in the same way as pus, except that it should be centrifuged and the sediment examined directly. When cryptococcosis is suspected, place a drop of sediment in a drop of India ink on a slide, cover with cover slip.

b. **All** materials from cases of suspected myotic infection should be *cultured* for fungi regardless of whether fungus cells are found on direct examination. As a routine procedure, it is suggested that blood agar plates be streaked, and Sabouraud's glucose agar slants inoculated, with material obtained from lesions. The blood agar plates should be incubated at 37° C. and the Sabouraud's slants kept at room temperature.

Smears

Direct examination of smears stained for bacteria may yield valuable information. In many protozoa) diseases, thick films of blood or tissue fluid should be prepared. Touch a clean slide to a drop of blood or tissue pulp and allow it to spread over an area about 1 cm in

diameter. Dry at 37° C. for one hour, or in a horizontal position at room temperature overnight in a dust-free atmosphere. Such smears should be stained with Giemsa stain within 48 hours, because they deteriorate on standing.

Disposition of Cultures

If a skilled bateriologist is not available locally, send the material collected at autopsy immediately to a bacteriological laboratory. Attach a short note containing in- formation that will serve as a guide in the selection of culture media and conditions of incubation. In smaller laboratories the pathologist may carry out the simpler isolations and identifications, but material from all important and doubtful cases should be sent to a laboratory equipped for bacteriological examinations. If the pathologist or clinician knows that a patient with an unusual bacterial disease is on the wards of the hospital, he should consult with a bacteriologist in order to anticipate what autopsy material will be required to establish the diagnosis. If facilities for bacteriological studies are not available, the blood and tissues collected at autopsy should be placed in sterile vessels, frozen with dry ice, and shipped to a bacteriological laboratory.

SPECIAL STUDIES OF VIRAL DISEASES

Suspected Viral Diseases

d. In any case of suspected viral disease, steps should be taken to identify the typical histological changes in the tissue and to isolate the virus.

e. For cytological studies ,fix representative blocks of tissue in Bouin's fluid or Zenker's fluid and cut in the usual way. For the isolation of the virus, not less than IO gm of fresh tissue should be removed with sterile pre- cautions from the lesions.

f. In view of the opportunities provided for diagnosis by means of tissue culture, submit fresh frozen tissues for isolation viruses. Samples of fluids such as whole blood, respiratory tract-exudate, or intestinal content should be frozen separately. Each specimen of fresh tissue or fluid should be placed in a *separate* sterile, airtight container of glass, metal, or plastic and sealed to prevent the entrance of carbon dioxide. The acidity of absorbed car- bon dioxide is detrimental to many virsuses and may inactivate them. If possible, the material should be quick- frozen in dry ice, but it can be preserved in 20 volumes of 50 percent buffered glycerol for each volume of tissue.

g. Directions for the preparation of *sterile buffered glycerol* are:

(1) Citric acid 21 gm. to 1,000 ml double distilled water.

(2) Anhydrous Na_2HP04 28.4 gm to 1,000 ml double distilled water.

(3) Take 9.15 ml of (1) above and 90.85 of (2) above to make 100 ml of buffer solution pH 7.4.

(4) Mix equal parts of (3) above and C.P. glycerol; fill cork-stoppered specimen bottles half full and sterilize at *15* lb. of steam pressure for 30 minutes.

h. If buffered glycerol is not available, sterilize a solution containing *50* percent glycerol and 0.9 percent sodium chloride. If dry ice is available, place each IO gm sample of tissue in a separate sterile test tube or glass bottle and keep frozen.

i. In viral diseases of the central nervous system it is desirable to have blocks of fresh tissue, about IO gm each, from the following 9 regions:

,(I) Temporal lobe, including the hippocampus.

(2) Motor cortex.

(3) Olfactory bulbs.

(4) Midbrain.

(5) Thalamus.

(6) Pons and medulla.

(7) Cerebellum.

(8) Cervical cord.

(9) Spinal cord as indicated.

j. Blocks of tissue immediately adjacent to the tissue removed for viral studies should be fixed in Zenker's or Bouin's fluid for microscopic study. Blocks should not exceed 2 mm in thickness. Specimens from cases of rick- ettsial disease should be fixed in Regaud's fluid.

k. At autopsy, obtain enough blood aseptically to provide approximately 10 ml of serum. The blood should be refrigerated immediately, the serum separated as soon as possible and stored without preservative in a tightly stoppered sterile tube. The tube should be labeled with the patient's name, autopsy number or other identifica- tion and the date of collection. It should be refrigerated or frozen and submitted with the tissue for virus isola- tion, together with any serum previously obtained from the patient. The serum may be used to obtain a disgnosis by serological means in the event that a virus is not isolated.

The Collection and Handling of Brain Tissue at Autopsy for the Diagnosis of Rabies

A face shield or goggles and rubber gloves to protect the prosector are essential during the exposure and removal of the brain. Take I gm blocks of tissue aseptically from the hippocampus, cerebellar cortex, medulla, pons, thalamus, and cerebral cortex of one cerebral hemisphere and pool for virus isolation. If virus isolation is to be attempted on the same day, refrigeration is adequate; if not, freeze the pooled tissue.

Take from the opposite cerebral hemisphere approximately I gm blocks of tissue from the hippocampus, cortex of the cerebellum, and the frontal and parietal lobe of the cerebrum. Fix one-half of each block in Zenker's fluid. Make impressions from the other half of the blocks by pressing slides on the cut surface, and stain while still *moist* with Seller's stain. If the impressions cannot be stained at once they may be fixed while still *moist* for two

minutes in absolute C.P. methyl alcohol.

Technique for Negri Bodies in Impressions

l. *Seller's Stain*. Immerse slides while the impression is moist in Seller's stain for 1 to *5* seconds depending on thickness of impression. Rinse gently under running tap water, and airdry (do not blot). Examine thin areas with the oil-immersion lens. Negri bodies stain bright cherry red. They are round or oval bodies up to 23 microns in diameter, in which vacuoles containing basophilic gran- ules usually can be demonstrated. Cytoplasm of nerve cells stains purplish-blue, nuclei and nucleoli deep blue, and stroma pink. The formula for Seller's stain is:

(1) Stock Solution A. Dissolve 1 gm of basic fuchin in 100 ml of absolute, acetone-free C. **P.** methyl alcohol.

(2) Stock Solution B. Dissolve 1 gm of methylene blue in 100 ml of absolute, acetone-free C. P. methly alcohol.

(3) Store both solutions in glass-stoppered bottles.

b. *Working Stain*. Take one part of Stock Solution A (basic fuchsin) and mix with two parts of Stock Solution B (methylene blue). Mix but do not filter.

Technique for Negri Bodies In Smears

m. With a small scissors cut through Ammon's horn (hippocampus). Clip a piece from the cut surface no **larger** than a grain of rice (a portion of the hippocampus **previ**ously removed may be used). Also use a piece of tissue from the cerebellar cortex.

n. Transfer tissue to a clean slide near one end. Press this out flat by means of another slide. Draw the top slide along the length of the bottom one, leaving a thin smear.

o. Stain with Seller's stain by the same technic as described for impressions. *It must be stained before it dries*. If staining cannot be done immediately, fix for 2 minutes while the smear is still moist in absolute C. P. methyl alcohol.

Technique for Negri Bodies Zenker **Fixed Tissue (Schlelfsteln's** Staln)·

p. Wash Zenker-fixed tissue for 24 hours in running tap water. Embed in paraffin and cut sections at 6 microns.

b. *Staining Procedure:*

(1) Deparaffinize sections in usual manner. Run through absolute and 95 percent alcohols to distilled **water.**

(2) Remove mercury precipitates in *5* percent iodine solution for *5* to 10 minutes.

(3) Rinse in running tap water for 2 minutes.

(4) Clear in *5* percent soduim thiosulfate solution for *5* to 10 minutes.

(5) Wash in running tap water for 10 minutes, rinse in distilled water.

(6) Place sections on warm electric hot plate, flood with freshly prepared Schleifstein's solution, and steam gently for *5* minutes.

(7) Cool and wash quickly in tap water.

(8) Decolorize and differentiate each slide individually by gently agitating in **90** percent alcohol until sections are faint violet color.

(9) Dehydrate with **2** changes of *95* percent alcohol, clear with xylene, and mount in Permount.

c. Results:

(1) *Negri bodies-deep* magenta.

(2) *Cytoplasm-bluish* violet.

(3) *Erythrocytes-copper.*

IMMUNOLOGICAL EXAMINATION

Relation of Virus to Disease

The isolation of a specific bacterium or virus from the tissues does not prove that it is the cause of the disease from which the individual died. The bacterium may be a contaminant or a secondary invader. A virus found after animal passage may be virus indigenous to the animal used for experimental inoculation. Proof of the relation of a bacterium or virus to the disease may be obtained by the demonstration of immune bodies in the serum. In all autopsies on patients suspected or known to have died of a bacterial or viral disease, 25 ml of blood should be removed under sterile conditions from the heart and placed in sterile centrifuge tubes.

Preservation of Serum

Immediately on completion of the autopsy, the sample of blood should be centrifuged, the serum removed with sterile pipettes and kept in sterile tubes in the refrigerator. If possible, tubes of serum without preservative should be held and shipped frozen in dry ice. An alternative is to hold the serum samples under refrigeration and ship via air mail. Preservatives are not recommended because they interfere with neutralization tests. When neutralization tests are not indicated and delivery to the laboratory may be delayed, 0.3 percent cresol may be added as a preservative.

Speculum examination and pelvic exenteration for sexual assault

- Consider involving the local jurisdiction specialist in sexual assault to attend the autopsy to assist with interpretation of possible injuries and the taking of samples
- Prior to any instrumentation or dissection any samples needed for evidentiary purposes (sexual fluids or DNA) must be taken to avoid potential contamination .
- Lithotomy position may assist in examination and dissection
- Speculum examination is completed as per the local jurisdiction protocols for sexual assault and is similar to that completed on a live victim

- Several methods exist for the dissection of the vagina / rectum
    - Traditionally, the routine anterior body incision is continued inferiorly to pass over the pubic symphysis and surround the vagina / rectum
    - Pubic bones are sawed through ~5 cm on either side of the pubic symphysis and the tissues are separated away from the inner surface of the pelvic brim until the pelvic contents can be removed en bloc
    - Tissue is fixed in formalin before dividing in the sagittal plane for assessment of the vagina / rectum
    - This pelvic exenteration is disfiguring and consideration should be given to less invasive approaches where possible
- Less destructive technique involves making an elliptical incision around the external genitalia, meeting anteriorly to the clitoral hood anteriorly and posteriorly to the anus posteriorly, extending laterally at approximately the level of the labia majora
    - This incision is continued into the deep pelvic tissues, following the contours of the inner aspect of the pelvis, to eventually communicate with the abdominal cavity; the entire tissue block including anus to rectum and vagina to uterus and ovaries can then be removed
    - Lateral incisions from the anus to the cut end of the rectal stump and from the vagina, through the cervix and through the uterus can then be made and the entirety of the genital tract examined for injury
    - Bladder is also opened and inspected

SECTION-03.

Reconstitution of the body

An important component of the autopsy is the reconstitution of the body such that it can be viewed, if desired, by relatives of the deceased following the procedure. After the examination, the body has an open and empty thoracic cavity with chest flaps open on both sides; the top of the skull is missing, and the skull flaps are pulled over the face and neck. It is unusual to examine the face, arms, hands or legs internally.

All organs and tissue must be returned to the body unless permission is given by the family to retain any tissue for further investigation & the tissues are handled as per the Human

Tissues act [if the act exists in the country)of the Region. Normally the internal body cavity is lined with cotton, wool, or a similar material, and the organs are then placed into a plastic bag to prevent leakage and are returned to the body cavity. The chest flaps are then closed and sewn back together and the skull cap is sewed back in place. Then the body may be wrapped in a Shroud, and it is common for relatives to not be able to tell the procedure has been done when the body is viewed in a Funeral Home.

SEVENTH CHAPTER

Paediatric/ Foetal Autopsy

PEDIATRIC AUTOPSIES WITH SPECIAL REFERENCE TO INFANTS AND FETUSES

PRELIMINARY CONSIDERATIONS

GENERAL

The techniques adopted in autopsies on adult bodies are applicable to children and older infants, but special attention must be given certain details and the procedures modified in the case of newborn infants and fetuses.

Permission

a. **A** fetus under 22 weeks gestation, born dead, and measuring less than 25 to 28 cm in length, is generally considered a surgical specimen or abortus. In such a case no autopsy permit, death certificate, or burial ceremony is required. It is important to know the local law in this respect since it varies somewhat in different localities. The local coroner, Medical Examiner or Public Health Officer should be consulted for legal procedures.

b. Regardless of the time of gestation or the measurements, a newborn infant that shows any evidence of life, even though it be only momentary, after complete birth, must be registered as a live birth, and a death certificate filed.

c. Legal permission is required to perform an autopsy on a child born alive, regardless of the length of gestation or measurements.

Such permission is also required in the case of newborn infants which are born dead but have developed to the stage of viability.

Proper Care of the Body

Viable infants and fetuses which are to be viewed after autopsy should be examined in such a manner that no incisions or mutilations will be visible. If there is little or no hair on the scalp, the skin incision for opening the head should be made as far posteriorly as practicable.

Clinical History

Since little or no history of the infant may be obtained, the clinical record of the mother should be consulted. Facts concerning pregnancy, labor, delivery, and past history, especially with regard to illnesses and pregnancies, may supply significant information. In some cases the blood type of mother and father and serologic studies for Rh antibodies in the mother are invaluable in final evaluation of the autopsy. Past history of siblings may also be helpful.

Pre-autopsy checklist

Preparation

Before starting the autopsy, check the type of consent given, the identity of the infant and consult the clinicians, to determine the questions that have to be answered by the autopsy.

Imaging

A radiograph of the whole body is helpful. Postmortem arteriography is advocated only if a vascular abnormality is present. Abnormalities shown by radiography ranged from 9% to 30% and provided a diagnosis in 0.9% of cases. Ossification centres provide a rough index of bone maturation. Metaphysitis of the long bones may be seen in congenital infections such as syphilis, and cerebral calcification in toxoplasmosis and cytomegalovirus infection. Radiographs may also show abdominal or vascular calcification, which may be calcification of the arterial walls or venous thromboses. If there has been trauma, radiography of the skull and limbs is essential. In skeletal dysplasia, radiography forms a major part of the diagnosis, and lateral views and views of the hands and feet should also be taken.

