

5: Autopsy

Terminology

An autopsy is a surgical procedure performed after legal death in an effort to determine how death occurred. Historically in the United States this procedure was performed by a coroner, who was either an elected or an appointed official employed by the county or city in which death occurred. A coroner was not required have to have any formal medical training, and in rural areas of the country the role may still be filled on that basis.

In many parts of the country the position of coroner has been superceded by that of a medical examiner, who is usually appointed to the job and is usually a physician, ideally specializing in pathology or forensic medicine.

For convenience, in this section we will use the term “medical examiner” throughout, on the understanding that our statements apply equally to a coroner.

Autopsy Fundamentals

To determine or confirm the cause of death, usually an autopsy entails removing and dissecting of the brain, which is then wrapped and placed in the abdominal cavity.

The procedure is catastrophic for anyone who wishes to be cryopreserved with minimal injury. The patient may be stored for more than one day (in some cases, for more than a week) while waiting for an autopsy to be performed. Storage is often around 5 degrees Celsius, but in rare instances freezing may be allowed to occur.

Typically the local medical examiner performs or supervises the autopsy after it has been requested by a physician. The cryonics organization usually is not allowed access to the patient until the autopsy has been completed.

Natural and Unnatural Death

Generally an autopsy is most likely in a case of unnatural death, and least likely in a case of natural death. It is important to understand the distinction between these terms.

Natural death is often caused by a known illness or by a chain of medical consequences stemming from a known illness. While state laws vary, natural death may be assumed if:

- A patient dies more than 24 hours after admission to a hospital, or under supervision of hospice staff, OR
- A patient dies of a condition which has been diagnosed or treated by a physician within the past 30 days.

Unnatural death is a catch-all definition which applies where accidents, foul play, suicide, drug overdoses, or unknown diseases have occurred. If a person dies alone and is discovered subsequently, the death may be considered unnatural. While the definition will vary depending on state law, the following list of causes is typical:

- Criminal violence.
- Accident.
- Suicide.
- Suddenly, when in apparent good health.
- Unattended by a practicing physician or other recognized practitioner.
- In any prison or penal institution.
- In police custody.

- In any suspicious or unusual circumstance.
- By criminal abortion.
- By poison.
- By a disease constituting a threat to public health.
- By disease, injury or toxic agent resulting from employment.
- When a dead body is brought into the State without proper medical certification.
- When a body is going to be cremated, dissected, or buried at sea, the inability to exhume the body for subsequent examination may provide some additional incentive to perform an autopsy.

How an Autopsy Occurs

A *forensic autopsy* is performed if there is any possibility of criminal investigation arising from suspicion of foul play, or civil suits relating to negligence, or other legal issues such as an insurance company seeking to withhold death benefit in a case of suicide. A forensic autopsy may also be justified on grounds of protecting the public from risk if death may have occurred as a result of an unknown pathogen.

A *clinical autopsy* usually has no legal basis and may simply provide useful information for any organization which has had custody of the patient. Thus, a hospital may seek to obtain data of medical interest, such as the effects of prior treatment or the accuracy of a diagnosis. Clinical autopsy is also used in the education of medical students.

A cryonics organizations may have a good chance of averting a clinical autopsy if it receives timely notification that the patient has died. A hospital representative may try to create the impression that an autopsy is customary, but if the medical examiner is not involved, the cryonics organization can argue strenuously against it (or can encourage next of kin to do so) with some confidence of success.

The situation is much more difficult in cases of unnatural death such as those itemized above. An attending physician may insist on notifying the medical examiner, and if the cryonics organization attempts to prevent this too strenuously, it risks being accused of obstruction of justice.

Because unnatural death often occurs suddenly and unexpectedly, the cryonics organization may not discover that it has happened until after the medical examiner has been informed. At this point the organization usually has only two options available:

1. Contact the medical examiner to dispute the need for an autopsy, and show readiness to seek an injunction against it if necessary.
2. If Option 1 is unsuccessful, request a minimally invasive procedure that will be performed as quickly as possible.

Switching from Option 1 to Option 2 may be difficult, as the first option tends to entail a confrontational position, while the second option entails a request for cooperation. However, requests for expedited autopsy have sometimes been successful. One of the authors (Platt) participated in a case where the waiting time was reduced from three days to one day, and dissection was relatively minor. The brain was still removed from the skull, however, making cryoprotective perfusion impossible. Under these circumstances, we can only speculate whether a one-day waiting period was significantly less damaging than a three-day waiting period.

Note that a mortician or funeral director may not have to be involved in an autopsy case, if cryonics personnel are able to complete all the necessary paperwork and arrange for shipment of the patient via a cooperating airline. While a mortuary is often used as a location in which to perform cryoprotective perfusion, this is impossible after a patient has gone through two or more days of ischemia and has then undergone some dissection.

How Likely is an Autopsy?

In 2009 the National Center for Health Statistics published the ten leading causes of death in the United States:

1. Heart disease
2. Cancer
3. Chronic lower respiratory diseases
4. Stroke (cerebrovascular diseases)
5. Accidents (unintentional injuries)
6. Alzheimer's disease
7. Diabetes
8. Influenza and Pneumonia
9. Nephritis, nephrotic syndrome, and nephrosis
10. Intentional self-harm (suicide)

On the positive side, only causes 5 and 10 will typically result in an autopsy, and if the cause of accidental death is obvious (such as falling off a step ladder) a medical examiner may feel that an autopsy is unnecessary.

On the negative side, an event such as cardiac arrest or stroke can lead to an autopsy if death occurs while the person is alone, and there is no recent medical history. For a discussion of ways in which a cryonicist can try to avoid a situation where autopsy is likely, see "How Not To Die Like That: Reducing Your Risk of Autopsy" by Mike Darwin and Steve Harris in *Cryonics* magazine, October, 1987, Volume 8 (10 & 12).

Pre-Emptying an Autopsy

The risk of an autopsy may be reduced preemptively by cryonicists while they are still alive. They may contact their local medical examiner and seek a meeting in which they can explain the rationale for cryonics and the reasons why an autopsy is extremely undesirable. The medical examiner may have some professional interest in learning about cryopreservation procedures, and in an ideal situation might become an ally rather than an adversary.

Unfortunately, experience has shown that this scenario is vanishingly unlikely, as few cryonicists have tried to pursue the strategy. Moreover, the medical examiner whom a cryonicist meets this year may be replaced by a different individual next year.

As a fallback strategy, cryonics organizations have encouraged their members to carry a wallet card expressing a strong objection to autopsy. The web sites of Alcor and the Cryonics Institute link to the relevant forms that their members can execute. The Venturist cryonics advocacy organization offers a card for their members stating a religious objection. An example is shown in Figure 5-1.

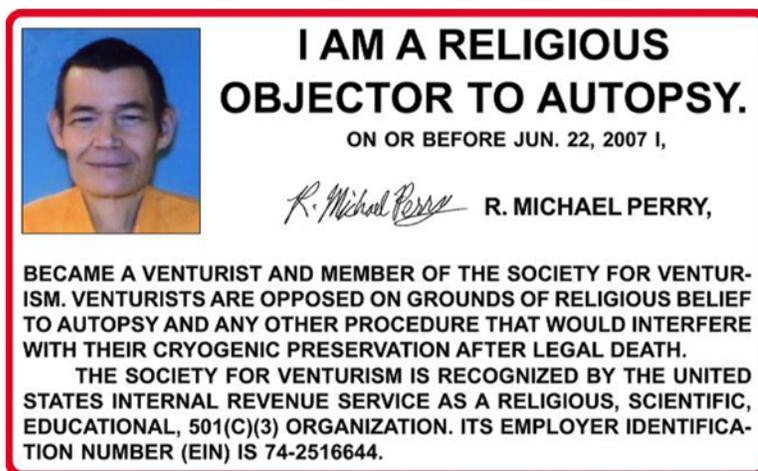


Figure 5-1. A wallet card for members of the Venturist society, objecting to autopsy.

The term “religious objection” may seem inappropriate to cryopreservation procedures, but is used because a medical examiner will be familiar with it. Many religious groups are strongly opposed to the mutilation of dead bodies. They may also believe that the body must be retained and buried as close to the location of death as possible, or that the body needs to remain intact for a successful passage to the afterlife, or that the body must be buried as quickly as possible after death has occurred. Orthodox Jews, certain schools within Islam, and Native Americans have a strong tradition of objecting to autopsy.

Seven states (California, Louisiana, Maryland, New Jersey, New York, Ohio, and Rhode Island) have passed laws that recognize the importance of these religious beliefs. The California statute is particularly strong, stating that if a coroner has received a certificate executed by a patient “stating the procedure [of autopsy] would be contrary to his or her religious belief, the coroner shall not perform that procedure on the body of the decedent.” Some states also respect the patient’s wishes even if they have only been expressed verbally.