A correlation of the findings of postmortem examination with those of ultrasound assessment is required and has ranged from 46% to 72%, with the postmortem examination providing an audit on the standard of ultrasonography. Early cardiac ultrasonography of unselected fetuses is not advisable. In fetuses with increased nuchal lucency, however, cardiac ultrasonography at 12–16 weeks showed a cardiac abnormality, either structural or functional, in 22% of cases, and an abnormal karyotype in 8%.A recent study from Norway described congenital cardiac defects that were missed on ultrasonographic screening and clinically at birth, and were diagnosed only after a second admission.

Magnetic resonance imaging (MRI) has been used for detecting malformations of the central nervous system (CNS) and neuronal migration disorders, as well as to study the development of myelination. A prolongation of relaxation times in the neonate occurs

because of the high water content in the brain. High-resolution multiplanar MRI provides good anatomical delineation and distinction between grey and white matter. Where consent for an autopsy is refused, it provides a good alternative for examination of the brain and may detect abnormalities of the CNS that are not seen at postmortem examination. Low-field dedicated MRI is a potential tool in perinatal autopsy. A detailed MRI study of malformations of the CNS, combined with postmortem examination and frozen tissue storage for DNA studies, has led to the detection of mutations of genes that are responsible for malformations. This has led to prenatal diagnosis on chorionic villous biopsy at 10–12 weeks of gestation. Comparison between ultrasound and MRI of a series of 100 cases with abnormalities of the CNS showed concurrence in 52 cases, and 35 cases in which additional information provided by MRI altered the management of the case.

Full body, face and facial profile photographs help in diagnosis and can be used for consultation. Digital photographs are particularly useful. A black and white print can be kept with the paperwork of the autopsy, providing for easy comparison with reference books. Photographs of malformations are essential.

Metabolic case

If a metabolic disorder is queried, tissue samples need to be taken within 4–6 h of death. Skin for fibroblast culture should be placed in growth media at room temperature. Muscle, heart, brain and liver should be snap frozen and taken for electron microscopy. Plasma, blood and urine should be frozen. Bile and blood should be stored on filter paper at room temperature. Other tissues that may be used include conjunctiva, intestine, peripheral nerve, bone marrow and amniocytes.

Performing the autopsy

External examination

Morphometry

Measurements of crown heel, crown rump, head circumference, foot length and weight are taken for comparison with standard charts. Wigglesworth provides weights and measurements for stillborn and liveborn infants by using data from the Women & Infants Hospital, Providence, Rhode Island, USA. Foot length is used to determine gestational age, which can then be compared with chronological age. The infant can be classified as small, appropriate and large for gestational age. Measurements of crown heel and head circumference should be equal. A discrepancy of 20 mm indicates microcephaly or macrocephaly, or a disproportionate body. The biparietal diameter can be directly compared with ultrasonographic measurements. With facial dysmorphism, inner and outer canthal distances, interpupillary distance and length of palpebral fissures are helpful. Systemic examination of the infant is conducted by using a checklist.

Head and skull

After a forceps or vacuum extraction, the infant is examined for abrasions, cephalhaematoma or subaponeurotic haemorrhage. Dissection of the suboccipital region is essential before opening the skull. Bulging fontanelles indicate intracranial disorder. The presence of additional fontanelles or defects of the skull raises the possibility of a chromosomal defect or Meckel–Gruber syndrome, where an encephalocoele is a frequent finding. Splayed sutures suggest hydrocephalus, and premature fusion of the sutures indicates craniosynostosis, where there is an abnormally shaped head, small fontanelles and proptosis owing to shallow orbital fossae. Defects of the scalp are seen in trisomy 13.

Skin

Multiple haemangiomas suggest Osler–Rendu–Weber syndrome and leaf-shaped café au lait spots tuberous sclerosis. Haemorrhages or blueberry muffin lesions may indicate a haematological condition, congenital infection or hypoxia. Bullae, pustules or scaling lesions may indicate a congenital infection such as varicella zoster or congenital syphilis, which includes the palms and soles, or dermatological conditions such as ichthyosis, and must be distinguished from maceration. If in doubt, take a skin biopsy specimen from a lesion. Meconium staining of the skin or orifices indicates intrauterine hypoxia.

Face

Cataracts may be present in congenital infections such as rubella and toxoplasmosis, as well as in systemic diseases, genetic conditions and inborn errors of metabolism. Hypertelorism with short palpebral fissures is part of the facial dysmorphism of fetal alcohol syndrome and fetal exposure to valproate. Low-set posteriorly rotated ears with flattened pinnae suggest anhydramnios due to renal disorder and Potter's sequence. Microtia and pre-auricular skin tags are frequent in Goldenhar syndrome. Creases of the ear lobe and pits on the undersurface are markers for Beckwith Weidemann syndrome. In otocephaly, both pinnae occur in the midline below the mouth, with congenital absence of the mandible. A short nose, a long smooth philtrum and a thin upper lip are seen in fetal alcohol syndrome and on exposure to valproate. A proboscis is frequent in trisomy 13 and may be situated above a midline cyclopic eye. Choanal atresia is found in CHARGE (coloboma, heart disease, atresia choanae, and retarded growth and development) syndrome. The CHD7 gene is mutated in 60% of postnatal cases.

Abnormal facial clefts may be seen in amniotic deformities, adhesions, mutilations (ADAM) syndrome. A visible tongue indicates the presence of macroglossia, as is seen in Beckwith Weidemann syndrome or with abnormalities of the CNS. An immobile tongue indicates a lack of swallowing and may be because of fetal akinesia. A tongue-tie may be present, which is associated with familial cleft lip and palate.

Micrognathia or retrognathia is often seen in aneuploidy. A horizontal crease on the chin may indicate renal disease.

Neck

The neck may show lateral skin webbing as is seen in monosomy X (XO) and multiple pterygium syndrome, or postnuchal cystic hygroma, which occurs frequently in XO, trisomy

21 and trisomy 18. A posterior midline swelling could be due to a cervical meningocoele. Fused cervical vertebrae raise the possibility of Klippel Feil syndrome. A groove around the neck with congestion of the face suggests strangulation by the umbilical cord.

Chest

A small abnormally shaped chest with short ribs is present in most skeletal dysplasias, which indicates pulmonary hypoplasia. A bell-shaped chest often indicates pulmonary hypoplasia, as may occur with anhydramnios. The chest may bulge asymmetrically, indicating a diaphragmatic hernia or pneumothorax. Palpable crepitus may occur following difficulty in ventilating the infant.

Abdomen

Abdominal distension can be due to ascites, organomegaly, gaseous distension of the bowel, intestinal obstruction and, rarely, a tumour. Defects of the body wall may be related to a short umbilical cord, a localised defect near the umbilicus as occurs in gastroschisis or failure of the bowel to return into the abdomen during development, as seen in an omphalocoele.

Extremities

A simian crease and sandal gap typically occur in trisomy 21, polydactyly occurs in trisomy 13 and some skeletal dysplasias, and overgrowth of a digit occurs in Proteus syndrome. Syndactyly of the third and fourth digits is typical of triploidy and the placenta should be examined for partial molar change.

Genitalia

The external genitalia may be malformed or ambiguous, with associated renal and anal anomalies. Defects of the neural tube, pigmented lesions, abnormal tufts of hair and midline masses are frequent in the lumbar area.

Dissection

Standard neonatal textbooks explain the various dissection techniques.

The heart is dissected following the blood flow sequentially starting from the right atrium. Before dissection, the outflow tracts, aortic isthmus and ductus arteriosus are measured, and the measurements indicate the pattern of blood flow through the heart. Inflation and wax impregnation of the heart provide a permanent specimen, which is useful for teaching.

The brain-to-liver weight ratio is normally 2.5–3.5. Ratios of 5 and greater indicate asymmetric intrauterine growth retardation. The ratio of the combined weight of the lungs to the body weight is used to determine pulmonary hypoplasia. In infants below 28 weeks, a ratio of 0.015 or less indicates hypoplasia; above 28 weeks, the ratio for hypoplasia is 0.012 or less. Special dissection techniques are indicated if stenosis of the foramen magnum is suspected, as seen in osteochondrodysplasia. Rapid heat-accelerated fixation of the brain has recently been described. The cerebral gyral pattern is compared with reference pictures that indicate when there is closure of the operculum and the development of gyri, culminating with three gyri in the temporal lobe at term. The transcerebellar diameter can

be compared with reference values, and cerebellar microscopy, determining the presence of a lamina dessicans, thickness of the outer granular layer and maturation of the Purkinje cells, all help in the assessment of maturation.

In the macerated infant measurements may be distorted, but the foot length remains a reliable estimate of gestational age. Estimating the time of death includes macroscopic and microscopic criteria of the placenta and fetal organs. The costochondral junction may show interruption of growth. Careful dissection shows malformations. Asymmetric intrauterine growth retardation is often seen.

Placenta

The Placenta and Umbilical Cord

Autopsy of a newborn infant or fetus is not complete without examination of the placenta and umbilical cord. In most cases it is possible to determine whether twins are of single or of double ovum type by microscopic exam-ination of the septum between the two amniotic cavities. In other cases, the weight and size of the placenta as well as the microscopic examination of the chorionic villi will aid in establishing a diagnosis of hemolytic disease of the newborn, congenital syphilis, or other disease.

The normal umbilical cord has one coil or twist per 5 cm. Hypercoiling of the umbilical cord indicates hypoxia. Horizontal blocks of the maternal surface or squares of membrane may indicate maternal vascular disease. Cases with positive placental findings at perinatal autopsy range from 30% to 61%. Chorioamnionitis is the most common placental lesion associated with cerebral palsy in term and preterm infants. Fetal thrombotic vasculopathy may be present. Extensive placental infarction correlates with ischaemic cerebral injury, particularly periventricular white matter necrosis in stillbirths.

Special techniques

A cytogenetic study of 136 cases showed an abnormal karyotype in 15.5% of stillbirths and in 25% of neonatal deaths. All infants with an abnormal karyotype had congenital malformations. Time delays were crucial for obtaining positive cultures. A Dublin series of 75 unexplained stillbirths had an abnormal karyotype in 6 of 26 cases.

Fluorescent in situ hybridisation was performed on autopsy material to diagnose trisomy 18. A chromosome 18-specific centromere probe was used, and the test was positive in 9 of 10 cases. Macerated and archival tissues can be used for testing.

Fluorescent in situ hybridisation using liver cell touch preparations fixed in 95% ethanol is a low-cost and simplified method for diagnosing trisomies 21, 18 and 13 and monosomy X in autopsies of infants with congenital abnormalities.

PCR directed against the SRY gene has been used for rapid sex determination in patients with ambiguous genitalia. Karyotyping is best reserved for patients with multiple congenital anomalies.

The Kleihauer–Betke test for fetomaternal haemorrhage was positive in 8% of a series of 75 unexplained stillbirths, but a series of 745 stillbirths did not find it useful. Fetal haemoglobin monoclonal antibodies in the maternal circulation can be detected by flow cytometry Differentiation of maternal and fetal erythrocytes in paraffin wax sections by using haemoglobin F immunostain with alkaline phosphatase as a substrate has been described.

Raised levels of amniotic fluid erythropoietin indicate chronic fetal hypoxia in the uterus and may explain the cause of death in stillbirths. They correlate well with fetal erythropoietin levels.

Detection of infectious agents

Common pathogens

Congenital infections (toxoplasma, rubella, cytomegalovirus and herpes simplex) and syphilis are screened for in early pregnancy. In rare cases, perinatal deaths may be due to a congenital infection acquired during vaginal delivery. Changes in *x* ray, the presence of hydrops fetalis and organomegaly, particularly of the liver and spleen, may suggest the presence of congenital infection.

Detection of DNA sequences of herpes simplex virus by PCR in babies dying of neonatal herpes also localises the virus. Herpes simplex virus isolated from an autopsy of the liver was serologically detected by immunofluorescence and confirmed by electron microscopy.

DNA, mRNA and early antigen for cytomegalovirus can be detected by immunocytochemistry, in situ hybridisation and in situ hybridisation—immunomax on autopsy of tissues. Early antigen was detected most often. DNA for cytomegalovirus was found more often than mRNA.

Most cases of syphilis have been treated in the uterus after maternal serology showed a positive result. Metaphysitis, marked splenomegaly, pericellular hepatic fibrosis and pulmonary fibrosis with extramedullary haemopoiesis are typical features. The diagnosis of congenital syphilis in severely macerated fetuses is facilitated by the examination of amniotic fluid by dark-field microscopy. Spirochaetes with the typical appearance and motility of *Treponema pallidum* are seen. Warthin Starry stain was positive in two of five cases and anti-treponema antibody immunofluorescence in one of three cases.

Toxoplasmosis causes hydrocephalus with intracerebral calcification. PCR of amniotic fluid recognises the B1 gene of *Toxoplasma gondii* and can be completed in a day. A reported series provided an excellent detection rate, no false positives and one false negative test. On autopsy Toxoplasma cysts may be seen in multiple tissues, ranging from the placenta to the brain. Testing for Rubella as a cause of death in stillbirths was not helpful.

Unusual pathogens

Coxsackie myocarditis is an uncommon cause of death in neonates. Coxsackie B3 antigens can be detected in formalin-fixed tissues by immunofluorescence on autopsy. In the myocardium, antigen is positive in both cardiac myocytes and endothelial cells. This

observation was confirmed by electron microscopy. Recombinant Coxsackie enteroviral B3 capsid protein, VP1, was observed in necrotic cardiac myocytes and in islet cells of the pancreas by immunofluorescence. Adeno-associated virus antigen was detected by fluorescent antibody technique in infants dying from respiratory infections on autopsy. Viral antigens were detected by immunofluorescence in frozen or formalin-fixed specimens of lungs, kidneys, spleen, liver and lymph nodes on autopsy. The virus was confirmed by electron microscopy. Immunofluorescence provides a rapid diagnosis.