Unfortunately these laws allow a major loophole. If the local medical examiner suspects that a criminal act may have occurred, or that the patient may have died from a disease that could endanger the community, he has the right to authorize a forensic autopsy regardless of the wishes of the patient, the cryonics organization, relatives, and almost anyone else, with the exception of a judge. Theoretically a cryonics organization may go to court to seek an injunction preventing a forensic autopsy, and in one instance was successful (during the case of Alcor member Dora Kent). Such cases are extremely rare.

If an autopsy cannot be prevented, representatives of the cryonics organization must do their best to appear cooperative in the hope of minimizing the damage. The procedure may seem intolerably destructive, but if the cryonics organization has decided to cooperate, team members should refrain from expressing their personal feelings about it.

A religious representative may attend an autopsy to ensure that it conforms as closely as possible to the guidelines of a specific belief. Similarly, a cryonics organization may ask to send a representative or a family member with good knowledge about cryonics, to observe that the autopsy does not do unnecessary harm to the brain and the patient is kept cold. To our knowledge such a request has not been made yet in cryonics but it might be possible, especially if the member has made a religious objection to autopsy or a relative is involved.

The Ultrastructural Case Against Autopsy

Cryonics advocates claim that people who are routinely designated as “corpses” may still retain the neuroanatomical basis of identity that makes

them who they are. Against the folk wisdom that a person's brain "dies" after five minutes after circulatory arrest, they point out that the challenge of resuscitating the person does not so much involve the instant decomposition of the brain but complex biochemical pathways that induce (delayed) apoptosis and prevent full cognitive recovery. Scientific studies that look at the ultrastructure of the brain after (permanent) ischemia support this outlook. In fact, even after a prolonged period of warm ischemia the damage does not seem sufficient to substantially damage brain structure to a degree that the original structure cannot be inferred.

In 2009 the Alcor Life Extension Foundation launched a research project to model ultrastructural alterations after various periods of warm ischemia (normothermia). As can be seen in the electron micrograph in Figure 5-2, even at 21 hours of warm ischemia well defined organelles and lipids (myelin) can still be observed in the image.

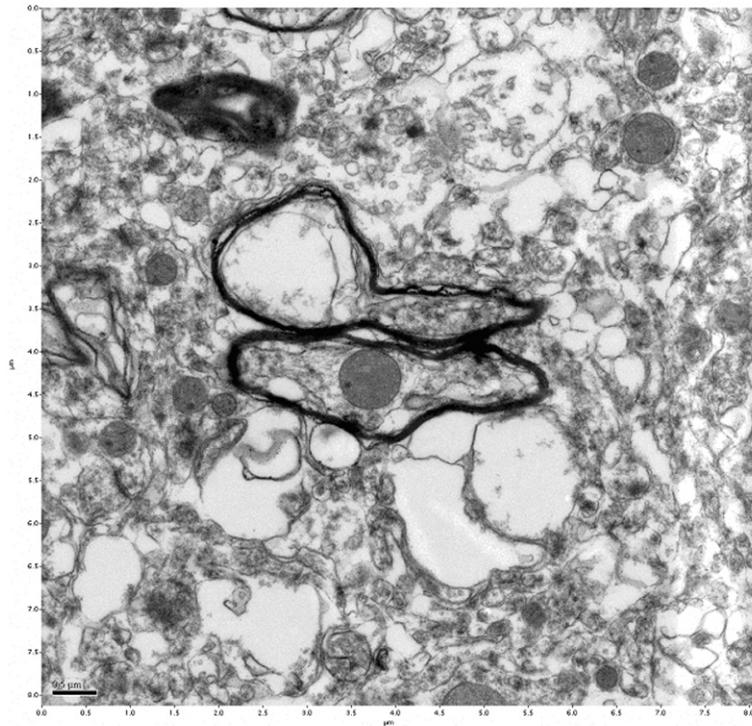


Figure 5-2. Electron micrograph of an animal brain after 21 hours of warm ischemia.

A potential rejoinder would be that if the neuroanatomical basis of identity is a lot more robust than common wisdom claims, then autopsy does not necessarily need to interfere with preservation of the brain. There are a number of problems in this argument. If a cryonics patient would be recognized as being potentially revivable in the future, then the patient should no longer be considered a “corpse” that is subject to rules and regulations involving forensics or the disposition of bodies. Instead, a cryonics patient would be recognized as a terminally ill patient, or at least a subject with rights that prohibit mutilation or experimentation.