In southern Brazil, Chagas's disease is prevalent in pregnant women. Examination of the pericardial fluid from stillbirths by immunofluorescence for trypanosome proteins provides a reliable means of diagnosis. Complement fixation and haemagglutination can also be performed on the fluid. *Trypanosoma cruzi* is rarely found in the placenta and infected infants may be negative for IgM antibodies.

Iatrogenic lesions

Prenatal maternal drug exposure may be due to therapeutic drugs—that is, warfarin for maternal prosthetic cardiac valves or deep vein thrombosis, and valproate for maternal epilepsy. Typical features of fetal Warfarin syndrome are a hypoplastic nose, stippled epiphyses or abnormality of the eye. Spina bifida and craniofacial dysmorphism are also characteristic of fetal valproate syndrome. Chorionic villus sampling, amniocentesis and cordocentesis carried out by experienced staff have a low risk of complication. In a series of 873 intrapartum deaths from Trent, UK, 37 cases had traumatic deliveries. Cranial traumatic injury was always associated with physical difficulty at delivery and the use of instruments. Rare cases of spinal cord injury may occur.

Late complications of hyaline membrane disease include bronchopulmonary dysplasia. Complications of extracorporeal membrane oxygenation mainly include haemorrhage and sepsis. Complications in neonatal intensive care may occur because of extreme prematurity or prolonged total parenteral nutrition. The death rates of infants from neonatal intensive care units have been declining. A study of 75 infants from a neonatal intensive care unit from New Mexico examined the correlation between clinical diagnosis and autopsy. In 92% of cases the clinical diagnosis was confirmed. Agreement regarding the cause of death, however, was seen in only 50% of cases.

Risk factors for perinatal injury

Premature infant

Maternal risk factors for preterm delivery include age <20 years, previous preterm birth, short interpregnancy interval, poor prenatal care, inadequate nutrition, low socioeconomic class, psychosocial stress, low prepregnancy weight, poor weight gain, short cervix, alcohol, cocaine, smoking, vaginal infections, urinary tract infections, sexually transmitted infections and sudden onset of pre-eclampsia. Probable placental lesions include the premature rupture of membranes, acute chorioamnionitis, placental ischaemia, chronic deciduitis, marginal separation with retroplacental haemorrhage, placenta praevia and marginal cord insertion. Causes of fetal death include fetal sepsis, abruption and fetal

vascular thrombosis.

Small for gestational age or fetal growth restriction

Maternal risk factors include short stature, low weight, poor weight gain during pregnancy, smoking and abnormal uterine structure, pre-eclampsia, thrombophilia and renovascular disease, reproductive failure, and autoimmunity. Fetal causes represent genetic and chromosomal disorders, including confined placental mosaicism. Placental lesions include chronic abruption, chronic villitis, fetal thrombotic vasculopathy, chronic intervillositis and massive perivillous fibrin deposition. Clinically reduced Doppler flow, followed by reversed Doppler flow, followed by intrauterine death occurs unless there is intervention. Causes of death include atherosis of maternal vessels and malformations in the fetus if aneuploidy is present.

SUMMARY

- Pre-autopsy checklist should include consent, *x* ray, correlation with ultrasound, and photography. Special cases may need magnetic resonance imaging or metabolic tests.
- Morphometry and careful examination, paying attention to head and skull, skin, face, neck, chest, abdomen, extremities and genitalia, followed by dissection of the fetus and placenta, should permit the pathologist to classify the fetus. Categories include normal macerated, hydropic, congenital anomaly or fresh normal, as well as small, appropriate and large gestational age. Foot length is most reliable in the macerated fetus.
- Special techniques may be required to make a definitive diagnosis, such as cytogenetics by fluorescent in situ hybridisation, and immunofluorescence for common and unusual infectious agents.
- Determine what risk factors, in utero, during delivery or postnatally, may have contributed to the adverse fetal outcome. Timing of death by assessing the degree of maceration may help in interpretation of the case.
- Ensure that the final report answers the questions that were posed by the clinicians and provides information for counselling for a future pregnancy.

Hypoxic–ischaemic injury or birth asphyxia

Maternal factors include thyroid disease, vaginal bleeding during pregnancy, postdated pregnancy, diabetes, renal disease, essential hypertension, malnutrition and anaemia. Fetal factors include thrombophilia, being large for gestational age and incomplete flexion of the head. Placental lesions that cause circulatory disruption include uteroplacental separation, fetal haemorrhage, umbilical cord compression, placentofetal thromboemboli and placenta praevia. Both villous oedema and infarction impair placental exchange. Placental lesions known to be associated with subsequent neurological impairment include avascular villi, haemosiderin in the chorionic plate, fetal vascular thrombosis and severe inflammation. Fetal lesions depend on gestational age, and the nature and duration of the insult. Preterm infants develop necrosis of white matter and gliosis. In term infants the

predominant site of injury is the central grey matter, although lesions of white matter may also occur.

Hydrops fetalis

Hydrops indicates the presence of heart failure, anaemia or hypoproteinaemia, or a combination. It is often non-immune. Cardiovascular causes include structural defects and arrhythmias, and account for 22% of cases. Pulmonary and thoracic lesions account for 16%, anaemias for 12% and chromosomal abnormalities for 10% of cases. Minor lesions include fetal infections, malformations of the urinary tract, tumours, storage diseases and metabolic causes. In all, 19% of cases remain undetermined after a complete autopsy.

Timing of insults

Placenta

Placental lesions may be chronic, subacute or acute. Villous intravascular karyorrhexis occurs 6 h after death, with septation of stem villous vessels by 2 days. If extensive, death occurred 2 weeks previously. Meconium is present in chorionic macrophages after 3 h. Meconium is often associated with chorioamnionitis and fetal thrombotic vasculopathy, which result in severe morbidity. A recent study has shown enhanced growth of group B Streptococcus in the presence of meconium.

Fetus

The degree of skin loss in maceration allows us to estimate the time of death. A skin loss of size 1 cm indicates 6 h and mummification 2 weeks after death. Microscopic examination for loss of nuclear basophilia in various tissues provides an estimate of the time of death. Adrenal fat distribution indicates whether the mode of death was acute or chronic. The costochondral junction may indicate growth arrest. The microscopic appearance of the thymus indicates the duration of illness. Mineralisation of necrotic neurones, vascular proliferation, gitter cells and cyst formation help in determining the duration of cerebral necrosis.

Cause of Death

Although the physician in charge of the patient is responsible for signing the death certificate, he usually depends on the pathologist for help in establishing the cause of death. In many cases, the pathologist will be unable to find anatomical evidence of the cause of death, especially in an infant or child, but a careful study of the historical events and attention to details of the autopsy, together with microscopic examination, will often pro- duce important evidence.

Conclusion

The role of perinatal autopsy is to provide answers to parents and clinicians regarding the

cause of death and congenital anomalies. It also provides an audit of ultrasonographic diagnosis, obstetric and neonatal intensive care. The cost of autopsy has a role in the diagnosis: it is vital for teaching, training, research and epidemiology. If perinatal autopsy fails to fulfil these requirements, it will be replaced by imaging techniques, needle biopsies and verbal autopsy. In cases of fetal malformation, only a complete autopsy will detect all abnormalities, which may be crucial in providing appropriate counselling to the family for a subsequent pregnancy.

EIGTH CHAPTER

INFECTION CONTROL
AUTOPSY SUITE FOR HIGH RISK AUTOPSIES
Bio Safety Level-3
BSL-3 Autopsy Laboratory

Accurately assessing the risks of autopsy allowed the design and construction of a high-throughput forensic autopsy laboratory that uniformly protects worker health and mitigates risk. The Office of the Forensic Medicine, BSL-3 autopsy laboratory, combined with corresponding policies and procedures and PPE commensurate with the facility, uniformly provides Doctors & Staff with a high level of protection from both airborne and blood-borne pathogens. Additionally, the facility design contains airborne pathogens through secondary barriers and thereby protects non autopsy workers and others occupying office space outside of the autopsy laboratory.

As it is impossible to accurately predict which autopsy cases have an infection potentially transmissible by autopsy aerosols, we believe that all autopsy laboratories should uniformly function at BSL-3, rather than having a separate, stand-alone BSL-3 autopsy room to be used only when a highly transmissible infection is suspected. This all-hazard approach will best protect autopsy workers and facility users and ensures that autopsies important for the maintenance of public health will continue to occur in an appropriately safe laboratory.

All autopsy Surgeons/Staff, and especially forensic pathologists & Lab workers, are routinely exposed to blood, open tissues, and a wide variety of sharp objects, including scalpels, needles, broken glass, Bony dust, and even body fluids. These sharp objects can perforate gloves and transmit various different types of infections, including hepatitis B and C, acquired immunodeficiency syndrome, tuberculosis, streptococcal sepsis, blastomycosis, coccidioidomycosis, rabies, tularemia, diphtheria, erysipeloid fever, and some of the viral hemorrhagic fevers. Though, These risks from Sharp instruments are now largely mitigated by using cut-proof mesh undergloves.

More insidious than blood-borne pathogens are the agents that can be carried by autopsy-generated aerosols and inhaled by both prosectors and individuals outside of the autopsy laboratory environment. The prototypical organism transmitted in this manner is *M tuberculosis*. Other infections, including rabies, plague, legionellosis, meningococcemia, rickettsioses (eg, Q fever), coccidioidomycosis, anthrax, severe acute respiratory syndrome, and COVID-19 can be potentially transmitted in this way, besides many of those unknown to us arising out of mutations.

Aerosols are composed of particles approximately 1 to 5 μm in diameter that remain suspended in the air for long periods of time and when inhaled can reach the pulmonary alveoli. Particles larger than 5 μm in diameter (eg, droplets generated by splashes) can be inhaled into the mouth or impact other mucosal surfaces and transmit infections. However, these droplets travel shorter distances, falling to the ground. All autopsies generate aerosols and larger droplets that can carry infectious agents. Oscillating saws used to divide bone and soft tissue, aspirator hoses used to suction fluid that vent into sinks, and hoses used to spray water onto tissues all generate potentially infectious aerosols. Oscillating saws generate large quantities of respirable particles, with concentrations measured as high as 5700 particles/mL in the breathing zone of autopsy prosectors. In an experiment where oscillating saws were applied to HIV-infected blood, HIV was recovered from the aerosols generated. Even using autopsy tools such as knives to cut lungs can generate infectious aerosols.

Autopsy can efficiently transmit tuberculosis from the decedent to prosectors and observers. For example, 8 of 35 medical students were infected from a 1-hour autopsy

exposure to a decedent with tuberculosis. Majority of the infections reported are attributed to inadequate respiratory protection ,inappropriate and inadequate facility ventilation. Absence of Negative pressure ventilation has resulted in the infection of a office personnels who worked outside of the autopsy room.

Hence, The combination of exposure to both blood-borne and airborne pathogens from procedures that can cause cutaneous inoculation and inhalation of aerosols indicates that autopsies should be performed at BSL-3 for the safety of prosectors and others in all High Risk Autopsies.

DESIGN OF A BSL-3 MEDICOLEGAL AUTOPSY FACILITY

Although biosafety standards have been well characterized for biomedical and microbiological laboratories, including agent-specific degrees of risk, less attention has been paid to biosafety in autopsy laboratories. However, the principles of biosafety developed for clinical and research laboratories can be translated and applied to autopsy laboratories. The key BSL-3 features identified for autopsy facility design are a separate autopsy room with lockable doors that restrict access to autopsy personnel; balanced room ventilation, so that airflow is unidirectional and inward (negatively pressured) and then exhausted to the outside; sealed penetrations through the laboratory envelope (walls, floors, and ceiling), including door frames; easily cleaned and decontaminated walls, floors, and ceilings; monolithic and slip-resistant floors; vacuum lines with liquid disinfectant traps and high-efficiency particulate air (HEPA) filters; and containment features verified by experts before work is initiated and annually.

General Design Concepts

The Office of the Medical Investigator autopsy and support laboratory space occupies a distinctly separate area of the building from administrative space and the decedent drop-off/pickup zone . The BSL-3 autopsy laboratory design uses the principles of concentric ring containment and access control. The concentric ring construction puts the area of highest biosafety need (BSL-3 isolation autopsy) at the core of the laboratory, surrounded by zones of decreasing biosafety (BSL-3 general autopsy followed by BSL-2 support laboratory space). The concentric ring design allows for unidirectional airflow. Because of constraints created by the building lot, these concentric rings are eccentric in shape. Both the BSL-3 isolation autopsy zone and the BSL-3 general autopsy zone are within the BSL-3 envelope, which is an airtight boundary created by the walls, ceiling, and floor. All penetrations of the envelope (power, water, sewer, air) and passage points for personnel, decedents, specimens, and waste are sealed to prevent air leakage and potential exfiltration of airborne biological

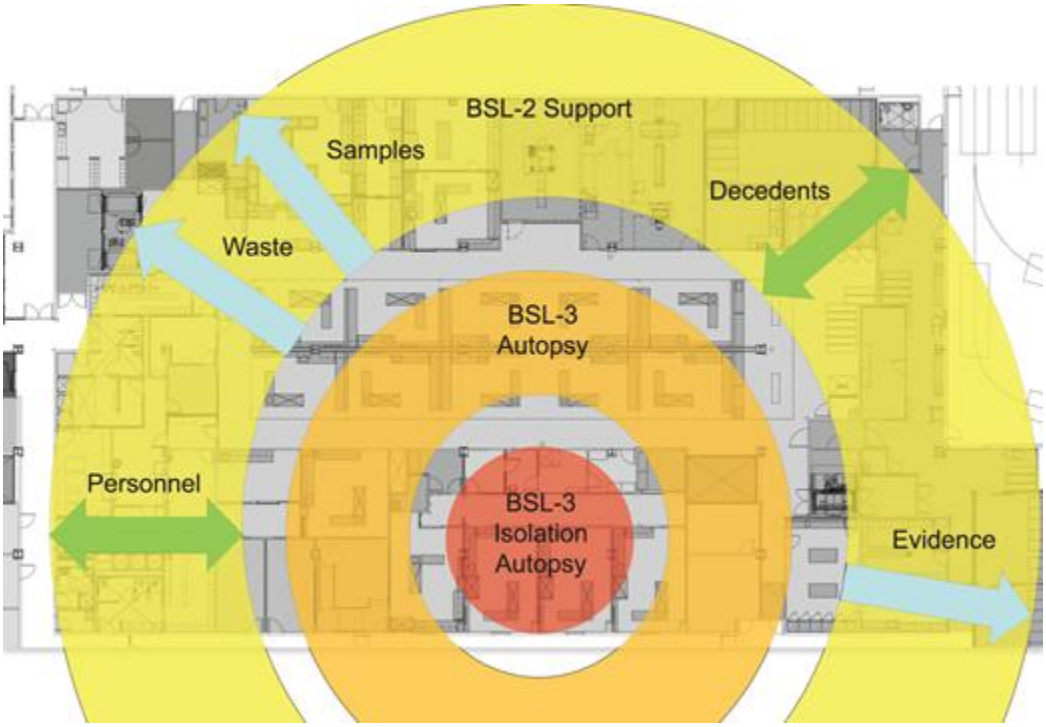
contaminants from the laboratory space to the external environment. The prevention of air leakage is also largely dependent on a unidirectional negative pressure ventilation system. To prevent contamination of the environment beyond the autopsy laboratory, access to and egress from the BSL-3 zone is controlled for personnel, decedents, samples, evidence, and waste.