Another argument against autopsy is that conventional autopsy does not just involve the ongoing accumulation of damage associated with prolonged warm (or cold) storage but also involves invasive procedures that could mechanically injure the brain, including actual removal and dissection of the brain, and post-autopsy procedures that further accelerate the decomposition of the brain, such as placing it in the abdominal cavity where gastric fluids can accelerate damage. It is also not likely that a brain that has been subjected to autopsy, let alone removed and dissected, can still be perfused with a cryoprotectant to protect it against freezing. As a result, conducting an autopsy will almost invariably lead to a combination of additional damage to the brain and complete freezing.

The History of Autopsy

The history of autopsy goes back to Ptolemy I of Egypt (367-283 BC) who was probably the first ruler to allow dissection of human bodies. In the early days of autopsy this mostly meant executed criminals. Herophilus (335-280 BC), “the father of anatomy,” routinely conducted autopsies on human beings and was one of the first contributors to the field of human anatomy. Other notable names include Galen of Pergamon (131-201 AD), author of ‘On the Usefulness of the Parts of the Body.’

During the renaissance, the study of human anatomy became more systematized but the actual autopsies were still performed by “dissectors” or “surgeons,” often on prisoners. The limitation of this division of labor is that physicians and students were mostly excluded from doing autopsies. Anatomy

professor Andreas Vesalius (1514-1564) broke with this separation of intellectual and practical research and conducted a large number of human autopsies, including studies late at night in the cemeteries of Paris. All this work culminated in the publication of his seminal work *The Seven Books on the Structure of the Human Body*.

During the 19th century autopsy became a routine part of research, medicine, and education. In Europe and the United States hospitals founded pathology departments, which were specifically tasked with gathering knowledge on disease and death. The pathologist Karl Rokitansky (1804-1878) performed more than 30,000 autopsies at the Vienna General Hospital.

The history of autopsy has not been without its share of controversy. In the 19th century occasional reports reached the press about supposedly dead people regaining consciousness upon the first cut of the scalpel. This and the related fear of pre-mortem burial provided ample materials for horror writers and the sensationalist press. As a result of these fears, more stringent criteria for determination of death and burial were developed.

Finally, as much as the practice of autopsy contributed to the advancement of science and medicine, early practitioners of both autopsy and medicine did not yet recognize the risks involved when they moved from dissecting a dead body to examining a live patient or even delivering a baby. The lack of hygiene enabled the transmission of diseases that killed thousands of patients. Ignaz Semmelweis (1818-1865) was one of the earliest advocates of hand-washing for surgeons and medical staff but was only vindicated after Louis Pasteur published his findings on microorganisms and provided a theoretical basis for Semmelweis's antiseptic recommendations.

In the medical and scientific profession the usefulness of autopsy is now widely accepted and in the 1950s autopsies were performed on almost 50% of all hospital deaths, a number that has declined to single digits in more recent times.

Autopsy Procedures

Although a detailed understanding of autopsy procedures is unnecessary to prove the undesirability of the procedure for cryonics patients, it is useful to

provide context. An autopsy will typically start when the body and all the required paperwork (identification, medical records, consent forms etc.) have been received by the office of the medical examiner. In case there is a delay in obtaining records of the patient, or when there is a backlog of autopsy cases, the body is stored in a cold room or refrigerator.

While an autopsy is not a “sterile” procedure, pathologists and morticians will typically don protective gear to protect themselves against infectious diseases such as TB and prion diseases. Maintaining cleanliness can also be important to preserve forensic evidence.

The autopsy starts with an external investigation in which the body is weighed, measured, and photographed. During this procedure the pathologist performs a detailed inspection in which individual oddities and abnormalities are noted. In some cases, such as blunt trauma or liver dysfunction, skin color can already provide important clues about the cause of death. This part of the procedure also provides an opportunity to collect hair, blood, skin, and vitreous samples.

The external examination is followed by the internal examination in which a careful study of the inside of the body and individual organs is made. This procedure can also include the dissection of individual organs to inspect for signs of cardiovascular disease, cancer, hemorrhage, and other pathologies.

Of special interest to cryonics is the examination of the brain. In cases in which detailed inspection of the brain is required (stroke, gunshot wounds to the head, Alzheimer’s disease, etc.) the brain is removed from the skull. The standard procedure is to do this in such a fashion that the head and face can still be displayed to family during a funeral. A scalpel is used to make a cut in the scalp and the front and back skin flaps are pulled away to expose the skull. The top half of the skull is then removed by either a bone chisel or bone saw to expose the brain, which is covered in a hard layer called the dura mater. After removal of the dura matter and severing the vessels of the brain, the brain can be removed. After the brain is removed the surface of the brain can be examined and, if necessary, the brain can be dissected.

After the body and organs are thoroughly examined, the abdominal and thoracic cavities are sewn closed and the body is cleaned for further

processing (embalming or cremation). An autopsy report is created and tissue samples or organs may be stored.

A forensic autopsy is usually performed by a forensic pathologist or medical examiner with special education in forensics. There is a greater emphasis on determining the cause of death, the mechanism of death, and the manner of death. The investigation is not just confined to medical history of the patient but can also include collection of evidence from a crime scene.

From a cryonics perspective, the most challenging aspect of an autopsy is the examination of the brain. If brain removal is inevitable, the first mandate for a cryonics organization is to obtain some assurance that the procedure will be conducted at a low temperature. The second mandate is to prevent dissection of the brain. If dissection of the brain cannot be prevented, the best course of action is often to request chemical fixation of the pieces of the brain prior to shipping. It is important here to realize that there is no medical or forensic need for this practice and cryonics organizations should firmly discourage this, or even contest it.

Alternatives to Autopsy

If the autopsy is focused on a specific part of the body and/or the examiner knows what (s)he is looking for (say, a bullet), a simple non-invasive investigation such as an X-ray, or a blood/fluid sample, or endoscopic procedure may be sufficient. For this reason it will always benefit the cryonics organization to have a good understanding of the aim of the autopsy and availability of alternative (non-invasive) procedures.

A more recent alternative for a full autopsy that is gaining in popularity is the virtual autopsy. Virtual autopsies are not only suitable in the case of religious or other objections to autopsy but also allow for modes of investigation and documentation that are not available in conventional autopsies. The use of virtual autopsies has been further strengthened by court rulings which, when confronted by a religious objection, mandate the use of the “least restrictive alternative” of achieving the government’s objective.

Virtual autopsy (or “virtopsy”) methods involve the use of noninvasive imaging technologies such as CT scans or MRIs to determine the cause of

death (or rule out other causes of death). Virtual autopsies can also be used in conjunction with toxicity reports or other kinds of evidence to allow for fact-finding without the use of traditional autopsy. Research has shown that in certain circumstances virtual autopsies can achieve comparable rates of accurate cause-of-death detection, or may even yield more accurate results. Virtual autopsies are also useful in cases where invasive procedures could alter or destroy evidence such as the detection of air embolisms in blood vessels.