Facility floor plan. Biosafety level (BSL)-3 envelope circumscribed by dashed line. The routes through which personnel enter and leave the BSL-3 laboratory are identified with fine arrows. A pass-through chemical dunk tank and laundry room to process contaminated personal protective equipment (PPE) are noted with heavier arrows.

Concentric ring design depicting relationships between biosafety zones and flow of personnel, decedents, samples, evidence, and waste overlying corresponding floor plan.

BSL-3 Isolation Autopsy Zone

The BSL-3 isolation autopsy zone is separated from the BSL-3 general autopsy space and is composed of 4 separate autopsy rooms designed to handle cases in which the decedent's antemortem symptoms or diagnoses indicate a likelihood of an infectious disease being present at autopsy. The isolation rooms limit the number of prosectors potentially exposed to a case. The rooms contain downdraft autopsy tables designed to pull air away from the prosectors' breathing zone, protecting them from airborne pathogens. The isolation rooms are outfitted with fully exhausted chemical fume hoods with HEPA-filtered exhaust. They can be used to dissect and sample specific organs and tissues that pose special biological or chemical hazards to prosectors (eg, tuberculous lungs and cyanide-containing stomachs). The isolation autopsy zone has an integrated decontamination transition path (personal protective equipment [PPE]-doffing room, shower/locker room, PPE-donning room) that bridges to the general autopsy zone. Each isolation autopsy room has an external vaporous hydrogen peroxide port for chemical decontamination.



Downdraft autopsy table.

Biosafety level 3 general autopsy zone.

Body transfer coolers: pass-through from autopsy zone to storage cooler.

Pass-through air lock for autopsy specimens.

Gurney washer.

BSL-3 General Autopsy Zone

The BSL-3 general autopsy space has an open floor plan with 12 downdraft autopsy tables and is designed for handling the daily caseload of decedents without symptoms or diagnoses predictive of infections. This zone connects to passage points for personnel, decedents, specimens, and waste. The zone also houses a radiologic imaging suite with computed tomography and magnetic resonance imaging scanners, an anthropology/decomposed body autopsy room, and an autopsy bay with an external observation area for police officers. The general autopsy zone is fully surface decontaminated daily. If there were to be a catastrophic event, this laboratory zone would be sterilized with chlorine dioxide.

BSL-2 Support Laboratory Zone

The BSL-2 support laboratory space is outside of the BSL-3 envelope and provides space for fixed tissue dissection, chemical preparation, dry bone anthropology examination, and

specimen processing. The BSL-2 zone can be accessed by personnel through a proximity card–secured door directly from the administrative zone.

Worker Access to Autopsy Laboratory

The entrance and egress of autopsy workers, decedents, and specimens to and from each area of the BSL-3 autopsy laboratory is controlled. Prosectors enter the laboratory from the administrative zone by first passing through a proximity card–secured door to a locker room. After removing street clothes and donning scrub suits and special autopsy socks and shoes, prosectors pass through a unidirectional door into an anteroom, where they don PPE. From the anteroom they pass through another unidirectional proximity card–secured door into the autopsy laboratory.

The PPE-removal process is isolated from the PPE-donning process . When leaving the autopsy laboratory, prosectors remove the most exterior and contaminated PPE (eg, aprons, sleeve covers, outer gloves, and middle mesh gloves) in the autopsy room while still wearing respirators and pass through a door into a dirty atrium, where they remove their gowns and high-top autopsy shoe covers, also while still wearing respirators. They then pass through a disinfectant-filled foot bath and through another door into a second atrium (which has a chemical safety shower that issues water in the event of a chemical exposure) to remove and decontaminate face shields and powered air-purifying respirators or remove N-95 respirators, surgical caps, and interior gloves and wash hands and arms in hands-free sinks. As a last step, prosectors return to the locker room to remove scrub suits, socks, and shoes; shower; and change into street clothes. The doors between all of the vestibular rooms are interlocked so that only one door to a room can be open at a time. An interlocked pass-through chemical disinfectant dunk tank is used to decontaminate autopsy gowns and autopsy towels before laundering.

Air Handling

The autopsy suite is negatively pressured with regard to the adjacent rooms (eg, anteroom) and has greater than 12 air exchanges/h. There is a stepwise gradient of negative pressure between the rooms as the prosectors move from the administrative zone through the intermediate rooms and into the general autopsy room. The BSL-3 isolation zone is negatively pressured with regard to the BSL-3 general autopsy zone. The pressure gradients are verifiable from pressure gauges. Air moves from clean zones to progressively dirtier zones and eventually is forcefully ejected from the roof of the building away from occupied areas and air intake locations. All of the air from the isolation autopsy rooms and from each of the downdraft autopsy tables in the general and isolation zones is HEPA filtered prior to exhaust.

We decided not to use HEPA filtration for the entire BSL-3 laboratory because it would require a much larger mechanical system and consume more energy.

Decedent Access

Decedents are transported to the facility in body bags and are dropped off at a sally port, where they are accessioned and moved on a gurney/tray to a rack in a large refrigerated cooler (capacity 150 bodies). The body cooler is connected to the BSL-3 general autopsy zone by 6 transfer coolers housing 2 tiers of trays (Figure 5). The doors on each end of the transfer cooler are interlocked so that only one door can be open at a time. Bodies move out of the autopsy room to the refrigerated coolers in decontaminated body bags through the same transfer coolers.

Specimen Processing

All specimens (eg, toxicologic, microbiologic) move out of the autopsy laboratory from a room where the specimen containers are surface decontaminated and pass through an air lock with interlocked windows into a specimen-receiving laboratory in the BSL-2 zone. They are received by PPE-clad technicians, who log the specimens, generate the request forms, and prepare the specimens in correct biohazard transport containers. From the receiving laboratory, the specimens are transferred to analytical laboratories. Personal effects from the decedents and medicolegal evidence from cases are processed in an evidence-processing zone. These materials are then transferred through an air lock in decontaminated containers to evidence and personal effects lockers in the BSL-2 zone for disposition. Postmortem specimen containers are decontaminated in the autopsy suite prior to being submitted to the specimen-receiving laboratory through the pass-through air locks with interlocked windows.

Solid and Liquid Waste Handling

Solid wastes that result from the autopsy process (eg, contaminated surgical sponges and PPE) are collected in biohazard trash bags and transferred to large pass-through autoclaves positioned between the autopsy zone and an external hallway adjacent to a service elevator. Autoclaved waste is stored short term outside of the autopsy laboratory for later collection as medical waste. The doors on the autoclaves are interlocked so that only one side can be opened at a time. Contaminated liquid waste from the autopsy tables, sinks, autoclaves, and gurney washer (described below) is drained to a large effluent decontamination system in the basement, where it is heated to 250°F (121.1°C) before passing into the sanitary sewer system. The system was designed to have the capacity for continuous running water at the autopsy tables. Contaminated surgical instruments can be cleaned and chemically

decontaminated at each autopsy table or processed with dishwashers in an instrument preparation room within the BSL-3 general autopsy zone.

Gurney Cleaning

Contaminated gurneys and body trays are cleaned in an adapted large pass-through animal cage washer positioned between the BSL-3 general autopsy zone and the body-receiving area outside the envelope. Gurneys and trays can be put into the washer from either side. However, only one door can be open at a time.

Unfortunately, a large majority of autopsy facilities both nationally and internationally were designed with limited biosafety features. A 2018 survey of US medical examiner and coroner offices serving populations greater than 300 000 people, including at least 1 respondent from 47 of 50 states and the District of Columbia, showed that only 19% had some form of BSL-3 autopsy space.

An earlier survey of US medical examiner and coroner offices serving similar populations revealed approximately half of the facilities had some features of BSL-3 (negative pressure ventilation, double-door access, air exchanges for ventilation). However, none were designed to fully function at BSL-3. Indeed, it is thought that many medicolegal autopsy facilities barely function at BSL-2. A survey of 48 medical isolation facilities for managing cases of highly infectious diseases in 16 European Union countries showed that only 16.6% had access to a BSL-3 autopsy room.

with the emerging infectious agents such as COVID-19 and infections of public health significance seen in a typical autopsy caseload, its necessary the national and international autopsy infrastructure needs to improve.

NINTH CHAPTER

AUTOPSY SUITE

An autopsy examination is a scientific and systematic study of a dead body.The Hospitals or Centers performing Medical or Forensic Autopsies should have a Dedicated Premises Suitable for performing Autopsy procedures at a minimum Biosaftey Level-2 & the Access to the Atuopsy rooms are controlled Access.

The centres should have the facility to accommodate Biologicsl Risk or so called High Risk Autopsies wherein, the Autopsy procedures are performed at a Biosaftey Level 3 environment.

Autopsies always provides valuable information as regards to the exact Cause of Death,Manner of Death ,Time Since Death ,Identification of the Dead besides collection of Evidence Materials, it also helps us to understand the aetiology, pathogenesis, and diagnosis of diseases.

Hence, more Efforts & importance should be paid in the design and construction of an autopsy section.

The autopsy section should always be located a little away from the main Hospital and should have its own entry exit to facilitate movements of the Cadaver Transport, Vehicle Movements, adequate Security, mourners accommodation, Police/Coroners/Magistrate/Administrators movements, and facility to proper handing over the body after autopsy to the relatives for further disposal.

A standard Autopsy Suite Should have the following Components to satisfy its objectives,

- The transportation of bodies from and to the morgue should be performed in areas not accessible to the public.
- Suitable Morgue Facility with systems for both Positive Temperature Storage [2-4 °C] storage of fixed and frozen biomaterials, and easy access to freezers (− 20 °C and − 80 °C).
- Shade/ waiting room for the relatives
- Office for the Autopsy Surgeon
- A Morgue Office with Clerk, Secretary available 24/7.
- A room for the Police/Agencies/Students to View the Autopsy
- Wardrobes with shower facilities must be available.

- Eyewash and other necessary first aid equipment must be present in the autopsy room.
- Security rules and procedures in case of accidents must be easily accessible.
- Protective clothing (surgical scrub suit, waterproof gowns, and plastic aprons), clear visor, gloves (disposable with long sleeves and protective), boots, and FFP3 masks should be used at all times.
- Tools and equipment should be easy to clean and provided with mechanical protection and suction devices, to avoid unnecessary exposition to aerosols, dust, and injuries. Disposable equipment should be available.
- Units/ rooms for performing autopsies/Dissection
- Fixation fluids (formalin) and fixated materials should be handled in ventilated areas.
- Cameras and safe IT storage facilities for photographic documentation should be provided.
- Autopsy facilities geographically separate from the procedure-requesting clinicians should be adequately equipped for a live video demonstration of gross findings and postmortem meetings.
- A room for delivering the dead body
- A servants/Staff room
- A room for special procedures on the Dead
- Rooms for laboratory and radiological procedures, storage, maintenance of records, etc.
- Adequate sanitary facilities

a) OFFICE FOR THE AUTOPSY SURGEON

Here the Doctor can study the relevant documents, such as case papers, dead body challan, inquest report, etc., and can view the x-rays. He can also obtain additional information either from the police or from the relatives accompanying the dead body. Depending upon the suspected cause of death, he can plan out the procedures to be adopted at the time of performing the Autopsy; further, yeah can refresh his memory (quickly) by referring to standard textbooks, to avoid any omissions while conducting the autopsy; further, he can refresh his memory (quickly) by referring to standard textbooks, to avoid any omissions while conducting the autopsy. He can have the autopsy reports typed. He can contact the police

or the relatives after the autopsy is over. Both internal and external telephones should be available in this office.

Changing Room

The Staff & Doctors should preferably have separate Changing Rooms with Storage Cabinets and hanger facility, including Shoe stand before their entry into the Dissection Area. This room should be connected to the both the entry & Exit to the Dissection area with Bathing facility accessible.

Sterile/Disinfectant Pool

The Staff before Entering or Exiting the Dissection/Autopsy section should stepin to the Pool for few seconds during their entry or exits from the Autopsy Section.

Bathing Section

The Autopsy Suite should have washing & Bathing facility preferably separate from the Doctors and other Staff,& should have easy connectivity to the exit area of the Autopsy Section.

b) UNITS/ ROOMS FOR PERFORMING AUTOPSIES

There should be provision of Four units/ rooms for performing autopsies-

1. One for, Clinical/Pathological/medical autopsy,
2. Another for, Forensic autopsies[BLS-2],
3. And the third one for High Risk Autopsies[BLS-3],
4. & the Fourth one for Decomposed Autopsies[BLS-3]

All Autopsy/Dissection Room should have a Provision for Viewing so as to accommodate the Police/Magistrate/Students/Agencies. This Rooms are specialy designed for Adequate Viewing & Discussion with sophisticated AV aids & are sealed completely from the Dissection Section.

The number of Tables in each of the different units depend on the Autopsy inflow expected in the region, for instance if there are high number of Forensic Autopsies More tables allotted for Forensic Autopsy Section, in case of rare instances of Clinical autopsies & High risk Autopsies ,single Tables may be allotted in each section.