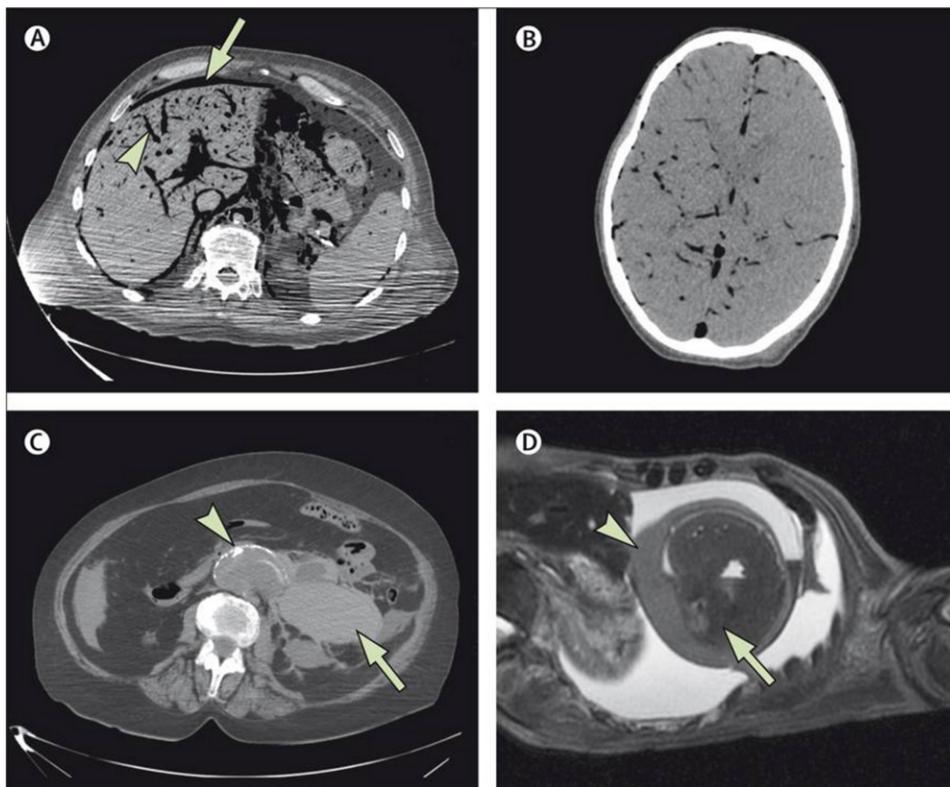


Figure 5-3. Scans revealing decomposition and pathologies. A: Axial CT image through the upper abdomen showing extensive intravascular gas (arrowhead), in keeping with decomposition. B: Axial CT image through the brain showing extensive intracranial gas due to decomposition. C: Axial CT image showing rupture of an abdominal aortic aneurysm (arrowhead) with extensive retroperitoneal haemorrhage on the left (arrow). D: Oblique axial (short-axis view) T2-weighted MRI image showing a haemopericardium (arrowhead) due to rupture of a myocardial infarct (arrow). The Lancet. 2012 January 14; 379(9811): 136–142

Notwithstanding these benefits, there are still a number of drawbacks to virtual autopsies. They are not equally effective for all kinds of examinations and are claimed to be inferior for detection of tumors, infections, and chronic conditions such as cardiovascular disease. In some cases, these limitations could be overcome by improvement of the technology or by using it in conjunction

The cost of virtual autopsy tables, MRI machines, and CT scanners may limit the number of cases in which virtual autopsy can be successfully requested or deployed. The use of a virtual autopsy may still require a court order, which can greatly increase the time the patient is at a (relatively) warm temperature, even if invasive procedures are ultimately averted.

The possibility of virtual autopsy constitutes an additional argument for members to overfund their cryopreservation, so that money will be available to cover the extra expense.

A Cryonics-Friendly Autopsy?

In case it is evident in advance that the autopsy only needs to concern itself with the trunk of the body (for example, a dispute about the effects of a drug on the kidney), the cephalon of the patient can be separated and shipped to the cryonics facility on water ice or dry ice, depending on the elapsed time since pronouncement and temperature history of the case. This option is also available if a transport permit cannot be issued on short notice but the head can be transported as an organ rather than as a person. Even if the patient has requested whole-body preservation, cephalic isolation may still be the most desirable option to minimize damage to the brain.

Cases in which an autopsy seems inevitable often preclude doing stabilization procedures because the death of the patient comes unannounced or the standby team is prevented from getting access to the patient for forensic reasons. Even in such cases it is important to ensure that the patient is cooled as rapidly as possible. Cooling a patient close to the freezing point of water (but not below!) does not preclude routine autopsy procedures and can drop the rate at which (autolytic) damage incurs substantially. The best way to ensure that rapid cooling is being done is to send team members to the hospital

to observe, even if standard standby procedures are not permitted. For a detailed discussion of the physics and logistics of cooling, see section 11: Induction of Hypothermia.

The objective of quickly cooling the patient does not stop at the hospital or hospice but should continue while the patient is under the control of medical personnel or has been transferred to the medical examiner's office. At the same time, the patient should not be allowed to cool below 0 degrees Celsius, to prevent freezing damage. A cryonics organization must bear in mind that these requirements will be regarded as unusual by the medical examiner's office. Therefore, they should be emphasized repeatedly, especially if the patient is transferred to different entities or individuals before being surrendered to the cryonics organization.

If the cryonics organization is successful in keeping the patient cool prior to conducting the autopsy, the next objective is to ensure that the patient remains cool during autopsy. The most obvious method to achieve this is to surround the patient with ice. For most autopsies this should not be a problem because autopsy procedures can be performed at cool temperatures and the inspection of organs and tissues for medical and forensic information does not require normothermia.

The autopsy of a cryonics patient should be guided by the principle to do no unnecessary harm, especially to the brain. In practice this means that the autopsy should be limited to the areas of interest and that the rest of the body is left intact. If organs need to be removed it is important (particularly in whole-body patients) to return them to their original locations. If the brain needs to be inspected it is crucial that brain removal is conducted with more care than usual to prevent mechanical damage, and the brain should not be placed in the abdominal cavity. If dissection of the brain is really unavoidable, great care should be taken to ensure that all parts of the brain will be kept together. In such circumstances the best way to proceed (for both whole body and neuro patients) is to keep the brain separate from the rest of the body and ship it well protected on water ice (or dry ice) to the cryonics facility.

There can be circumstances in which it can be prudent to request that the body or brain is chemically fixed (embalmed). Usually, such a scenario would involve situations in which an autopsy is inevitable plus long delays are

expected. While chemical fixation may not be compatible with all medical and forensic investigations, it is compatible with some, and it could be beneficial to discuss this with the mortician or medical examiner. The chemical fixation approach is also suitable in case the brain has been removed from the skull and dissected to stabilize tissue before and during shipping. Research at cryonics-associated companies has even demonstrated that it is possible to conduct cryoprotective perfusion on a chemically fixed body. If the brain has been promptly perfusion-fixed or the parts of the brain have been placed in fixative, cryoprotection by immersion of the brain (or parts of the brain) in a cryoprotectant is still possible.

In all circumstances (including chemical fixation) it is important to insure that temperature of the patient remains as close to 0 degrees Celsius as possible. Even if an autopsy cannot be avoided, the depression of metabolism prior, during, and after autopsy can make the difference between damage and decomposition in the brain.

A Case History

On February 14th, 2010, at approximately 10:30 am local time, Alcor member A-1712 experienced sudden cardiac death at his home in Florida. His case report at <http://www.alcor.org/Library/pdfs/casereportA1712DavidHayes.pdf> illustrates the power of a medical examiner to perform an autopsy despite strident objections and a clear indication of the preferences of the patient. At the same time, it demonstrates the ability of a cryonics organization to limit the injury that is inflicted.

A-1712 arrested in the presence of a friend, who called 911. Emergency personnel responded promptly and made an unsuccessful attempt at resuscitation. They called Alcor to notify the organization.

The patient was moved to Delray Medical Center where he was pronounced legally dead at 11:12 am local time. Alcor contacted the Medical Center and requested that the patient's head should be packed in ice.

There was no external sign of injury, but because the death was unexpected and was not preceded by any medical history that provided an obvious explanation, the Medical Center notified the medical examiner. By

the time a representative from Suspended Animation, Inc. (the local Florida service provider) reached the Medical Center, the patient had been moved to the medical examiner's office. By the time the representative reached the medical examiner's office, it had closed.

Alcor's attorney drew up a draft letter requesting that any autopsy should be limited, exempting the brain. On February 15th the medical examiner's office agreed on condition that it would retain the body, while the head could be released after a CT scan was performed using portable equipment at Alcor's expense. A court order was necessary to approve this procedure.

Because of delays related to a national holiday, the court order was not delivered to the medical examiner's office until February 17th. The portable CT scanner could not reach the office until after working hours, so a representative from Suspended Animation was authorized to drive A-1712 to Columbia Hospital where the scan could be carried out. After a review of the scan by a radiologist, Suspended Animation was allowed to perform cephalic isolation so that the patient's head could be transferred to Alcor for neuropreservation.

The head was packed in dry ice in a container suitable for air shipment. Around noon on February 18th the head was at a temperature of -64 degrees Celsius in 20 lbs. of dry ice. The patient was placed on a flight departing from Fort Lauderdale at 7:05pm local time.

A-1712 endured at least 72 hours without cooling to near 0 degrees Celsius, despite prompt notification of the cryonics organization and efforts to prevent the autopsy. A court order was required before personnel at the medical examiner's office were willing to deviate from their usual procedure, which would have been to include dissection of the brain.

The case raises issues about sudden death generally. Even if an autopsy had not been required, the patient would have been in circulatory arrest for a considerable period of time before a standby-transport team reached him. In addition, clearly there is no substitute for team members going to the hospital or mortuary in person, to insure that Alcor's cooling instructions are actually followed and maintained. Hospital staff and mortician staff may be willing to implement basic Alcor procedures but will not have the sense of our urgency or specific knowledge to insure rapid cooling.

Still, these factors are relatively trivial compared with the power of a medical examiner to take possession of a patient and perform a forensic autopsy regardless of statements of religious (or nonreligious) belief.

An autopsy remains one of the worst things that can happen to a cryonicist.