Autopsy/Dissection Section

Each Autopsy unit should have ample natural light or adequate artificial light, which may be supplemented by adjustable lights for a proper view. these units should be adequately air-conditioned ,Alternatively, in case of absence of Airconditioning, there should be provision for adequate ventilation, and sufficient number of exhaust fans. Facilities equipped with communication facility, adequate AV facility for easy recording and Teaching & Training activity. Adequate Water & Drainage facility is a must for the unit.

Each unit should display charts to show the average weights of organs of the body. There should be x-ray viewing boxes and black boards in each of these units.

Autopsy Tables

Mobile and stationary tables with Pedestal Autopsy Tables or elevating and rotating autopsy table , designed to hold cadavers during autopsy procedures. Available in a range of sizes and materials preferably made of stainless steel with a built-in downdraft ventilation system and/or autopsy sink.

There should be arrangements for adequate water supply at each of these tables, and for the proper drainage of water, and blood stained and other discharges from the center of each of these tables. Each autopsy unit should have two sinks (one each for dirty and clean work) and one wash basin.

Grossing Station

The Organs are preferably inspected & Dissected in this Grossing Station, away from the Autopsy tables.at places, majority of the dissection are done over the Autopsy tables, but it is always advised to place organs over the Grossing/Dissection Section for washing,adequate examination, viewing and dissection of organs including sampling.

Evidence Room/Tissue Station

This room connected to the Autopsy Section,wherein the Evidence or samples collected from the body are stored/preserved,packed labeled before it handed over to the respective Laboratories.

Store Room

Attached to the Dissection room for Storage of Chemicals, Cleaning & Washing equipment's, Protective Gears, containers etc.

Defined Access:

The Dissection Area should have defined Entry & Exit Defined for the Body and the Staff.

The Dissection area should have multiple stain free or Easily cleanable cabinets for adequate storage.

c) MORGUE

- This is a place where the dead bodies are kept till they are ultimately handed over to the relatives or others for further disposal after the Autopsy. The mortuary should have refrigerated boxes to keep the bodies cool, otherwise the latter would emanate foul smell due to decomposition. the Facility should have systems for both Positive Temperature Storage [2-4 °C] storage & for fixed and frozen biomaterials with easy access to freezers (– 20 °C and – 80 °C). In a 1000 bed Hospital, there should be provision normally to keep 16- 20 dead bodies. However, it is advisable to have 28- 32 compartments to meet additional requirements following a major disaster.

d) A ROOM FOR DELIVERING THE DEAD BODY

The dead body is brought in this room after it has been washed well in the autopsy room. The body is placed over a table. The relatives are called to identify the body, which is then dressed according to the religious customs. A suitable place can be designated for performance of Minor traditional and religious rights attached to the handing over room. It is necessary that the Administrative Staff be present while handing over the autopsied body either to the police/Funeral home/Under takers or to the relatives, though in medico-legal autopsies, it is necessary, to hand over the body to the police and not to the relatives unless there is an advanced directive on this. In either case a receipt for having delivered the body should be taken and the same preserved.

e) A SERVANTS' ROOM

A separate room should be available for servants who are on 24 hours duty either for autopsy work or for receiving the dead bodies.

f) A ROOM FOR SPECIAL PROCEDURES ON THE DEAD

Here cornea from a dead body or other organs may be removed for transplantation purposes. A refrigerator should be provided to preserve the organs removed for transplantation. This room should be preferably air conditioned.

g) ROOMS FOR LABORATORY AND RADIOLOGICAL PROCEDURES, STORAGE, MAINTENANCE OF RECORDS, ETC.

Although these rooms should be of small size, they should be separate as they serve a definite purpose.

One room is used for storing the various organs removed at the autopsy, till they are despatched to the respective departments for further investigation. There should be adequate number of buckets/ trays and big sized glass jars to preserve the autopsy organs.

Side laboratory

Where minor laboratory tests such as staining by Gram's Method, or Ziehl-Neelsen's method, examination of urine for sugar, simple tests for detection of poisons, etc, can be performed. Further, a freezing microtome or a cryostat can be installed in this room, and histological sections can be prepared, stained and examined. Gas connection should be provided in the autopsy units, room for special procedures and in the laboratory.

All the stores of the autopsy section can be placed in one room. The stores include miscellaneous items such as test-tubes, glass jars, enamel buckets and trays, linen inclusive of gowns and masks, rubber gloves, cotton, formalin solution, first-aid equipment, new and discarded instruments, etc.

There should be one room for maintaining the medico-legal records, such as police inquests, autopsy reports, etc.

Radiological Section

A suitable x-ray machine should be installed to facilitate taking of radiological plates of dead body, before, after, or during autopsy. A side room attached to this room should be used for developing an x-ray plate. The side room can also be used for developing and

preparing photographs of the medical and medico-legal importance. CT & MRI facility accommodated in this section.

REGISTERS TO BE MAINTAINED IN THE AUTOPSY SECTION

It is advisable to maintain five types of registers in the autopsy section-

· Two general registers medical and medico-legal Autopsies,

· Two report registers for medical and medico-legal autopsies, and

· One morgue register.

Entries in all the five registers should be made in the autopsy section only, and these registers should not be removed from this section under any circumstances.

h) A SHADE/ WAITING/MOURNING ROOM FOR THE RELATIVES

This area is meant for the relatives who are required to wait till the autopsy is over and the dead body is handed over to them. This place should be a little away from the main autopsy section/ complex and the relatives should not have easy access either to the morgue or to the autopsy units. After the body has been autopsied and brought to the room meant for delivering the dead body, a few of the relatives should be called to this room and body is handed over.

i) ADEQUATE SANITARY FACILITIES

Adequate sanitary facilities should be provided to the Medical Officers, servants and to the relatives at respective places.

TENTH CHAPTER

The Morgue

The Morgue Unit is a facility for the viewing and/or identification of a body and the temporary holding / storage of bodies prior to transfer to a Mortuary.

The needs of hospital staff, relatives of the deceased, Police, Magistrate and attendant authorised persons should be considered in the design, layout and functionality of the unit to provide a safe and private environment.

The design must address the following:

- number of bodies to be stored;
- method of storage i.e. refrigerated cabinets, cool room, freezing capacity;
- separation of entries for families to view/identify bodies, and
- delivery of bodies from inside the hospital and external delivery (if applicable).
- It should be noted that the standard hospital Morgue facility should not be used for storage of
- a body associated with a criminal investigation. In this case the body is evidence and
- enhanced security should be provided.

Morgue Working Hours

Working hours will be on a routine eight hours per day, all days a week. Work times are assumed 8.00am-5.00pm. The Morgue Unit will also be accessible to authorized personnel 24 hours per day, 7 days per week.

Body Storage:

Two options are available as follows:

- Walk-in cool room for individual trolleys; or
- Bank of refrigerated cabinets.

Consideration should be given to the following:

- security of bodies;
- isolation and bariatric needs; and
- expected length of time for retention of bodies.

There are two types of morgue cold chambers:

- positive temperature +2/+4°C (the most common type),

- negative temperature -15°C/-25°C (used by forensic institutes for the storage of bodies that have not yet been identified).

Location of the Morgue:

The Unit should be located in the same building as the main health facility away from any public area to ensure that is appropriately screened from visibility.
It should be located to ensure easy and discrete access to deliver and/or remove bodies viaan exit lobby.

Functional Areas

The Morgue Unit will consist of the following Functional Areas depending on the size of the facility and the Operational Policy:

- Entry Lobby / Administration / Exit Lobby;
- Body Holding Area;
- Waiting / Viewing Area;
- Staff Area.

Entry Lobby/Administration/Exit Lobby

The Entry and Exit Lobbies form part of a single space with direct access to the Body Holding Area. The area should include

- hand basin;
- workstation for body registration and removal details;
- parking space for the transport trolley;
- parking space for a hoist / elevating trolley.

Body Storage Area

The Body Holding Area provides refrigerated space for the temporary storage of bodies. The area should allow for the following:

- Separate spaces / cabinets should be allowed for isolation;
- Manoeuvring space in front of refrigerated cabinets to insert/withdraw the trays;
- 3 square metres is required for a body on a loose tray or trolley in a cool room.

Waiting/Viewing Area

The area should allow for the following:

- Discrete entrance away from the main hospital to the Waiting Area for relatives, police and others;
- Direct visibility into the adjoining Viewing Area.

Storage

The area should allow for the following dedicated areas:

- Lockable storage area for the deceased's personal effects;
- Clean linen area;
- Cleaning materials and agents;
- Used linen collection area;
- Plastic body bags and sealing machine area.

Staff Area

The area should allow for the following:

- Staff areas comprising of office, workstations, meeting / teaching rooms and amenities;
- Office for use by the pathologist and police.

Functional Relationships

External

Mortuary / Holding facilities shall be accessible through an exterior entrance and shall be located to avoid the need for transporting bodies through public areas. Close proximity to Anatomical Pathology laboratories and relevant clinical areas is desirable for transportation of laboratory specimens.

Morgue Unit is to have separate access as follows:

- direct access from the Hospital for delivery of the body;
- direct but separate and discreet access for relatives of the deceased from all relevant
- areas of the hospital to Morgue waiting / viewing area;
- adequate access for funeral directors for vehicle parking and discrete, weather protected,
- facilities for the collection of bodies;
- adequate access for ambulances delivering bodies;
- adequate access for police vehicles.

Internal

The Waiting Area and Viewing Area should be collocated however there should be no access to other sections of the Morgue for viewers.

Entry Lobby, Exit Lobby and Administrative Area form part of a single area.

The Body Holding Room is to have direct access to/from

- the hospital corridor for use by staff;
- Viewing Room;
- discreet access from body hold / cool room to hearse and ambulance parking bays.

Infection Control

Bodies stored in the Morgue which may contain infectious diseases that must be contained.

Cleaned instruments and materials shall be re-circulated under normal procedures through the

Sterile Supply Unit or autoclaved within the Morgue Unit. The unit shall be designed to control

infection utilising the following:

- layout designed to minimise cross contamination in work areas;
- provision of a small wash-down / disposal / booting area;
- provision of an adequate number of hand wash facilities;
- provision of appropriate cleaning, waste storage and waste disposal;
- use of suitable materials and finishes;
- specimen storage facilities;
- first aid facilities;
- adequate isolation of space and ventilation systems which present potential hazard.

Environmental Considerations

GENERAL

The Morgue Unit needs to be designed to provide staff with sufficient space, working surfaces and appropriate equipment to safely carry out their duties.

INTERIOR DESIGN

The interior design of the Morgue Unit shall have due consideration for the following as primary items of design:

- infection control;
- cooling and ventilation

The Viewing Room should be a pleasant space and consideration given to adjustable lighting and a music system in the room.

Acoustics
Acoustic design shall ensure that conversations in adjoining rooms cannot he overheard by relatives in the viewing area.

Space Standards and Components

Ergonomics
The Morgue Unit shall be ergonomically designed to any potential avoid injury to staff, patients, visitors or maintenance personnel.

Safety and Security

SAFETY
The interior design of the Morgue Unit shall consider the impact of finishes, surfaces and fittings on safety including the following:

- floor covering selection;
- adequate drainage;
- protection from protrusions or sharp edges;
- stability and height of equipment or fittings;
- adequate protection against infection and any other hazards;

Security
The security aspects of the Morgue Unit shall consider the following:

- deceased bodies;
- valuables left on the body;
- specimens removed during autopsy;
- staff personal belongings and security;
- access and egress, particularly after hours.

Ceiling Finishes
Ceilings must be washable, impermeable and non porous.

Floor Finishes
Floor finishes shall be non-slip for all wet areas or areas subject to water. It should be impervious, easy to clean, sealed with coving at the edges and have adequate drainage. Drains should be fitted with appropriately filtered traps for ease of hosing down.

Wall Finishes
Wall surfaces in the body holding area should be washable and/or scrubbable.

Fixtures and Fittings

The equipment layout of the Morgue Unit shall ensure:

- adequate provision for operation and maintenance;
- provision of services as required;
- doors sized to allow for delivery and removal of the equipment;
- design for the required heat loads;
- Adequate provision for weight loads.

Safety Showers & Eye Washes
Provide safety shower and eye wash or eye / face wash equipment.

Air Conditioning ,Heating & Ventilation
The temperature of the body holding area should be maintained within a comfortable range not exceeding 20-21°C. The ventilation system should be isolated from other ventilation systems by being designed to minimise the spread of odours and airborne pathogens.
Air conditioning to the unit is to be isolated - there should be no return air. Discharge air should be treated with UV to destroy pathogens coming from infected bodies. The exhaust air distributive elements should be with low speed (up to 0.5m/s) and depending upon the type of dissecting utilized, the air extraction may be at the top (utilizing a hood) or at low level.
In gross specimen storage rooms, the extraction grill should be in the ceiling, above the sink counter area to exhaust chemical fumes with another grille installed at low level. It may be also be beneficial to consider installing an oxygen depletion sensor in the vicinity.

Alarms
The operating temperatures of all cooled and freezing facilities should be continuously monitored by CCTV and fitted with alarms which are activated when the temperature exceeds a predetermined level. The alarms should be transmitted to a permanently manned station.

Communications
It is recommended that an intercom be provided from the main / exit door to the to the body preparation room, to alert attendants.

Lightning
Provide adequate lighting in all areas.

Power Supply
Provide protective covers to power supply outlets to protect outlets from wetting. Provide an
emergency back-up system for the power supply to the refrigeration, high priority equipment
and illumination.

ELEVENTH CHAPTER

Infection control at Autopsy

General Biosafety Practices

Historically, most physicians and other health care workers have accepted the moral responsibility of caring for patients with contagious disease.[5] The occupational exposure, however, places them at risk for developing communicable diseases. Infective agents such as viruses, bacteria, fungi, parasites, and prions are capable of causing disease in health care workers exposed to sufficient inocula, especially when usual body defensive barriers are either disrupted or bypassed. In general, infective material is introduced through accidental puncture wounds from needles or other sharps, splashes into mucous membranes, inhalation, or the passage of the infective agent through preexistent wounds. To minimize the risk of infection, adequate barriers should be in place.

It is best to perform as complete a postmortem examination, including brain and spinal cord, as the signed autopsy permit allows. Because it is difficult to ascertain which cases harbor infective agents, it is prudent to consider *all* autopsies as potential infective sources. The cornerstone of any autopsy biosafety program, therefore, is the practice of standard (universal) infection control precautions as established by the World Health Organization. This approach includes proper attire, barrier protection, care while using sharp instruments, tissue fixation, decontamination of equipment and work surfaces, and hand washing. It also demands containment and treatment, proper cleaning of spills, immediate treatment of any injuries, and notification of the proper authorities (e.g., infection control, environmental health and safety).

Standard (Universal) Precautions for performing Autopsy.

- Prevention of puncture wounds, cuts, and abrasions by safe handling of needles and sharp instruments
- Protection of existing wounds, skin lesions, conjunctiva, and mucous membranes with appropriate barriers
- Prevention of contamination of workers' skin and clothing with appropriate barriers and hand washing
- Control of work surface contamination by containment and decontamination
- Safe disposal of contaminated waste

General Rules

All autopsies or fresh autopsy tissues must be handled as if they contain an infective agent (standard precautions). The entire autopsy area and its contents are designated a biohazard area and posted with appropriate warning signs. The ideal autopsy suite is well ventilated with a negative room pressure airflow exhaust system and contains a separate low-traffic isolation room. Whenever possible, postmortem examinations are carried out during normal working hours by adequate, well-trained staff. It is helpful to have a second autopsy assistant who remains “clean” to record weights, measurements, and other observations, as well as to circulate for any needed supplies. If multiple autopsies are to be performed sequentially, those with the greatest infective risk should be done first, before the staff becomes fatigued. All procedures are carried out in a way that reduces the risk of splashes, spills, droplets, or aerosols. All contaminated equipment, instruments, containers, and so forth should be confined to designated areas (autopsy table, instrument table, dissection area, sink). Paperwork leaving the autopsy suite must not be contaminated, and information from contaminated paperwork can be transferred out of the autopsy suite by photocopy or data-secure photographs.

Attire

For all autopsies, personal protective equipment (PPE) includes scrub suits, gowns, waterproof sleeves, plastic disposable aprons, caps, N95 particulate masks, eye protection (goggles or face shields), shoe covers or footwear restricted to contaminated areas, and double sets of gloves. Cut-resistant and puncture-resistant hand protection (plastic or steel gloves) is also available and certainly recommended for high-risk procedures. A retrospective study has demonstrated their effectiveness in reducing injuries.

Use of Sharp Instruments

One should exercise extraordinary care to minimize the risk of injury from sharp instruments and needles. Whenever possible, the use of needles should be avoided. Needlestick injuries occurring during routine autopsy procedures are entirely preventable; blunt needles and bulb syringes should be used to aspirate fluids in most situations. Because many needlestick accidents occur during disposal of needles, needles should *never* be recapped after use. Needles and other sharps should be disposed of directly into the approved receptacle; they should not be left lying around the work area.

Accidental self-inflicted cuts, particularly to the distal thumb and index and middle fingers, are the most frequent injuries sustained by pathologists. This type of injury usually occurs during dissection or trimming of tissues for microscopy. The frequency of hand injuries sustained while performing autopsy procedures can be reduced by several simple practices. A pair of scissors can adequately substitute for a scalpel during most autopsy procedures, including evisceration. The use of blunt-tipped, rather than pointed, scissors for almost all autopsy tissue dissection is advisable. When dissecting with a sharp implement in one hand, one should apply countertraction on tissues by using a long-handled tissue forceps held in the opposite hand; do *not* hold tissues with the fingers of the noncutting hand. For high-risk cases or dissections, steel-link gloves or some other scalpel-resistant material can be used. Plastic or Kevlar cut-resistant gloves provide protection while still allowing relative dexterity, and we encourage their use whenever possible.

Rules That Reduce Injury from Scalpels and Other Sharp Autopsy Instruments.

- Minimize the use of scalpels for tissue dissection.
- Never use a scalpel to make blind cuts.
- Prepare a sufficient number of scalpels before beginning the autopsy to obviate the need for changing scalpel blades during the procedure.
- Remove blades only with a special safety scalpel blade remover.
- Allow only a single individual to use a scalpel at any given time, especially in a limited dissection area.
- Be mindful of where you rest scalpels and other sharp instruments; do not put them haphazardly on the dissection table, but rather place them back in clear sight on an instrument table.
- Never hand off scalpels directly; place the instrument on a flat surface for transfer.
- Announce in advance any movements that involve repositioning of a sharp instrument.

Rib cutters or shears are used to cut the costal cartilage near the costochondral junction during removal of the sternum. Surgical towels should be placed over the cut edges of the ribs to protect against a scrape injury. When making slices of large organs with a long knife, the prosector should use a thick (3-inch) sponge or wadded towel to stabilize the organ with the noncutting hand. When suturing the body wall at the end of the autopsy, hold skin flaps with a large toothed forceps or toothed clamp rather than with a hand.

Limiting Aerosols

Aerosolization of bone dust during the removal of the calvaria or vertebral bodies can be reduced with a plastic cover and/or a vacuum bone dust collector on the saw. A number of systems that use high-efficiency particulate air (HEPA) filtering systems are commercially available. Bone surfaces should be moistened before sawing to cut down the dispersal of bone dust. To limit aerosols, screw cap containers are preferable to snap-top, rubber-stoppered, or cork-stoppered containers. When opening capped containers, cover the opening with a plastic bag to contain aerosols and splashes. Do not overfill a blood specimen vacuum tube by applying pressure through a syringe. When sterilizing tissue before obtaining a culture, be aware that searing tissue with a hot metal instrument can create splatter and a plume of smoke that may contain infectious agents. As an alternative, the organ surface can be sterilized by swabbing centrifugally with an iodine solution.

Photography

Photography of fresh specimens requires the same precautions employed for doing the autopsy, and the camera must be kept clean. In situ photographs obviate the additional risk of moving fresh tissue around the room. Photography of fixed specimens is cleaner and, in this respect, preferable, especially when an infective agent is known to be present. Whether the specimen is fresh or fixed, a pan is used for cleanliness during transport of the organ to the photographic stand. The camera should be handled with clean gloves or by a second person who stays clean. After photographs have been taken, the photostand should be cleaned with disinfectant. Cameras, lenses, and other photographic equipment may be disinfected with a variety of germicidal substances without compromising their functionality. A hands-free camera system would also reduce contamination risk.

Tissue Fixation

Adequate fixation in 10% formalin (containing 3.7% formaldehyde) requires an amount that is at least 10 times the tissue volume; this kills or inactivates all important infective agents except prions and mycobacteria. Embalming fluid containing glutaraldehyde is similarly effective. Mycobacteria remain viable in tissues for days, and these organisms are even difficult to kill with standard formalin fixatives or embalming fluids. Mycobacteria are killed

in a fixative of 10% formalin in 50% ethyl alcohol. Adequate time must be allowed for fixatives to penetrate tissues before trimming blocks for histology. Fixation of tissue suspected of containing prions is discussed in a section devoted to prion disorders later in this chapter.

Decontamination of Equipment, Work Surfaces, and Laundry

For decontamination, one should use a germicidal solution appropriate for any known or suspected agents. For routine decontamination, all instruments and autopsy devices should be immersed in an enzymatic cleaner or detergent solution for at least 10 minutes, then rinsed with water and decontaminated with disinfectant such as 5.25% sodium hypochlorite (1:10 solution of household bleach in water) for an additional 10 minutes. Instruments used for infective cases are immersed in an enzymatic cleaner or detergent, then rinsed and soaked in 2% aqueous glutaraldehyde or 1:10 solution of bleach for at least 10 minutes. Glutaraldehye is advantageous because, unlike bleach, it does not damage aluminum and steel. One should rinse work surfaces with hot water followed by a 1:10 solution of bleach. Several commercial products containing bleach are suitable. Splashing should be avoided. Floors in the autopsy work area should be cleaned with a detergent solution, decontaminated, and rinsed with water. If available, ultraviolet light provides a secondary source for decontaminating room surfaces and air. All laundry should be treated as contaminated and disinfected in a routine fashion. Any wet clothing, towels, or other reusable laundry should be placed into leakproof biohazard bags before transport.

Remains

After autopsy, one should wash the body with a detergent solution followed by an antiseptic such as a 1:10 solution of household bleach. The body should be rinsed with water and placed in a disposable leakproof plastic body bag. By law, in many states, all bodies with known infective diseases must be labeled as such for the mortician and others who may come in contact with the remains. Usually this is indicated on the death certificate as well. Absence of this warning, however, should *not* be taken to mean there is no risk; all bodies should be handled with caution. We find it helpful to inspect bodies in storage on a daily basis to assess whether there has been any undue leakage of fluid into the body bag. Obviously, fluid accumulations should be carefully removed by aspiration or blotting. If necessary, place a warning on the outside of the body bag, alerting others to the possibility of leaking fluids.

Storage and Transportation of Tissue and Waste

Tissue to be stored should be placed in a nonbreakable, water-tight plastic container. Before transporting tissue outside the autopsy suite, the container should be placed in a plastic bag

and sealed adequately. Waste for disposal should be double-bagged in specially designated biohazard waste bags, secured, and stored in metal or plastic canisters until removal.

Handling of Spills

Spills should be cleaned up with absorbent, disposable paper towels. The contaminated area should be cleaned with detergent, then decontaminated using a 1:10 dilution of bleach. After the area has been decontaminated, wipe it dry.

Hand Washing

After removing gloves, the pathologist should wash his or her hands with soap and water. In fact, hands should be washed immediately and thoroughly any time they become contaminated.

Employee Health

Employees are strongly urged to be vaccinated against hepatitis B. Each employee is encouraged to maintain tetanus and diphtheria immunity. Other immunizations (e.g., against rubella, measles, and polio) are also advisable. postexposure prophylaxis that includes vaccination and administration of rabies immune globulin should be undertaken. All employees should have yearly tests for tuberculosis.

Cuts and puncture wounds should be washed and irrigated *immediately* with soap and water. If conjunctival splashes occur, the eyes should be washed immediately at the nearest eye wash station in the autopsy suite. Injured employees should go to the emergency department or employee health service; the infection control nurse or appropriate employee health official can be notified from there. Most hospitals have hotlines staffed by personnel trained in counseling, treatment, and follow-up for health care workers who suffer on-the-job injuries. The employee should always protect his or her rights by completing an incident report. Persons with uncovered wounds or dermatitis should not assist in autopsy procedures unless the injured skin can be completely covered with a waterproof dressing or other acceptable barrier.

Isolation Procedures

Although all autopsies are performed in a manner that reduces the risk of contamination, autopsies of bodies that harbor a known pathogenic microorganism are best performed in a separate specially designed room to isolate and contain any infective material. While performing these autopsies, personnel are limited to only those necessary—the pathologist, autopsy assistant, and possibly a circulating assistant—to accomplish the task. As usual, standard precautions are strictly enforced. Special safety and decontamination procedures are instituted as required. With proper precautions, overhead ultraviolet lights may be used

for secondary decontamination. If an isolation room is nonexistent and there is more than one autopsy table in the room, the table with the least traffic should be used for the infective case. In cases in which facilities are inadequate, it is advisable to identify alternative, better-designed, safer sites for postmortem examinations. Health and safety requirements may exceed the capabilities of even the best hospital morgues in suspected cases of infection with highly contagious organisms such as arboviruses, arenaviruses, or filoviruses. In such situations, guidance should be sought from the appropriate public health agency.

Some Infections for Which Postmortem Examinations Should Be Performed in a Separate or "Isolation" Room.

- Anthrax
- Hantavirus
- Hepatitis
- Human immunodeficiency virus/acquired immunodeficiency syndrome
- Influenza
- Leprosy
- Meningococcal meningitis
- Multidrug-resistant bacteria (methicillin-resistant *Staphylococcus,* vancomycin-resistant *Enterococcus*)
- Plague
- Prion diseases
- Rabies
- Rickettsial diseases (Rocky Mountain spotted fever)
- Systemic infections of unknown etiology
- Tuberculosis
- Typhoid fever

Practices to Reduce Transmission by Infective Aerosols

Even in the current age, those performing and attending autopsies are at increased risk for tuberculous infection via aerosols produced during the procedure on a patient with tuberculosis. Other infections, including rabies, plague, legionellosis, meningococcemia,

rickettsioses, coccidiomycosis, and anthrax, may also be acquired by aerosols such as those generated during an autopsy. Thus it is clear that the utmost care must be taken to provide adequate protection against infective aerosols. For protection against diseases transmissible by aerosols, such as tuberculosis, N95 particulate masks (masks able to filter 1-μm particles in the unloaded state with a filter efficiency of 95%, given flow rates up to 50 L/min) or containment hoods or suits equipped with powered, air-purifying respirators with HEPA filters are used. Collecting body cavity fluids with a ladle or bulb syringe generates less aerosol than a hose aspirator connected to a sink faucet. Placing plastic bags over the head of the decedent during removal of the calvarium with a Stryker saw or saws equipped with HEPA filters within the vacuum system can also reduce the amount of aerosolization. Towfighi and colleagues designed a relatively simple tent-like device for reducing aerosal dispersion during brain removal.

Practices Specific to Autopsies If a Prion Disorder Is Suspected

The infective agent that transmits Creutzfeldt-Jakob disease (CJD) and related prion disorders has been termed a *prion* because it does not have the morphologic and chemical composition of a virus or other conventional infective agent. Rather, all the evidence indicates that the sole functional component of the prion is an abnormal protease-resistant isoform of a normal brain protein. The normal isoform is designated PrP^{C} and the pathogenic isoform PrP^{CJD} in humans and PrP^{Sc} in animals. Some investigators refer to the pathogenic form as PrP^{res} because of resistance to protease digestion.

Consistent with these characteristics, prions are resistant to inactivation by procedures that denature nucleic acids, such as ultraviolet radiation, but are inactivated by procedures that denature or hydrolyze proteins, such as exposure to some detergents or to NaOH. Because it is a protein, PrP^{CJD} is not easily aerosolized by routine procedures used in the morgue or in the histology laboratory. The procedures outlined here are more than adequate to prevent aerosolization of prions. Although CJD can be transmitted to laboratory animals by intracerebral inoculation of formalin-fixed tissues, it should be noted that aldehyde fixatives cross-link proteins in a tissue block, and therefore prions are not readily transmissible from the tissue block.

The incidence of CJD among medical personnel, histotechnologists, and morgue attendants is the same as that in the general population (1 per million), and the disease in these medical personnel resembles sporadic CJD and not CJD caused by infection, such as occurred with contaminated lots of human growth hormone. In contrast, many medical personnel have contracted serious illness due to tuberculosis or hepatitis acquired directly or indirectly from patients. Thus, although CJD and related disorders are transmissible, they are not contagious.

When working with prion-infected or contaminated material, caution must be taken to avoid breach of the skin. The prosector should wear cut-resistant gloves. If accidental contamination of skin occurs, swab the area with 1 N sodium hydroxide for 5 minutes and then irrigate with copious amounts of water. list specific modifications to routine safety procedures for cases of suspected spongiform encephalopathies.

Autopsies of Patients with Suspected Prion Disease (Human Transmissible Spongiform Encephalopathies)—Modifications of Standard Precautions.

- 1.Attendance is limited to three staff members, including at least one experienced pathologist. One of the staff avoids direct contact with the deceased but assists with handling of instruments and specimen containers.
- 2.Standard autopsy attire is mandatory. However, a disposable, waterproof gown is worn in place of a cloth gown. Cut-resistant gloves are worn underneath two pairs of surgical gloves, or chain mail gloves are worn between two pairs of surgical gloves.
- 3.Containment hoods or suits equipped with powered, air-purifying respirator with high-efficiency particulate air (HEPA) filters are worn by all staff.
- 4.Reduce contamination of the autopsy suite.
    - a.Cover the autopsy table with an absorbent sheet that has a waterproof backing. Drape instrument trays, working surfaces, and weighing pans with plastic or disposable plastic underpads. Use clear 2-inch plastic tape to connect seams and to secure edges against the table.
    - b.Because prion infectivity is retained after drying and the dried material is harder to clean from surfaces, reusable instruments should be kept wet between time of use and disinfection.
    - c.Use disposable equipment (headrest, cutting board, scalpels, forceps, scissors, brain knife, plastic formalin containers) to the greatest extent possible.
    - d.Dedicate a set of instruments for autopsies involving possible transmissible spongiform encephalopathies, to include Stryker saw, blade and wrench, skull breaker and hammer, 5-inch forceps, 5-inch scissors, and rib cutter.
    - e.Reduce bone dust aerosol during brain removal. Place a plastic bag over the head, and tie it securely around the neck. Open the sealed end of the bag. Remove the brain within a plastic bag to reduce potential aerosol exposure.

    - f.Immediately place brain into a preweighed container of 10% neutral buffered formalin. Reweighing the container provides the weight of the brain.

- 5.Mix liquid waste 1:1 with 2 N NaOH in a waste collection bottle.

Autopsies of Patients with Suspected Prion Disease (Human Transmissible Spongiform Encephalopathies)—Modifications of Autopsy Suite Decontamination Procedures*.

- Place instruments (open box locks and jaws) and saw blades into a large stainless steel dish.
- Soak instruments for 1 hour in enzymatic cleaner (such as Klenzyme); immerse for 1 hour in 1 N sodium hydroxide, and rinse for 2 to 3 minutes in water. (Collect all waste.)
- Transfer instruments into red autoclavable biohazard waste bags and autoclave at 134°C (gravity displacement steam autoclaving for 1 hour; porous load steam autoclaving for one 18-minute cycle at 30 lb psi or six 3-minute cycles at 30 lb psi).
- Clean the vibratory bone saw by repeated wiping with 1 N sodium hydroxide solution.
- Double bag the absorbent table cover and instrument pads, disposable clothing, and so forth in appropriate infective waste bags for incineration.
- Decontaminate any suspected areas of contamination of the autopsy table or room by repeated wetting with 1 N sodium hydroxide over 1 hour, followed by thorough rinsing and washing.

Autopsies of Patients with Suspected Prion Disease (Human Transmissible Spongiform Encephalopathies)—Modifications of Brain Cutting Procedures*.

- After adequate formaldehyde fixation (at least 10 to 14 days), examine and cut the brain on a table covered with an absorbent pad with an nonpermeable (i.e., plastic) backing.
- Place samples for histology in cassettes labeled with “CJD precautions.” Place cassettes in 95% to 100% formic acid for 1 hour, followed by fresh 10% neutral buffered formalin solution for at least 48 hours. This procedure eliminates all prion infectivity in the embedded specimen.
- Decontaminate all instruments and surfaces that come in contact with the tissue, as described in .
- Discard tissue remnants, cutting debris, and contaminated formaldehyde solution in a water-tight plastic container as infective hospital waste for incineration.

Exposure to Other Biohazards at Autopsy

Formaldehyde

Formaldehyde is a toxic chemical, and exposure to formaldehyde or its vapors may cause a variety of symptoms or diseases. These include contact dermatitis; headache; eye, nose, and throat irritation; shortness of breath; wheezing; chronic cough; mucus hypersecretion; asthma; chronic airway obstruction; bronchitis; rhinitis; pharyngitis; menstrual and reproductive disorders; and sexual dysfunction. Although many individuals have experienced the milder irritative disorders following acute limited formaldehyde exposure, the incidence of most of the more severe reactions is extremely low. Nonetheless, the sensitivity of individuals is highly variable. Exposure studies performed in rats have shown that formaldehyde may induce nasal squamous cell carcinomas; however, implications for humans are equivocal. Studies relating the rat and human data indicate that the carcinogenic risk for humans at relevant levels of formaldehyde exposure is minimal; further, it is likely that precautions effective against noncarcinogenic toxic effects of the chemical are sufficient to protect against its carcinogenic effects.

The autopsy suite should have sufficient ventilation and effective chemical fume hoods to reduce employee exposure to formaldehyde vapor. employers must monitor formaldehyde levels in the workplace and maintain employee exposures below the legal safe limits. Institutions should provide a mandatory training program for all employees exposed to formaldehyde at or above 0.1 ppm on an 8-hour time-weighted average. lists some important components of a safety training program for employees exposed to formaldehyde.

Components of Mandatory Training for Employees Exposed to Formaldehyde Above 0.1 ppm on an 8-Hour Time-Weighted Average Basis.

- 1.A description of the medical surveillance program including potential health hazards, signs and symptoms, and instructions to report the development of signs and symptoms the employee suspects are related to formaldehyde exposure
- 2.A description of operations in which formaldehyde is present and explanation of safe work practices for jobs requiring the use of formaldehyde
- 3.A discussion of the purpose, proper use, and limitations of personal protective equipment
- 4.Instruction on the handling of spills, emergencies, and cleanups
- 5.An explanation of the importance of engineering and work practice controls and instruction and, if applicable, training in how to use the controls

- 6.A review of emergency procedures and the role of each employee in the event of an emergency

Radioactivity

On rare occasions, the autopsy pathologist may be required to examine the body of a patient who died shortly after receiving diagnostic or therapeutic radioactive substances or after accidental radioactive contamination. In such circumstances, the body may contain a level of radiation that would result in a radiation exposure risk to autopsy staff. Handling of the radioactive cadaver requires special care and is best done with the assistance of personnel trained in radiation safety.

In most cases, radioisotopes used for diagnostic studies are given in small doses (less than a millicurie) or have short half-lives, and patients who die after recent nuclear medicine examinations are usually not a radiation hazard. Patients who die after receiving therapeutic doses of radioisotopes or implanted radioactive sources may require special handling, depending on the level of radioactivity remaining. Hospitals where such patients are treated will have patient treatment records available, as well as radiation safety specialists who can advise the pathologist.

The United States Atomic Energy Commission recommends that patients who have received radioisotopes remain in the hospital until the level of radioactivity falls to 30 mCi or less. Thus most patients who die after hospital discharge present minimal hazard. However, because radioisotopes may be concentrated in tissue or body fluids, the attending physician signing the death certificate should alert the pathologist and the radiation safety officer if the body contains more than 5 mCi. The assigned mortuary should also be advised. A form identifying the isotope, the amount given, and the time of administration should be attached to the death certificate, the autopsy consent form, and the medical record.

If an implanted radioactive source cannot be removed from the patient before an autopsy, if radioactive fluid is present after administration of an isotope, or if high levels of radioactivity are likely to be present in a specific organ, a radiation safety specialist should be consulted for assistance in the safe collection and proper disposal of the radioactive source, fluid, or tissue. In consultation with the specialist, the amount of activity remaining in the body should be estimated by reference to the half-life of the isotope. If the remaining amount is less than 5 mCi, no special precautions are necessary, other than the usual wearing of gloves. An exception is cases of ^{131}I therapy or therapy with insoluble radioisotopes, in which specific tissues (e.g., thyroid) or body cavities contain most of the activity.

When the residual activity exceeds 5 mCi, a survey of residual radioactivity before the body is opened helps establish the maximum working time allowed. A team of pathologists, each prosector performing a limited portion of the autopsy, may be required to limit individual exposures. Film badges may be required to monitor exposure. The pathologist should drain potentially contaminated body fluids carefully first and immediately shield them for assay later. For example, in cases of ^{131}I therapy, the blood, urine, and thyroid are radioactive. Highly radioactive fluids should be stored behind appropriate shields until they can be safely removed from the autopsy suite.

After the body is opened, a second survey should be made to estimate the level of beta dose for ^{32}P or other beta-emitting radionuclide. In cases of ^{131}I administration, the thyroid gland may emit a sufficient gamma dose that it should not be touched by hand directly but rather removed with the aid of a long instrument.

After the autopsy, all instruments, towels, and clothing involved in the procedure should be checked for radioactivity and either stored shielded until safe or decontaminated before being returned to general use or sent to the laundry. The autopsy room should be monitored for radioactive contamination and decontaminated if necessary.

Similar to gamma rays, x-rays pass easily through fairly thick materials. X-ray machines, including the cabinet type used commonly by pathologists, have built-in shielding. The radiation safety specialist should assist the pathology department in monitoring and complying with any safety measures required for the operation of these machines.

Implantable Cardioverter-Defibrillator

An implantable cardioverter-defibrillator (ICD), also known as an automatic ICD (AICD), consists of a pulse generator, one or two sensing electrodes, and a set of anode and cathode electrodes for countershock. As with pacemakers, which they resemble, the generator is usually placed subcutaneously within the left anterior chest wall. Depending on the make and model, the electrodes reach their attachment points on the heart by a transthoracic or transvenous route.

A small but definite risk of electric shock exists when the detection lead of an ICD is broken or cut, resulting in a discharge of 25 to 40 J. Although shocks of this magnitude are unlikely to cause death, manufacturers recommend that the ICDs be deactivated before manipulation and that high-quality latex surgical gloves be used when handling the devices. Double gloving, with two layers of surgical gloves, provides more protection against shock and is recommended for autopsies with ICDs. In many cases, the autopsy prosector is aware of the presence of an ICD after review of the medical history of the deceased. Before the autopsy, cardiology personnel at most medical facilities can be asked to interrogate the

device for antemortem information, deactivate it, and provide instructions regarding its proper disposition. At our institution, there is a “device nurse” on call for such issues. However, in cases in which history is incomplete or totally lacking, the pathologist encountering an implanted device during autopsy dissection should ascertain whether it is a pacemaker or an ICD before continuing with the autopsy. Biventricular pacemakers are also relatively large, so size alone cannot distinguish an ICD from pacemaker. The outside of the metal case usually has the manufacturer and model information etched into the surface, which can lead to helpful information with a quick Internet search. If an ICD is present, the pathologist should discontinue the postmortem examination until the device is properly deactivated. Because ICDs may explode if incinerated, they should never be discarded without special attention, and the disposition should be guided by either cardiology personnel or the manufacturer.

Box 3-8. Safety Precautions for Autopsies on Patients with an Implantable Cardioverter-Defibrillator (ICD).

- Obtain medical history.
- Use universal precautions (gloves) and other insulating devices.
- Locate and identify all implanted electrical devices; avoid cutting leads.
- If ICD is present, do NOT proceed until deactivated.
- Call cardiology personnel or manufacturer.
- Wait for cardiology personnel to deactivate ICD, or follow manufacturer's instructions for deactivation.
- Request cardiology personnel to obtain electrophysiology information from internal memory of ICD.
- Do NOT discard ICD.
- 9.Do NOT incinerate ICD.
- 10.Ask cardiology personnel or the manufacturer about proper disposition of ICD.

Foreign Bodies and Occult Medical Devices

Bullet Recovery

Bullets may fragment on impact or may by design raise pointed edges on entering their target. In either case, the resulting deformation can produce sharp edges in shrapnel that present a risk for injury to those who remove or handle it. For autopsies of gunshot victims,

Russell and co-workers recommended that anteroposterior and lateral radiographs be taken to locate bullets, bullet fragments, and any sharp or irregular edges. Bullets should be handled only by personnel wearing double heavy-duty gloves. To prevent marring of the projectile surface, a rubber-tipped bullet extractor fashioned from a Kelly forceps fitted with 2 cm of rubber catheter over its ends or a plastic forceps should be used to recover bullets and bullet fragments. After collection of any trace evidence on the projectile itself, the bullet should be gently rinsed to remove contaminating blood or body fluids to decrease its subsequent infective risk. Finally, the bullet or bullet fragments should be double packed in leakproof packaging with at least one of the containers composed of hard plastic to prevent injury during subsequent handling. In addition to the appropriate identifying information, the container should be labeled with a biohazard sticker.

Needle Fragments and Other Sharp Objects

Medical devices such as surgical staples, vena-caval (Greenfield) filters, metal stents and shunts, and other devices may have sharp edges or points that can be encountered unexpectedly at autopsy. Use of forceps and separate storage in thick-walled bags or jars is recommended for such sharp metal hazards. Needle fragments are a potential hazard to pathologists performing autopsies on drug-addicted patients. Embolized needle foreign bodies have been discovered in soft tissues of the neck and even within internal organs. In high-risk cases, Hutchins and colleagues recommend preautopsy radiographic screening, reduced tissue manipulation during prosection, and delay of autopsy in human immunodeficiency virus–positive cases, in addition to the standard recommendations for protection against injury from sharp instruments.

Cyanide Exposure

Exposure to cyanide vapors during autopsy has been associated with clinical symptoms and toxic concentrations of cyanide in autopsy personnel. Autopsies on victims of cyanide poisoning should be performed in a negative-pressure isolation room. Although cyanide may vaporize from other tissues, stomach contents containing ingested cyanide salts present the highest risk, because the gastric acid converts cyanide salts to volatile hydrocyanic gas. Therefore the prosector should open the stomach only in a chemical fume hood or externally vented biologic safety cabinet to reduce the risk of exposure to the toxic gas. Similarly, toxicology laboratory workers handling samples possibly containing cyanide should wear gloves and face and eye protection and manipulate the specimen only in a chemical fume hood.

TWELTH CHAPTER

The Autopsy Report

The proposed report is an outcome of my Work experience in many countries, hence I consider this report is elaborate, Complete & Efficient in Documentation and Description.

The autopsy report may contain the following first-level headings, indicated in boldface capital letters if possible. Preferable over the Left hand side or Centralized.

A. Autopsy Face Sheet

B. External Examination

1. Presentation, Clothing, Personal Effects, Associated Items
2. Therapeutic/Clinical/Hospital Evidence
3. Postmortem Changes
4. Postmortem Imaging Studies
5. Features of Identification
6. Evidence of Injury

C. Internal Examination, includes all systems,

1. Organ Weights
2. Chest & Abdomen Walls
3. CVS System,
4. Respiratory System,
5. GastroIntestinal System,
6. Hepatobiliary system,
7. Reticuloendothelial System,
8. Urogenital System
9. Endocrine system
10. Musculoskeletal system,
11. Central Nervous System
12. Neck & Pharynx
13. Additional Dissection(if any)

D. Ancillary Procedures, Laboratory Tests, and Results
E. Block Listing and Histologic Description
F. Time Since Death
G. Summary of Injuries/Findings and Diagnoses
H. Cause-of-Death Statement
I. Comments
J. Amendments

A. Autopsy Face Sheet

This section constituting the first page of the Autopsy Report, indicating all the details of the Deceased ,including Summary of Autopsy Findings & Cause of Death, that can assist the Police & Court to get the First Hand information in Brief on the Autopsy Examination.

a. Autopsy no
b. Demographic Details
c. Date ,Time & place of Autopsy & completion of Autopsy
d. Inquest details
e. Attendees in the Morgue[assistants and attendees]
f. Body Identified by
g. History[Focus mainly on What happened,Where Happened,How Happened,When Happened,Any Witness or Photographs]
h. Hospital/Clinical Presentation /Details
i. Anatomical Findings/ Summary/clinical Findings/Diagnosis
j. Cause of Death
k. Signature ,Designation & Date.

B. External Examination

The findings noted on external examination may be very important in any autopsy, especially forensic ones.

Anatomic regions of the body

- Head
- Neck
- Torso includes chest and abdomen (anterior) and back (posterior)
- Upper extremity includes the shoulder, arm, elbow, forearm, wrist, hand
- Lower extremity includes the hip, thigh, knee, lower leg, ankle, foot
- Genitalia, perineum, and groins

Usually the body can be described with customary anatomic descriptors with the body assumed to be in a standard anatomic position. These terms include: superior, inferior, lateral, medial, anterior, posterior.

For the forearms, which can be in various positions in life relative to the body and standard anatomic position (i.e., arms up in defensive posture, running), better terms to describe lesions include flexor or extensor aspect and radial or ulnar aspect.

Body build

- Small frame
- Medium frame
- Large frame

Body length should always be measured at autopsy; body weight can be taken from medical record or approximated using i.e., thin, normal, overweight, obese, morbidly obese.

Skin color

- Use objective color, not subjective race or ethnicity
- “White” or “light skinned”, “Brown”, Black” or “dark skinned”
- Avoid using “Caucasian”, “African-American”, “Asian”

If a light-skinned person is tan from sun exposure, you can describe that as “The skin is light with areas of hyperpigmentation on the head, face, extremities, and trunk consistent with sun exposure”.

Common findings

- Pitting edema should be assessed by firmly pressing for 5 seconds on affected soft body parts, such as the medial lower legs and medial thighs.
- Ecchymosis - area of discoloration; unknown etiology

Contusion -ecchymosis caused by blunt force trauma; a “bruise”

Best to use ecchymosis if unsure about etiology of lesion

- Congestion is intravascular
- Hemorrhage is extravascular blood; requires defect in vessel and circulation to defect
- Hematoma is a space-occupying collection of blood; should be measured in cm3

Injuries-Blunt Injuries & Sharp Injuries,thermal injuries,Firearm Injuries.

Evidence of Postmortem Tissue Harvest for Donation

- Bilateral eye tissues
- Long bones of each upper and lower extremity. Each anterior arm shows a linear incision closed with a running suture extending from the anterior shoulder to the antecubital fossa. Each medial lower extremity shows a linear incision closed with a running suture extending from the lower abdomen to the foot. Hard cylindrical pieces of material are palpated in place of the harvested bones.

Example description: “In each Lower extremity there is a recent incision closed with a running suture extending from the anterior hip to the proximal thigh (right 37 cm, left 40 cm). In each upper extremity there is a recent incision closed with a running suture extending from

the anterior shoulder to the medial forearm (right 95 cm, left 92 cm). Cylindrical segments of hard material are palpably present in the place of long bones underneath each of these incisions.

1. Presentation, Clothing, Personal Effects, Associated Items

Describe how the body was wrapped, protected, prepared, or stored prior to autopsy, as well as to document items (personnel Belongings) present with the body, such as jewelry, clothing, or items of potential evidentiary value. Documentation of personal effects, such as jewelry, might help address claims that items have been stolen or lost. If for some reason the body was stored face down, documentation of that fact might be useful in explaining to an angered family why the face was “purple and swollen,’’ and would document that the findings were not related to the autopsy procedure.

2. Evidence of Medical Intervention

Documenting all tubes, bandages, devices, and markings, such as venipunctures, that are known to have been iatrogenic in origin.

When appropriate, the position of devices within the body should be described within the relevant portion of the in-ternal examination description. Changes related to organ or tissue procurement may also be noted here.

Evidence of Therapeutic Intervention

- Orotracheal tube terminates in the trachea
- Orogastric tube terminates in the stomach
- Cardiovascular access line in right wrist.
- Foley catheter in urinary bladder and penile urethra.
- Findings consistent with cardiopulmonary resuscitation:
    - A circular, brown-red, dry abrasion on the middle chest, ~5-6 cm diameter
    - Multiple bilateral anterior rib fractures
    - Localized hemorrhage in anterior mediastinum.
- *Example*. “A nasogastric tube exits the left nares. An endotracheal tube exits the right side of the mouth. An indwelling venous cannula is present in the left cubital fossa and is surrounded by a 1-inch, circular area of blue-green ecchymosis. The cannula is connected to an intra-venous line and bag of 0.9% sodium chloride solution. A urinary catheter is present. Electrocardiograph conductors are adherent to both clavicular regions and to the left lateral chest wall. Apparent cardioversion markings exist

- over the sternum, consisting of 2 rectangular superficial burns with dimensions of 4 inches by 3 inches.''
- *Note*. The location of various devices within organs, tissues, and lumens may be described under the appro-priate organ system heading in the description of the internal examination.

3. Postmortem Changes

Rigor mortis, Postmortem Staining, degree of corneal clouding and collapse, presence or absence of skin slippage, blisters, discolorations, and cutaneous drying are some of the routine parameters to be included. Documentation of postmortem changes may be helpful in establishing or confirming the postmortem interval and in the interpretation of other autopsy findings.

Example. "Rigor mortis is generalized and well-developed. Lividity is distributed dorsally, is the usual violaceous color, and blanches with light pressure. The extremities and torso are cold to the touch. The corneas show early clouding. The vermilion borders of the lips show slight darkening due to drying. No other postmortem changes are visible externally.''

4. Postmortem Imaging Studies

Details of all Radiologic, CT or Ultra Sonography, Fluroscopy or MRI findings are documented in this section.

5. Features of Identification

Items such as height, weight, and body build; hair color, length, tattoo, Moles,Ear piercing, nose piercing, and texture; eye color; condition of teeth; presence (and location) or absence of scars; externally missing appendages; circumcision status; and other distinctive features (rhinophyma, cleft in chin, etc) are typically included.

Example. "This is the body of a white male, which weighs 170 pounds and measures 72 inches in height. The physique is mesomorphic and muscular. The head hair is brown, wavy, and measures about 2 inches in greatest length. There is no balding, no beard, and no moustache. The irides are blue. The teeth are natural with occlusal amalgam fillings in teeth 30 and 31. There are no tattoos, no missing body parts, and no visible surgical scars. The penis is circumcised. No other distinctive markings are visible.''

6. Evidence of Injuries:

Describe the Nature & Type injuries ,with particukar reference to the Shape, Size, Dimension, Site, Fresh or Old and the damage to the muscle ,vessels, bones, amount of blood lost or retrieved, organ damage.

C. Internal Examination

The internal examination is obviously a major component of the autopsy and deserves thorough reporting. System Wise Examination ,layer by layer description of the Tissues and Organs is very essential. Organs described over the Colour, Consistancy, Smell, Walls, Contents, Type of Tissue, Pathological Changes, Discolouration, Thickness.

Bilateral: Doesn't need to be used when describing a change present in both of two organs (e.g., lungs, kidneys, adrenals, upper extremities, feet, etc)

Evisceration/Dissection Method. This section in-cludes a statement about whether organs were removed en masse (Letulle method), piecemeal (Virchow method), or en bloc (Rokitansky or other).

1. Organ Weights: Organ weights may be included under the respective organ system description, but a table or list of organ weights is convenient and helpful.

2. Chest & Abdomen Walls & Cavities: The appearance of the soft tissues and ribs is documented in this section, including the presence or absence of hemorrhage, masses, fractures, and other relevant findings. Reference to breast tissue may also be made here. Statements about the presence or absence of fluid collections in body cavities, abnormal color changes, unusual odors, adhesions of pleura or peritoneum, the retroperitoneum, and other relevant findings may also be included.

3. Central Nervous System-Scalp,Membranes,Brain,Spinal Cord,Peripheral nerves

4. Respiratory System- Descriptive references to the Tongue,Pharynx, trachea,Vocal cords, bronchi, lung, visceral pleura, diaphragm, and pulmonary vessels are reported in this section.

5. Cardiovascular System- A description of the heart and major vessels is included in this section. Reference to the pericardium, epicardium, myocardium, endocardium and valves, chordae, ventricular thicknesses, and Large & medium Blood vessels may be included.

6. Hepatobiliary System- References to the liver, gallbladder, extrahepatic biliary tract, and pancreas are reported in this section.

7. Reticuloendothelial System- References to mediastinal nodes, abdominal nodes, inguinal nodes, axillary nodes, other relevant nodes, spleen, bone marrow, and thymus are included in this section.

8. Gastrointestinal System- References to the esophagus, stomach, small bowel, Large Bowel, rectum, and pancreas are reported in this section.
9. Genitourinary System- References to the kidneys, renal vessels, ureters, and bladder are provided in this section, as are references to the vagina, cervix, uterus, fallopian tubes, and ovaries in females, or to the testes, vas, seminal vesicles, and prostate in males.

10. Musculoskeletal System-Muscles and Skeletal System

11. Endocrine System- References to the thyroid, adrenal glands, and parathyroids are reported here, including a statement of whether the parathyroids were located or examined. Relevant findings about paraganglia are also included in this section.

12. Neck & Pharynx-includes Skin, Neck Muscles, Nerves, neck Vessels, paravertebral vessels, Pharynx, Larynx, Vocal Cords, Epiglottis, Tonsils, thyroid glands, Tongue & Cervical Spine

13. Additional Dissections (if any), Specialized dissections of nonroutine areas, such as the popliteal fossa; a hip dissection; dissection of an extremity, muscle, other soft tissue; peripheral nerves; removal of eyes; or placental examination may be described in this section, especially in condition of Surgical deaths, Gunshot Deaths(track),Sudden deaths, Strangulation Deaths, Hanging Deaths..

D. Ancillary Procedures, Laboratory Tests, and Results

This section is used to list the tests, procedures, and consultations that are performed or requested in conjunction with the examination. The listing may also include specimens that were retained. Typical examples are culture of pulmonary abscess, documentary photographs, peripheral blood test for drug abuse screening, and the like. Relevant results are included.

a) Microbiological Test
b) Histopathological Examination (Block Listing and Histologic Description)
c) Serological Examination

d) Toxicological Examination
e) Biological Examination'
f) Ballistic Examination
g) DNA Examination
h) Clothes Examination
i) Biochemical Test

E. BLOCK LISTING AND HISTOLOGIC DESCRIPTION FINDINGS, SUMMARY AND COMMENTS
F. Time Since Death-based one the Status of Food in Stomach, Postmortem changes the time since death is inferred.in case of interventions like cold storage, the same to be mentioned about the duration of preservation and the approximate time since death conclusion may be avoided in such circumstances.

G. **Summary/Anatomical /Pathological Findings/Diagnosis:** This section includes a summary of Final Anatomic Diagnosis, internal injuries, including correlation with evidence of injury noted on external examination, Pathological Changes or other Important findings ,which are directly contributing to Death. This contents appear on the Face sheet.

H. Preliminary Cause of Death(if Needed): in case of Poisoning, Sudden deaths(pending ancillary investigation),Asphyxia deaths etc.

I. Final Cause of Death: this should contain all information about the Underlying causes, Weapon of causation, Contributing causes and Immediate causes.

J. Comments: This section may be used to address foreseen questions, to provide commentary, for clinicopathologic correlations, Injury correlation to the internal damage and cause of Death, Fatal period and possible Manner of Death. Speculation and lengthy commentary are discouraged.

K. Amendments: This section allows for continual updating of findings or interpretations as needed. The final conclusion can be modified as new information or results of ancillary investigation are made available. The date of any amendments should be included.